DOE/ER-0241
(Previous No. DOE/CE/0078)

ENERGY MATERIALS COORDINATING COMMITTEE (EMACC)

Fiscal Year 1984
with Fiscal Year 1985 Data

July 1985

ANNUAL
TECHNICAL REPORT

U.S. Department of Energy
Office of Energy Research
Division of Materials Sciences

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Washington, D.C. 20545

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PREFACE

The Department of Energy funded approximately 374 million dollars of materials science and technology activities in both fiscal years 1984 and 1985. These funds and the commensurate program management responsibilities resided in 21 DOE program offices, each of which has its own mission and responsibilities. The Energy Materials Coordinating Committee (EMaCC) provides a formal mechanism to insure coordinated planning and maximum programmatic effectiveness for the Department's 374 million dollar per year materials effort. The EMaCC reports to the Director of the Office of Energy Research who in turn has oversight responsibilities for proper coordination of the technical programs of the Department. In carrying out this responsibility, EMaCC hosts meetings, organizes working groups, and publishes an annual technical report. This report is mandated by the EMaCC Terms of Reference. Its purpose is to disseminate information on the DOE materials programs for more effective coordination. It describes the materials research programs of various offices and divisions within the Department for FY 1984, contains funding information for FYs 1984 and 1985, and summarizes EMaCC activities for FY 1985.

The FY 1984 and FY 1985 funding levels for materials related activities in each of 21 programs within DOE are presented on pages vi and vii. These 21 programs fall under five major categories: Conservation and Renewable Energy, Energy Research, Nuclear Energy, Defense Programs, and Fossil Energy. The first part of this book, pp. 1-316, is separated into five sections which correspond to these five categories, and contains detailed programmatic and funding information.

Each year there is a particular need for special interprogrammatic coordination within certain topical areas because of the timeliness of the subject within DOE. In order to fulfill this need without imposing unnecessarily on non-involved parties, in this past year we have established four topical sub-committees. Each of these four sub-committees has carried out its own program and three of them have prepared reports which are contained herein, as follows:

EMaCC Topical Sub-Committee	Sub-committee Chairperson	Sub-committee Report Pages
Structural Ceramics	Stanley J. Dapkunas	317 - 329
Batteries and Fuel Cells	Iran L. Thomas	330 - 364
Radioactive Waste Containment	Henry F. Walter 353-5510	365 - 419
Steel	Theodore C. Reuther, Jr.	* 353-4963

* To be published separately.

The FY 1985 EMaCC Program is contained on page 420. In order to facilitate easy communications a Directory which contains the address and phone number of all program managers and investigators that are identified in this report is contained on pages 421-447. Finally, a Keyword Index of Projects is contained on pages 448-451.

The Executive Secretary of EMaCC for FY 1985 was Robert B. Schulz. I am grateful to him and to EMaCC sub-committee chairpersons Stanley J. Dapkunas, Iran L. Thomas, Henry F. Walter, and Theodore C. Reuther, Jr. for their contributions to our program and to this report. The compilation of this report was assisted by DHR, Incorporated with the skilled capabilities of Donald M. Horne.

Robert B. Schulz has been elected Chairperson and Iran L. Thomas has been elected Executive Secretary for the EMaCC for FY 1986.

Robert J. Gottschall
FY 1985 EMaCC Chairperson

FY 1984 AND FY 1985 BUDGET SUMMARY FOR DOE MATERIALS ACTIVITIES

(These numbers represent materials-related activities only. They do not include that portion of program budgets which are not materials-related.)

Jim Eberhardt 252-1499 252-1484

	FY 1984	FY 1985	FY-86	FY-87
Energy Conservation	$ 31,746,600	$ 31,554,400		
Office of Energy Systems Research	$ 10,824,000	$ 11,226,000 4,500	5,600	5,400
Office of Building Energy Research and Development	2,370,000	1,653,000		
Office of Industrial Programs	851,600	791,400		
Office of Vehicle and Engine R&D	17,701,000	17,884,000		
Renewable Energy	$ 29,744,000	$ 30,940,000		
Office of Solar Heat Technologies	$ 4,792,000	$ 4,750,000 5.2	4.7	3.3
Office of Solar Electric Technologies	23,645,000	23.7 24,600,000	23.5	19.2
Office of Renewable Technology	1,307,000	1.6 1,590,000	0.8	0.5
Energy Storage & Distribution		2.7	1.3	1.1
Office of Energy Research	$153,619,384	$154,579,000		
Office of Basic Energy Sciences	$126,229,000	$134,361,000	134,261	156,556
Office of Health and Environmental Research	$ 858,000	$ 868,000	650	778
Office of Fusion Energy	$ 21,780,000	$ 19,350,000		
Small Business Innovation Research Program	$ 4,752,384	$ * 7,900,000		
Office of Nuclear Energy David McGoff 353-3456	$130,892,000	$126,648,000		
Office of Converter Reactor Deployment	$ 5,865,000	$ 7,020,000	3,000	0
Office of ~~Terminal~~ Waste ~~Disposal~~ ~~and~~ Remedial Action and Technology	12,100,000	9,700,000	6,500	0
Office of Uranium Enrichment	55,229,000	* 62,500,000 77,708,000	47,000	25,600
Office of ~~Breeder Reactor Programs~~ Reactor Systems, Development, & Technology	57,698,000	~~32,220,000~~ 23,100,000	16,700	18,300
Office Naval program				
Office of Defense Programs	$ 18,690,000	$ 19,855,000		
Office of Inertial Fusion	$ 1,000,000	$ 1,000,000	1M	1M
Office of Military Applications	$ 17,690,000**	$ 18,855,000**	19M	19M

*Cancellation of centrifuge program

* FY 1985 funding levels are not available because awards change annually.

** At the time of publication funding levels were not submitted for portions of this office.

FY 1984 AND FY 1985 BUDGET SUMMARY FOR DOE MATERIALS ACTIVITIES
(Continued)

	FY 1984	FY 1985
		9,713 9,180 6,87C
Office of Fossil Energy	$ 9,225,000	$ 7,071,000
Office of Technical Coordination	$ 6,463,000	$ 5,141,000
Office of Surface Coal Gasification	$ 1,065,000	$ 860,000
Office of Oil, Gas, Shale, and Coal Liquids	$ 143,000	$ 0
Office of Coal Utilization	$ 1,554,000	$ 1,070,000
TOTAL	$373,916,984	$370,647,400

MEMORANDUM OF CALL

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TO: ILT

[X] YOU WERE CALLED BY— [ ] YOU WERE VISITED BY—

Sondy Dapkunas

OF (Organization)

[X] PLEASE PHONE ▶ [ ] FTS [ ] AUTOVON

3-2784

[ ] WILL CALL AGAIN [ ] IS WAITING TO SEE YOU

[ ] RETURNED YOUR CALL [ ] WISHES AN APPOINTMENT

MESSAGE

Fossil Mdtls. Fund. Est.

~~FY~~ 85	9,713	mil
86	9.180	
87	6.870	

RECEIVED BY	DATE	TIME
K	3/18	2:34

63-110 NSN 7540-00-634-4018

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[ ] RETURNED YOUR CALL [ ] WISHES AN APPOINTMENT

MESSAGE

FY 85	$868,000
FY 86	$650,000
FY 87	$778,000

RECEIVED BY	DATE	TIME
H	3-18	10

63-110 NSN 7540-00-634-4018

STANDARD FORM 63 (Rev. 8-81)
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CONSERVATION AND RENEWABLE ENERGY

The Office of Conservation and Renewable Energy seeks to develop the technology needed for the Nation to use its existing energy supplies more efficiently, and for it to adopt, on a large scale, renewable energy sources. Toward this end, the Office conducts long-term, high-risk, high-payoff R&D that will lay the groundwork for private sector action.

A number of materials R&D projects are being conducted within the Conservation and Renewable Energy program. The breadth of this work is considerable, with projects focusing on coatings and films, elastomers and polymers, corrosion, materials characterization, transformation, and other research areas. The level of funding indicated refers only to the component of actual materials research.

PROGRAM SUMMARIES

The Office of Conservation and Renewable Energy conducts materials research in the following offices and divisions:

			1984	1985
1.	Energy Conservation		$30,895,000	$30,763,000
	a.	Office of Energy Systems Research	10,824,000	11,226,000
	(1)	Energy Storage Division	5,756,000	3,880,000
	(2)	Energy Conversion and Utilization Technologies Division	2,143,000	4,181,000
	(3)	Electric Energy Systems Division	2,925,000	3,165,000
	b.	Office of Building Energy Research and Development	2,370,000	1,653,000
	(1)	Building Systems Division	804,000	658,000
	(2)	Building Equipment Division	1,566,000	995,000
	c.	Office of Industrial Programs	851,600	791,400
	(1)	Improved Energy Productivity Division	851,600	791,400
	d.	Office of Vehicle and Engine R&D	17,701,000	17,884,000
2.	Renewable Energy		29,744,000	30,940,000
	a.	Office of Solar Heat Technologies	4,792,000	4,750,000
	(1)	Active Heating and Cooling Division	2,033,000	2,455,000
	(2)	Passive and Hybrid Solar Energy Division	1,220,000	600,000
	(3)	Solar Thermal Technology Division	1,539,000	1,695,000
	b.	Office of Solar Electric Technologies	23,645,000	24,600,000
	(1)	Photovoltaic Energy Technology Division	23,600,000	24,600,000
	(2)	Wind Energy Technology Division	45,000	0
	c.	Office of Renewable Technology	1,307,000	1,590,000
	(1)	Geothermal and Hydropower Technologies Division	1,235,000	1,360,000
	(2)	Energy from Municipal Waste Division	72,000	230,000

Brief summaries of the materials research programs associated with each office and division are presented in the following text, including tables listing individual projects and the FY 1984 budgets for each. More details on the individual projects within the divisions and the specific tasks or subcontracts within the various projects are given in the paragraph descriptions.

OFFICE OF ENERGY SYSTEMS RESEARCH

	FY 1984	FY 1985
Office of Energy Systems Research Grand Total	$10,824,000	$11,226,000
Energy Storage Division	$ 5,756,000	$ 3,880,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 4,581,000	$ 3,075,000
Hydrogen Technology Evaluation Center	$ 300,000	$ 100,000
Anode Depolarization Studies	120,000	15,000
Proton Conducting Electrolytes	100,000	100,000
Materials for Advanced High Temperature Molten Salt Storage	106,000	0
Ceramics Research	1,400,000	1,000,000
Metals and Alloys	1,200,000	900,000
Organometallic Compounds	400,000	300,000
Polymers	250,000	180,000
Superconducting Magnetic Energy Storage	250,000	250,000
Chemically Bonded Ceramic Heat Storage Materials	15,000	0
Composite High Temperature Thermal Storage Media	350,000	150,000
Formation of Encapsulated Metallic Eutectic Thermal Storage Alloy	90,000	80,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,070,000	$ 795,000
Solid State Radiative Heat Pump	$ 125,000	$ 80,000
Use of Micro Particles as Heat Exchangers and Catalysts	75,000	90,000
Formation and Dissolution of Gas Clathrates	150,000	80,000
Evaluation of Advanced Thermal Energy Storage Media	50,000	250,000
High Temperature Electrolysis	450,000	200,000
Hydrogen Embrittlement of Pipeline Steels	120,000	45,000
Geochemical Stability of Sandstones	100,000	50,000
Device or Component Fabrication, Behavior, or Testing	$ 30,000	$ 0
Prototype Flywheels	$ 20,000	0
Elastomeric Storage	10,000	0
Instrumentation and Facilities	$ 75,000	$ 10,000
Analysis of Zeolite Augmented Ice Storage	$ 75,000	10,000

OFFICE OF ENERGY SYSTEMS RESEARCH (Continued)

	FY 1984	FY 1985
<u>Energy Conversion and Utilization Technologies Division</u>	$ 2,143,000	$ 4,181,000
<u>Materials Preparation, Synthesis, Deposition, Growth, or Forming</u>	$ 810,000	$ 1,550,000
Reactive Metallic Brazes for Ceramic-Ceramic and Ceramic-Metal Joints	$ 140,000	$ 125,000
Electromagnetic Joining of Ceramics	72,000	90,000
Recovery and Reuse of Plastic Scrap Via Separation and Bonding	5,000	35,000
Recovery and Reuse of Plastic Scrap Via Decomposition	0	185,000
Economics of Recovery and Reuse of Plastic Scrap	45,000	15,000
Cubic Boron Nitride and Diamond-Like Carbon Coatings	40,000	0
Magnetron-Sputtered Adherent Amorphous Metal Wear-Resistant Coatings	73,000	0
Supercritical Fluid Equations of State	0	0
Laser Surface Modifications of Ceramics	0	150,000
Solid Lubricants Deposited From the Gas Phase	55,000	75,000
Plasma Sintering of Ceramics	10,000	100,000
Ion Implantation of Ceramics	70,000	300,000
Tribological Surface Modifications and Coatings	300,000	475,000
<u>Materials Properties, Behavior, Characterization, or Testing</u>	$ 1,277,000	$ 2,450,000
Ordered Metallic Alloys for High Temperature Applications	$ 610,000	850,000
Modeling of Solid Ceramic Joints	0	150,000
Aging of Rigid Urethane Foam Insulation	0	0
Materials by Design	89,000	600,000
Coatings for High Temperature Energy Conversion Systems	0	0
Friction and Wear of Ceramics at Elevated Temperatures	261,000	300,000
Observations of "Hot Spots" on Ceramics and Development of Theory	40,000	75,000
Lubricant Qualities of the Constituents of Base Stock Oil	245,000	400,000

Energy Conversion and Utilization Technologies Division (Continued)	FY 1984	FY 1985
Materials Properties, Behavior, Characterization, or Testing (Continued)		
Heats of Adhesion of Molecular Constituents of Base Stock Oils	$ 0	$ 0
Ordered Metallic Alloys for Lightweight Applications	10,000	75,000
Materials Approaches to Ice Abatement	17,000	0
Friction and Wear of Ceramics Under Oscillatory Sliding	5,000	0
Instrumentation and Facilities	$ 56,000	$ 181,000
Instruments for Harsh Environments	$ 0	$ 100,000
Assessment of X-ray Methods for Investigations of Ceramic Wear Surfaces	56,000	81,000
Electric Energy Systems Division	$ 2,925,000	$ 3,165,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,325,000	$ 1,665,000
High Voltage Breakdown Strengths of Insulating Gases and Liquids	$ 580,000	$ 520,000
Aging Process in Solid Dielectrics	100,000	150,000
Threshold and Maximum Operating Electric Stresses for Selected High Voltage Insulations	150,000	150,000
Multifactor Aging and Evaluation of Polymeric Materials	220,000	220,000
Solid Dielectrics and Interfacial Breakdown	100,000	150,000
Investigation of Interfacial Phenomena in Compressed Gases	75,000	75,000
Interfacial Aging Phenomena in Power Cable Insulation Systems	0	150,000
Study of Dynamic Insulation with Advanced Metal Oxide (ZnO) Materials	0	100,000
Development of Amorphous Ferromagnetic Alloy for Motors and Transformers	100,000	150,000
Device or Component Fabrication, Behavior, or Testing	$ 1,600,000	$ 1,500,000
AC Superconducting Power Transmission Cable Development	$ 1,600,000	$ 1,500,000

OFFICE OF ENERGY SYSTEMS RESEARCH

This office supports generic research of a long-term, high-risk, high-payoff nature aimed at stimulating innovation in conservation technology. The research is both broadly based and multi-sectoral, providing a technology base for the other conservation programs. The Office consists of three divisions: Energy Storage Technology, Energy Conversion and Utilization Technologies (ECUT), and Electric Energy Systems.

Energy Storage Division

The principal function of the Energy Storage Division is to foster more efficient and more economical use of intermittent energy sources. A vital part of this R&D effort is the development of new and improved materials. Activities include materials development, fabrication, characterization and compilation of data bases.

Materials Preparation, Synthesis, Deposition, Growth or Forming

Hydrogen Technology Evaluation Center - DOE Contact M. Gurevich, 202-252-1507; BNL Contact P.D. Metz, 516-252-4091

- Establishment of a test/simulation facility which includes a 5 kW photovoltaic array with automated data control and recording equipment, an advanced 15 kW General Electric SPE electrolyzer, and an advanced technology metal hydride compressor.

Anode Depolarization Studies - DOE Contact M. Gurevich, 202-252-1507

- The objective has been to investigate whether an anode depolarizing agent could be used to reduce the overvoltage required to produce hydrogen at the same time producing an alternate product at the anode.

- BNL work was directed at identifying redox couples that could provide a two-step reaction sequence and the University of Virginia work at the upgrading of hydrocarbons via the conversion of alkanes to alcohols in electrochemical reactions.

Proton Conducting Electrolytes - DOE Contact M. Gurevich, 202-252-1507; BNL Contact F. Salzano, 516-282-4458

- Development of proton-conducting electrolytes capable of operating in 500 - 600 degrees C temperature regime.

Materials for Advanced High Temperature Molten Salt Storage - DOE Contact M. Gurevich, 202-252-1507; SERI Contact Werner Luft, 303-231-1823

- Various alloys and fused cast refractories are being identified as internal thermal insulation for high temperature molten-salt storage.

- Compatibility of alloys and ceramics with molten salt is under investigation.

Ceramics Research - DOE Contact A. Landgrebe, 202-252-1483

- Superconducting ionic materials

- Materials for electrochemical corrosion prevention in batteries

Metals and Alloys - DOE Contact A. Landgrebe, 202-252-1483

- Aluminum alloys prepared as negative electrodes

- Platinum alloys prepared for use as electrocatalysts in fuel cells and aluminum/air batteries

Organometallic Compounds - DOE Contact A. Landgrebe, 202-252-1483

- Macrocyclic compounds of transition metals for use as electrocatalysts in fuel cells

Polymers - DOE Contact A. Landgrebe, 202-252-1483

- Electronically and ionically conducting polymers for use as electrodes and electrolytes in batteries and fuel cells

Superconducting Magnetic Energy Storage - DOE Contact R. Shivers, 202-252-1488

- Development of low-cost polyester-glass support structure for cryogenic service

- Development of high purity aluminum stabilizer conductor

Chemically Bonded Ceramic Heat Storage Materials - DOE Contact Imre Gyuk, 202-252-1508; MCA Inc. Contact Dennis Brosnan, 803-843-6444

- Olivine brick heat storage media development

- Fabrication techniques for large monolithic segments with cast integral heating elements

Composite High Temperature Thermal Storage Media - DOE Contact Imre Gyuk, 202-252-1508; IGT Contact Randy Petri, 312-567-3985

- Development of prototype fabrication process for impregnating ceramic powder (MgO, $NaAlO_2$, $LiAlO_2$) with carbonate salts for thermal storage pellet

Formation of Encapsulated Metallic Eutectic Thermal Storage Alloy- DOE Contact Imre Gyuk, 202-252-1508; Ohio State University Contact Prof. Robert Rapp, 614-422-2491

- Develop a method of achieving an impermeable coating on pellets of metallic eutectic with high melting temperatures for latent heat thermal energy storage.

Materials Properties, Behavior, Characterization, or Testing

Solid State Radiative Heat Pump - DOE Contact Imre Gyuk, 202-252-1508; Lawrence Berkeley Laboratory Contact Roland Otto, 415-486-5289

- Investigation of a cooling effect using galvanometric luminescence from indium-antimonide.

Use of Micro Particles as Heat Exchangers and Catalysts - DOE Contact Imre Gyuk, 202-252-1508; Lawrence Berkeley Laboratory Contact Roland Otto, 415-486-5289

- Measurement of dissociated fraction for SO_3 --> SO_2 + 1/2 O_2 when concentrated sunlight is absorbed by a gas particle mixture.

Formation and Dissolution of Gas Clathrates - DOE Contact Imre Gyuk, 202-252-1508; ORNL Contact Juan Carbajo, 615-574-3784

- Study of use of gas clathrates of mixed refrigerants for thermal energy storage for air conditioners and heat pumps.

Evaluation of Advanced Thermal Energy Storage Media - DOE Contact Imre Gyuk, 202-252-1508; ORNL Contact J. F. Martin, 615-576-3977

- Development of dual temperature TES media for heat and cool storage

- Evaluation of heats of mixing and crystallization in multicomponent solutions

- Identify through computer molecular modeling, clathrates suitable for dual temperature storage

- Determine phase behavior of selected singly-complexing and multiply-complexing ammoniated salts in phase regions appropriate to dual temperature storage

High Temperature Electrolysis - DOE Contact M. Gurevich, 202-252-1507; Westinghouse R&D Center Contact E. Buzzeli, 412-256-1952

- Solid oxide electrolyte fuel cells operated in reverse to produce hydrogen at 1000 degrees C.

Hydrogen Embrittlement of Pipeline Steels - DOE Contact M. Gurevich, 202-252-1507; Battelle Columbus Contact J. Holbrook, 614-424-4347

- Pipeline steel fracture-mechanics and fatigue-crack growth rates investigation
- Identification of additives that inhibit effects of hydrogen embrittlement
- Results will serve as input to a Design/Operation Manual for pipeline designers concerned with hydrogen transmission

Geochemical Stability of Sandstones - DOE Contact R. Shivers, 202-252-1476; Pacific Northwest Laboratory Contact Landis Kannberg, 509-375-3919

- Laboratory testing the effects of 150 degrees C water flow through porous sandstones
- Determination of the degree and rate of change in sandstone hydraulic and mechanical properties

Device or Component Fabrication, Behavior, or Testing

Prototype Flywheels - DOE Contact R. Shivers, 202-252-1476; ORNL Contact J. Martin, 615-576-3977

- Composites of kevlar, glass, and graphite fibers with various matrix materials for flywheel fabrication

Elastomeric Storage - DOE Contact R. Shivers, 202-252-1476; ORNL Contact J. Martin, 615-576-3977

- Fabrication of elastomers for prototype storage systems
- Materials development for low fatigue characteristics

Instrumentation and Facilities

Analysis of Zeolite Augmented Ice Storage - DOE Contact R. Shivers, 202-252-1476; Pacific Northwest Laboratory Contact Landis Kannberg, 509-375-3919

- Facility for testing solar regenerated zeolites for augmenting the chill obtained from seasonally stored ice by using heat of sublimation rather than simply heat of fusion
- Facility will involve cyclic absorptive capacity of several types of zeolites under highly varied operating conditions

Energy Conversion and Utilization Technologies Division

The mission of the ECUT Program is to support generic, long-term, high risk directed basic and applied research and exploratory development of new or improved concepts to produce a technology base which private industry can use in producing products that use energy more efficiently. Materialsrelated research in the ECUT Program is found in fiscal year 1984 in two projects, the Materials Project and the Tribology Project. In FY 1984 both projects were managed for ECUT by the Oak Ridge National Laboratory (ORNL). Beginning in FY 1985, the Tribology Project will be managed by Argonne National Laboratory (ANL). The goal of both projects is to develop innovative concepts to a point where they can be taken over for further development by private industry or other government programs. The materials work in the Materials Project is in the areas of intermetallic compounds, ceramic-ceramic and ceramic-metal attachments, surface modifications of ceramics, recovery and reuse of plastic scrap, ceramic coatings, and materials structures theory. Materials research in the Tribology Project is in the areas of wear of lubricated solids, the friction and wear of ceramics, and tribological surface modifications and coatings. The DOE contact is James J. Eberhardt, (202) 252-1484 for the Materials Project and Terry Levinson, (202) 252-1484 for the Tribology Project.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Reactive Metallic Brazes for Ceramic-Ceramic and Ceramic-Metal Joints - ORNL Contact Artie Moorhead, 615-574-5153

- Development and testing of reactive metal brazes for joining ceramics to ceramics and metals.
- Main applications in joining parts for high temperature service up to 900 degrees C.

Electromagnetic Joining of Ceramics - DHR, Inc. Contact Richard Silberglitt, 703-556-8660

- Investigations of the potential of using radiofrequency radiation to effect solid bonds between a ceramic piece and another ceramic or a metal piece.

Recovery and Reuse of Plastic Scrap Via Separation and Bonding - Plastics Institute of America Contact Mike Curry, 201-420-5552

- Development of methods of producing useful materials from mixed plastic scrap via bonding of the scrap as-is or by separations and subsequent processing.
- Current work centered mainly on scrap from shredded automobiles.

Recovery and Reuse of Plastic Scrap Via Decomposition - ORNL Contact Joseph A. Carpenter, Jr., 615-574-4571

- Investigations of technologies for reuse of or recovery of value from plastics via methods involving the molecular decomposition of the plastics.

- FY 1984 activities are concerned with the planning of future work.

Economics of Recovery and Reuse of Plastic Scrap - ORNL Contact Randy Curlee, 615-576-4864

- Studies of the economic viability of the recovery and reuse of plastic scrap and institutional barriers to be overcome.

Cubic Boron Nitride and Diamond-Like Carbon Coatings - ORNL Contact Dave Stinton, 615-574-4556

- Attempts to produce coatings of cubic BN and diamond-like C coatings via plasma-assisted chemical vapor deposition.

Magnetron-Sputtered Adherent Amorphous Metal Wear-Resistant Coatings - Jet Propulsion Laboratory Contact Satish Khanna, 213-792-4489

- Deposition and testing of adherent wear-resistant amorphous metal coatings via magnetron sputtering.

Supercritical Fluid Equations of State - National Bureau of Standards Contact James Ely, 303-320-5467

- Investigations of the exact thermodynamic states of fluids in the supercritical state.

- Useful for separations and extractions in various materials processing methods.

Laser Surface Modifications of Ceramics - NC State Contact Bob Davis, 919-737-3272

- Investigations of the effects induced by pulsed laser irradiation of thin films of metals deposited onto surfaces of ceramics.

- Films of Fe, Cr, and Ni on SiC, Si_3N_4, and Al_2O_3.

Solid Lubricants Deposited From the Gas Phase - Pennsylvania State University Contact Larry Duda, 814-865-2574

- Determine the kinetics of formation and the structures of solid lubricant films deposited on ceramic or metal surfaces from the gas phase.

Plasma Sintering of Ceramics - Northwestern University Contact Lynn Johnson, 312-492-3537

- Exploration of the sintering of ceramics via plasmas.

Ion Implantation of Ceramics - ORNL Contact Carl McHargue, 615-574-4344

- Exploration of the effects of ion implantation on certain properties (viz. strength, fracture toughness, hardness, friction coefficient and wear rates) of ceramics.

- Current work is on ion implantation into TiB_2, ZrO_2, and Al_2O_3.

Tribological Surface Modifications and Coatings - Argonne National Laboratory Contact Manfred Kaminsky, 312-972-4074

- Development of novel surface modifications and coatings for various tribological applications.

- Emphasis of FY 1984 work is on coatings for cutting tool wear.

Materials Properties, Behavior, Characterization, or Testing

Ordered Metallic Alloys for High Temperature Applications - ORNL Contact Chain Liu, 615-574-4459

- Development and determinations of properties of ductile long-range ordered alloys based on the $(Fe,Ni)_3V$ system and ductile intermetallic alloys based on the Ni_3Al system.

- Main applications in high temperature service in steam turbines, heat engines, and heat exchangers.

Modeling of Solid Ceramic Joints - Norton Company Contact Pierre Charreyron, 617-863-1000, ext. 2667

- Development of finite element models of stress states in and around solid joints between ceramic and a ceramic or metal part of specific geometry.

- Initial work on butt-on-butt in cylindrical and rectangular cross sections.

Aging of Rigid Urethane Foam Insulation - Massachusetts Institute of Technology Contact Leon Glicksman, 617-253-2233

- Development and experimental verification of models for heat transfer and gas diffusion in rigid urethane foam insulation.

- Purpose is to understand mechanisms of degradation of insulating properties over time.

Materials by Design - Universal Oil Products Contact Al Wilks, 312-391-3179

- Assessment to determine if it is now, or soon will be, possible to develop, experimentally verify, and use ab initio or semiempirical interatomic or intermolecular models to design and optimize practical engineering materials and processes.

Coatings for High Temperature Energy Conversion Systems - Lawrence Berkeley Laboratory Contact Al Levy, 415-486-5822

- Friction and wear tests to 1400 degrees F of candidate coatings for use on the top piston rings of the adiabatic diesel engine.

Friction and Wear of Ceramics at Elevated Temperatures - ORNL Contact Charlie Yust, 615-574-4812

- Measurements of the friction coefficient and wear rates under unidirectional sliding and investigations of the wear mechanisms of ceramics during tests of ceramics run against themselves and other ceramics up to 800 degrees F.

- Emphasis in FY 1984 is on PSZ, Al_2O_3, and SiC.

Observations of "Hot Spots" on Ceramics and Development of Theory - Georgia Institute of Technology Contact Ward Winer, 404-894-3270

- The wearing surfaces of the ends of ceramic pins are observed through a rotating sapphire (Al_2O_3) disk to see if they exhibit "hot spots" (i.e., extremely hot surface asperities) and, if so, to develop a theory of wear of ceramics based on the observations.

Lubricant Qualities of the Constituents of Base Stock Oil - NBS-Gaithersburg Contact Stephen Hsu, 301-921-2113

- Commercial base stock (without additives) oils are separated into molecular fractions and the fractions are tested for friction and wear qualities and oxidation stability.

- Objectives are to prove that there are significant differences in the lubricant qualities of the various molecular constituents of base stock oils and to improve the understanding of the influence of the molecular structure of lubricant molecules on their lubricant qualities.

Heats of Adhesion of Molecular Constituents of Base Stock Oils - Martin Marietta Laboratories Contact Keith Bridger, 301-247-0700, ext. 229

- Heats of adhesion of molecular fractions of base stock oils on steel are determined by measuring the angle of wetting of a drop on the steel immersed in water.

- Joint effort with NBS-Gaithersburg which supplies the oil fractions.

Ordered Metallic Alloys for Lightweight Applications - ORNL Contact Chain Liu, 615-574-4459

- Identification and development of ductile intermetallic alloys for lightweight structural application such as in automobile bodies.

- Work in FY 1984 is mainly an assessment to determine if Mg-based ductile intermetallic alloys might be possible.

Materials Approaches to Ice Abatement - Consultant Contact Larry Casper, 612-541-2508

- Assessment to determine if there may be any viable materials approaches to ice abatement on surfaces such as heat pump condenser coils, roofs, and solar collectors.

Friction and Wear of Ceramics Under Oscillatory Sliding - Carborundum Contact Jim MacBeth, 716-278-2282

- Initial measurements of the friction coefficients and wear rates for ceramics under linearly oscillating sliding up to 1200 degrees C.

- Joint effort with U.S. Army (TACOM).

Instrumentation and Facilities

Instruments for Harsh Environments - NBS-Gaithersburg Contact Ken Kreider, 301-921-3281

- Develop thin film sensor for less intrusive temperature measurements inside combustion chambers.

- Oxide layer grown on MCrAlY deposit adhering to Fe substrate to insulate substrate from thermocouple (e.g., Pt:Pt/Rh) junction and leads subsequently sputter-deposited on the oxide layer.

Assessment of X-ray Methods for Investigations of Ceramic Wear Surfaces - Virginia Polytechnic Institute and State University Contact Charles Houska, 703-961-5652

- Determine the potential of x-ray diffraction and fluorescence methods for nondestructive analyses of the near-surface wear regions of ceramics.

- Considers conventional x-ray sources as well as the Brookhaven Light Source.

Electric Energy Systems Division

The EES program supports R&D to expedite the development of high-risk, long-term payback technologies which have a significant potential for improving the reliability, efficiency, and safety of the nation's electrical energy system. Research is also conducted in technologies for integrating new electrical energy sources (dispersed generation and storage) into the grid. DOE contact is Russell Eaton, 202-252-4844.

Materials Properties, Behavior, Characterization, or Testing

High Voltage Breakdown Strengths of Insulating Gases and Liquids - ORNL Contact Lucas Christophorou, 615-574-6199

- Physiochemical factors of breakdown strength of gaseous and liquid dielectrics

Aging Process in Solid Dielectrics - Battelle Columbus Contact Mike Epstein, 614-424-6424

- Insulating aging characteristics of solid dielectrics for underground cable transmission
- Testing procedures to predict insulation life for rated service

Threshold and Maximum Operating Electric Stresses for Selected High Voltage Insulations - Cable Technology Lab Contact Carlos Katz, 201-846-3220

- Threshold voltage and maximum operating electric field strengths for selected high voltate insulation systems

Multifactor Aging and Evaluation of Polymeric Materials - DOE Contact Russell Eaton, 202-252-4844; ORNL Contact Steinar Dale, 615-574-4829

- Investigate aging of polymeric film materials. The aging will be done under combined mechanical, electrical, and thermal stresses, as well as under single stress application. The materials will be periodically analyzed for characteristic changes.

Solid Dielectrics and Interfacial Breakdown - DOE Contact Russell Eaton, 202-252-4844; ORNL Contact Steinar Dale, 615-574-4829

- Investigate electron and ion transports across interfaces between a solid dielectric and metal. Effects of electric fields, impurities, defects, and microstructures at the interfaces will be studied.

Investigation of Interfacial Phenomena in Compressed Gases - DOE Contact Russell Eaton, 202-252-4844; ORNL Contact Steinar Dale, 415-574-4829

- Investigate the initiation and propagation mechanisms of surface discharges along insulators in compressed gases. Measurements will be made of the secondary yield coefficients from insulator surfaces in the N_2 and SF_6. Models of the discharge propagation will be made.

Interfacial Aging Phenomena in Power Cable Insulation Systems - DOE Contact Russell Eaton, 202-252-4844; ORNL Contact Steinar Dale, 415-574-4829

- Investigate aging of semi-conducting/polymer interfaces. Phase II will be initiated using purified materials of semi-conducting shields. Union Carbide has agreed to supply the required varieties of materials.

Study of Dynamic Insulation with Advanced Metal Oxide (ZnO) Materials - DOE Contact Russell Eaton, 202-252-4844; ORNL Contact Steinar Dale, 415-574-4829

- Determine performance of ORNL-developed sol-gel ZnO material in overhead line insulators. The performance will be compared with that of insulators with commercial ZnO material which was studied in FY 84 and FY 85.

Development of Amorphous Ferromagnetic Alloy for Motors and Transformers - DOE Contact Russell Eaton, 202-252-4844; ORNL Contact Steinar Dale, 615-574-4829

- Investigate micro-alloying of Fe- and Ni-based metallic glasses. A major effort will be to develop understanding of the mechanism by which cerium additions affect the mechanical and magnetic properties. Other elements which can improve the embrittlement problem in metallic glasses will also be investigated.

Device or Component Fabrication, Behavior, or Testing

AC Superconducting Power Transmission Cable Development - Brookhaven Contact E. Forsyth, 516-282-4676

- Development of underground ac superconducting cable system (138 kV, 4000 A) employing Nb_3Sn tape

- Insulation system will consist of synthetic tape impregnated with supercritical helium

OFFICE OF BUILDING ENERGY RESEARCH AND DEVELOPMENT

	FY 1984	FY 1985
Office of Building Energy Research and Development Grand Total	$ 2,370,000	$ 1,653,000
Building Systems Division	$ 804,000	$ 658,000
Materials Properties, Behavior, Characterization, or Testing	$ 804,000	$ 658,000
Unguarded Flat Insulation Nichrome Wire Screen Tester	$ 100,000	$ 170,000
Settled Density Studies of Loose-Fill Insulation	25,000	50,000
Heat Flow Modeling	100,000	100,000
Gas Diffusion and Effective Conductivity of Foam Insulation Versus Age	95,000	50,000
Corrosiveness of Thermal Insulating Materials	30,000	20,000
Improved Standard Reference Materials	197,000	100,000
Smoldering Combustion Hazards of Thermal Insulation Materials	64,000	8,000
Reflective Foil Thermal Performance Modeling	39,000	40,000
Assessment of Urea-Formaldehyde Foam Insulation	50,000	0
High Temperature Insulation Standard Reference Materials	50,000	50,000
Radiation Transmission Properties of Thermal Insulation	41,000	40,000
Theory of Radiative Heat Transport in Low-Density Insulations	13,000	30,000
Building Equipment Division	$ 1,566,000	$ 995,000
Materials Properties, Behavior, Characterization, or Testing	$ 836,000	$ 775,000
Materials for Condensing Heat Exchangers	$ 485,000	$ 125,000
Advanced Insulation for Appliances	162,000	250,000
Non-Azeotropic Refrigerant Mixtures	189,000	400,000

OFFICE OF BUILDING ENERGY RESEARCH AND DEVELOPMENT (Continued)

		FY 1984		FY 1985
Building Equipment Division (Continued)				
Device or Component Fabrication, Behavior, or Testing	$	230,000	$	120,000
Mercury Isotope Separation Process		50,000		0
Mercury Isotope Enrichment		120,000		80,000
Zeeman Effect on Lamp Gas Plasma		60,000		40,000
Instrumentation and Facilities	$	500,000	$	100,000
Absorption Fluid Pairs Research		500,000		100,000

OFFICE OF BUILDING ENERGY RESEARCH AND DEVELOPMENT

The Office of Building Energy Research and Development works to increase the energy efficiency of the buildings sector through performance of R&D on building systems, building equipment, and community energy systems. In addition, the Office carries out the statutory requirements of appliance standards and labeling, building energy performance standards, the residential conservation service, and Federal energy management program. Specific objectives include providing the technology to:

- reduce energy consumption in existing buildings, and in new buildings;
- increase the energy efficiency of oil and gas combustion heating systems and of oil- and gas-fired heat pump systems;
- improve the energy efficiency of advanced electric heat pump and refrigeration systems, and of light systems; and
- develop new planning techniques and systems that will decrease the energy consumption of communities.

Building Systems Division

The goal of this Division is to provide a scientific and technical basis (including model standards) for reducing the use of energy in residential and commercial buildings by 35% by the year 2000 from that used in 1975, while maintaining existing levels of human comfort, health and safety. The Division's primary objectives are to support research that advances the scientific and technical options for increased energy efficiency in buildings, to promote the substitution of abundant fuels for scarce fuels in buildings, and to promulgate standards for increased efficiency of energy use. To accomplish a portion of this, the Building Materials Program seeks to increase the knowledge base concerning the physical, chemical and mechanical properties of building materials that determine their effectiveness, durability, safety, and health impacts; to develop and verify useful models for the behavior of those materials; to develop improved test methods for measuring the performance of the materials; and to develop consensus standards for characterizing the materials. The DOE contact is Bill Gerken, 202-252-9191.

Materials Properties, Behavior, Characterization, or Testing

Unguarded Flat Insulation Nichrome Wire Screen Tester - ORNL Contact David McElroy, 615-574-5976

- Study of transient thermodynamic processes in insulation materials including mineral fiberboard and powdered insulations

Settled Density Studies of Loose-Fill Insulation - ORNL Contact David McElroy, 615-574-5976

- Laboratory and field studies of loose fill insulation materials to determine the effects of settling on density and R-value
- Testing involves vibration of these materials in a simulated wall cavity and in actual residential attics

Heat Flow Modeling - ORNL Contact David McElroy, 615-574-5976

- Mathematical modeling of heat transfer along longitudinal and radial coordinates
- Elucidation of "apparent" thermal conductivity in materials

Gas Diffusion and Effective Conductivity of Foam Insulation Versus Age - MIT Contact Dr. Leon Glicksman, 617-253-2233

- Freon-blown rigid urethane foam is studied for changes due to diffusional effects as insulation ages
- Experimental measurements of gas permeability through cell wall materials
- Investigation of new concepts which reduce overall thermal conductivity of foam material

Corrosiveness of Thermal Insulating Materials - Stevens Institute of Technology Contact Dr. Rolf Weil, 201-420-5257

- Effects of leachants on interaction of cellulose, rockwool, fiberglass and urea formaldehyde foam with contact metals

Improved Standard Reference Materials - NBS Contact Brian Rennex, 301-921-3195

- Candidates for improved standard reference materials are being investigated using a one meter diameter line-heat- source guarded hot plate

Smoldering Combustion Hazards of Thermal Insulation Materials - NBS Contact Thomas Ohlemiller, 301-921-3771

- Examination of cellulosic insulation transition from smoldering to flaming combustion with emphasis on the effects of forced air flow
- Determination of level and effects of various combustion retardants on transition process

Reflective Foil Thermal Performance Modeling - Tennessee Technological University Contact David Yarbrough, 615-528-3494

- Modeling of reflective foil radiation barrier systems is being conducted as part of an effort to develop an acceptable method for determining the R-value of such systems

Assessment of Urea-Formaldehyde Foam Insulation - National Bureau of Standards Contact Walter Rossiter, 301-921-3109

- Assessment of current knowledge concerning urea-formaldehyde foam insulation properties and use relevant to energy conservation

High Temperature Insulation Standard Reference Materials - National Bureau of Standards Contact Jerome Hust, 303-497-3733

- Cerroboard and a high temperature loose-fill insulation are candidates to be investigated for use as new Standard Reference Materials, using a new 800 degrees K guarded hot plate

Radiation Transmission Properties of Thermal Insulation - University of Kentucky Contact Timothy Tong, 606-257-3236

- A data-reduction method for determining the thermal conductivity of thermal insulation from transient heat transfer data is being developed

- Radiation transmission properties of thermal insulation are being measured

Theory of Radiative Heat Transport in Low-Density Insulations - University of Connecticut Contact Paul Klemens, 203-486-3134

- Theoretical mathematical and physics analysis of radiative heat flow under transient conditions

- Realistic model used to derive a new heat transfer equation, to be applied to steady-state and transient test cases

- Leads to computer simulations of heat transfer for diurnal cycle and for measurement techniques such as laser diffusivity and the flat screen tester

Building Equipment Division

The mission of the Building Equipment Division is to provide the long range technical support needed to supply the private sector with the technological basis for developing and testing high efficiency equipment utilized in the operation of residential and commercial buildings. This equipment supplies the heating, cooling, lighting, hot water, and other services required to operate a building efficiently and offer its occupants a comfortable environment. The division supports applied research in the engineering phenomena surrounding the conversion of raw energy in the form of oil, gas, and electricity into the useful energy forms of heat, refrigeration, and light. The division supports the development and revision of the DOE test procedures for consumer products. As part of the applied research program, the division conducts research on materials problems that are key to advanced technology equipment.

Materials Properties, Behavior, Characterization, or Testing

Materials for Condensing Heat Exchangers - DOE Contact Danny C. Lim, 202-2529130; Battelle Contact Richard Razgaitis, 614-424-4212; Brookhaven Contact Roger J. McDonald, 515-282-4197

- Investigation of materials feasible for use in heat exchangers for condensing oil- and gas-fired heating systems

Advanced Insulation for Appliances - DOE Contact Ronald Fiskum, 202-252-9130; ORNL Contact Fred Creswick, 615-574-2009

- Thermal conductivity of materials potentially suitable for advanced insulation for refrigeration systems

Non-Azeotropic Refrigerant Mixtures - DOE Contact Ronald Fiskum, 202-252-9130; ORNL Contact Phil Fairchild, 615-574-2020

- Development of knowledge base of non-azeotropic refrigerants for use in refrigeration systems

- Testing of novel mixtures to generate properties data

Device or Component Fabrication, Behavior, or Testing

Mercury Isotope Separation Process - DOE Contact Robert Boettner, 202-252-9136; GTE Sylvania Contact Bill Staubitz, 617-777-1900

- Investigation of Hg isotopes used as fill gas in discharge lamps aimed at determining efficiency improvement in fluorescent lamps that have altered isotope composition

- Development of effective separation process, construction and operation of a laboratory scale reactor

Mercury Isotope Enrichment - DOE Contact Robert Boettner, 202-252-9136; LBL Contact Dr. Sam Berman, 415-486-5682

- Determination of optimum isotope mix both technically and economically in Hg discharge lamps

- Goal is a 10-15% efficiency improvement in test lamps

Zeeman Effect on Lamp Gas Plasma - DOE Contact Robert Boettner, 202-252-9136; LBL Contact Dr. Sam Berman, 415-486-5682

- Determination of efficiency improvements of radiation of ultraviolet spectrum through application of a magnetic field to the lamp discharge

Instrumentation and Facilities

Absorption Fluid Pairs Research - DOE Contact Ronald Fiskum, 202-252-9130; ORNL Contact George Privon, 615-574-1013

- Development of complete data base on known fluid pairs over the temperature and pressure ranges of heat pumps

OFFICE OF INDUSTRIAL PROGRAMS

		FY 1984		FY 1985
Office of Industrial Programs Grand Total	$	851,600	$	791,400
Improved Energy Productivity Division	$	851,600	$	791,400
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$	394,000	$	487,000
Corrosion Resistant Amorphous Metallic Films	$	225,000	$	220,000
Investigation of Material for Inert Electrodes in Aluminum Electrodeposition Cells		169,000		267,000
Materials Properties, Behavior, Characterization, or Testing	$	65,000	$	84,000
Diagnosis Sources of Current Inefficiency in Industrial Molten Salt Electrolytic Cells by Raman Spectroscopy		65,000		84,000
Instrumentation and Facilities	$	392,600	$	220,400
Non-destructive Evaluation of Weldments	$	165,000	$	0
Automatic Inspection of Hot Steel Slabs		63,000		0
Rapid In-Situ Analysis of Molten Metal		150,000		51,400
Direct Measurement of Thermal State of Solids		146,000		169,000

OFFICE OF INDUSTRIAL PROGRAMS

This office supports cost-shared research and development for industrial energy conservation technologies that offer large potential for saving scarce fuels and to encourage the private sector to implement and deploy such technologies as they are developed. Materials research is done in support of the technologies under development or to develop materials with lower embodied energy.

Improved Energy Productivity Division

This division conducts research and creates new energy conserving processes for ore reduction, base metals, and basic shape processing; sensing and control instrumentation; concentration, evaporation, separation, and reaction processes and food production and processing.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Investigation of Material for Inert Electrodes in Aluminum Electro-Deposition Cells - DOE Contact M.J. McMonigle, 202-252-2087; MIT Contact - J.S. Haggarty,

- Generation of ultra pure powders and single crystals of candidate ceramics (TiB_2, LaB_6, NiO-$NiFe_2O_4$) using laser units

Corrosion Resistant Amorphous Metallic Films - DOE Contact Robert Massey, 202-252-2079; JPL Contact Dennis Fitzgerald, 818-577-9079

- Magnetron sputtering of MoRuB and FeCrPC on carbon steel is being developed to provide corrosion resistant surface.

Materials Properties, Behavior, Characterization, or Testing

Diagnosis Sources of Current Inefficiency in Industrial Molten Salt Electrolytic Cells by Raman Spectroscopy - DOE Contact M.J. McMonigle, 202-252-2087; MIT Contact D.R. Sadoway,

- Analysis of molten salts with Raman Spectroscopy to determine bath chemistry during electrolysis

Instrumentation and Facilities

Non-destructive Evaluation of Weldments - DOE Contact Robert Massey, 202-252-2079; EG&G Idaho Contact Basil Barna, 208-526-6124

- Development of equipment for real time detection of welding flaws using ultrasonic sensing and computer analysis to permit immediate flaw correction.

Automatic Inspection of Hot Steel Slabs - DOE Contact J.C. Fulton, 202-252-8668; Honeywell Incorporated Contact D. Waters, 612-638-5944

- Proof of concept of an automated instrument to identify and locate surface cracks in hot steel slabs and encourage hot charging or direct processing of these slabs

Rapid In-Situ Analysis of Molten Metal - DOE Contact J.C. Fulton, 202-252-8668; Los Alamos National Laboratory Contact L. Blair, 505-667-6250

- A laser-based system for spectrographic analysis of liquid steel is being developed for a faster analytical method to increase productivity in the steel industry

Direct Measurement of Thermal State of Solids - DOE Contact J.C. Fulton, 202-252-8668; PNL Contact - Douglas Lemon, 509-375-2306

- Use of an ultra-sonic device to determine temperature distribution in a piece of steel slab or recently poured ingot before entering reheating furnaces

OFFICE OF VEHICLE AND ENGINE R&D

	FY 1984	FY 1985
Office of Vehicle and Engine R&D Grand Total	$17,701,000	$17,884,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 3,024,000	$ 3,155,000
Powder Characterization	$ 34,000	$ 31,000
Powder Synthesis and Characterization	130,000	0
Silicon Carbide Powder Synthesis	112,000	110,000
High Pressure Sintering Furnace	79,000	80,000
Si_3N_4 Powder Synthesis	112,000	110,000
Sintering of Si_3N_4	71,000	70,000
Ceramics for Stirling Engine Applications	170,000	26,000
Silicon Carbide Whiskers	35,000	0
Dispersion Toughened Silicon Carbide	100,000	77,000
Si_3N_4 - Metal Carbide Composite	300,000	38,000
Si_3N_4 - SiC Whisker Composite	120,000	35,000
Si_3N_4 Matrix Transformation-Toughened Si_3N_4	140,000	35,000
Advanced Transformation-Toughened Oxides	90,000	160,000
Improved Transformation-Toughened Ceramics	83,000	100,000
Injection Molded Composites	0	200,000
SiC Whisker Reinforced Ceramic	200,000	345,000
Sol Gel Oxide Powder	105,000	100,000
Mullite-SiC Whisker Composite	0	130,000
Transformation-Toughened Ceramics	178,000	200,000
Advanced Coating Technology AGT	0	100,000
CVD and Sol Gel ZrO_2	200,000	0
Development of Thermal Barrier Coatings	87,000	255,000
Cr_2O_3-ZrO_2 Coating Evaluation	113,000	0
Advanced Coating Technology Diesel	0	200,000
Active Metal Brazing PSZ-Iron	180,000	250,000
Ceramic-Metal Joints AGT	0	105,000
Diesel Ceramic-Metal Joint Scale-up	0	100,000
Ceramic-Ceramic Joints AGT	0	100,000
Materials Development - Intermetallic Evaluation	200,000	48,000
Cast Iron Alloy Containing Nonstrategic Elements	185,000	150,000
Materials Properties, Behavior, Characterization, or Testing	$ 2,728,000	$ 2,909,000
High Temperature Coating to Reduce Contact Stress	123,000	150,000
Dynamic Interfaces	139,000	110,000
Friction and Wear Characteristics of Load Bearing Materials	159,000	0
Advanced Statistical Calculations	25,000	40,000
Advanced Statistics Calculations	222,000	100,000

Materials Properties, Behavior, Characterization, or Testing (Continued)	FY 1984	FY 1985
Design Allowables Code	$ 130,000	$ 130,000
Failure Analysis	65,000	0
Ceramic Durability Evaluation	190,000	100,000
Characterization of Transformation-Toughened Ceramics	70,000	80,000
Cyclic Fatigue of Toughened Ceramics	0	90,000
Fracture Behavior of Toughened Ceramics	0	190,000
High Temperature Creep Evaluation	65,000	44,000
Time-Temp Properties of Advanced Ceramics	100,000	85,000
Experimental Life Testing	230,000	0
Alloy Properties in High Pressure Hydrogen	110,000	0
Structural Ceramics Corrosion/Erosion Studies	0	120,000
Corrosion/Erosion Effects	0	240,000
Environmental Effects in Toughened Ceramics	139,000	125,000
Static Behavior of Toughened Ceramics	112,000	120,000
Static Fatigue of Toughened Ceramics	175,000	0
High Temperature Fracture Toughness Measurement	66,000	150,000
High Temperature Tensile Testing	338,000	100,000
Standard Tensile Test Development	0	90,000
Ceramic Component Technology	90,000	95,000
Characterization Needs Assessment	0	80,000
Non-Destructive Characterization	0	70,000
International Exchange Agreements	90,000	100,000
NBS Standard Reference Material	0	50,000
Specimens and Hardware for IEA	0	50,000
Technical Support and Monitoring Contracts	0	250,000
Technology Assessment and Planning	30,000	30,000
Technology Transfer	60,000	120,000
Device or Component Fabrication, Behavior, or Testing	$11,949,000	$ 9,760,000
Advanced Gas Turbine Engine Technology (AGT-100)	5,879,000*	4,860,000*
Advanced Gas Turbine Engine Technology (AGT-101)	6,070,000*	4,900,000*

* Estimated funding for ceramic materials design, fabrication, and rig acceptance testing.

	FY 1984	FY 1985
Instrumentation and Facilities	$ 0	$ 2,060,000
HTML Pre-Operational Support	$ 0	$ 160,000
Capital Equipment for Advanced Materials Development Program	0	1,900,000

OFFICE OF VEHICLE AND ENGINE R&D

The Office of Vehicle and Engine R&D (OVERD) has established a number of programs to conserve energy used for transportation and to shift transportation energy demand to nonpetroleum fuels.

The Vehicle Propulsion Technology Development program is underway to provide industry with proof-of-concepts for advanced gas turbine and Stirling engine technologies that demonstrate improvements in fuel efficiency and to develop technology for heavy-duty diesel operation under uncooled minimum friction conditions, including waste heat utilization.

The Advanced Materials Development program, is to establish an industrial technology base capable of providing reliable and cost-effective structural ceramics for application to advanced heat engines. Project management responsibility for the Heat Engine Highway Vehicle Systems project (gas turbine and Stirling engines) and the Heavy Duty Transport Technology project (diesel engine) has been delegated to the NASA Lewis Research Center. Project management of the Ceramic Technology for Advanced Heat Engines project (Advanced Materials Development program) has been assigned to the Oak Ridge National Laboratory (ORNL). The Army Materials and Mechanics Research Center (AMMRC) support is part of the Ceramic Technology project under ORNL technical management.

The success of these advanced heat engine systems depends strongly on the development of new or improved materials. Ceramic materials are needed for the hot-flow-path components of the advanced gas turbine and the minimum friction adiabatic (uncooled) diesel engines, to meet operating temperature and manufacturing cost requirements. The Stirling engine requires low-cost iron-based alloys capable of operating at high temperatures while exposed to high-pressure hydrogen. Material technology development programs are underway for each of these heat engine systems. The generic ceramic technology program consists of three general topics: materials and processing; data base and life prediction; and design methodology. To support the advanced material work conducted under this and other research programs, a High Temperature Materials Laboratory (HTML) is being constructed at ORNL.

Key elements of each program are organized and described briefly in the following. Robert B. Schulz is the DOE contact, (202) 252-8055, for overall coordination of the following OVERD material projects.

<u>Materials Preparation, Synthesis, Deposition, Growth, or Forming</u>

<u>Powder Characterization</u> - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; MIT Contact H.K. Bowen, 617-253-6892

- Develop novel processes to make very small, highly pure, mono-size particles of various materials.

Powder Synthesis and Characterization - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact V.J. Tennery, 615-574-5123

- Experimental effort to investigate SiC powder synthesis flow sheets to produce sinterable powder superior to state-of-the-art.

Silicon Carbide Powder Synthesis - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact E.L. Long, Jr., 615-574-5172; SOHIO/ Carborundum Contact John Halstead, 716-278-2330

- Develop improved, sinterable SiC powder that is scalable, environmentally acceptable, amenable to doping, low cost, sub-micron particle size and narrow distribution, high surface area, and high purity.

High Pressure Sintering Furnace - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; AMMRC/GEO Contact George E. Gazza, 617-923-5408

- Provide technical support for sintering of silicon nitride (AMMRC) via on site personnel assignment to conduct high nitrogen pressure sintering experiments.

Si_3N_4 Powder Synthesis - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact E.L. Long, Jr., 615-574-5172; Ford Motor Co. Contact Gary M. Crosbie, 313-574-1208

- Develop improved, sinterable Si_3N_4 powder that is scalable, environmentally acceptable, amenable to doping, low cost, submicron particle size, narrow distribution, high surface area, high purity.

Sintering of Si_3N_4 - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; AMMRC Contact R.N. Katz, 617-923-5415

- Determining optimum sintering aid and time-temperature pressure for sintered Si_3N_4.

Ceramics for Stirling Engine Applications - DOE Contact Patrick L. Sutton, 202-252-8012; NASA LeRC Contact Tom Herbell, 216-433-4000, ext. 6905

- Assessment of potential candidate ceramics for application to Stirling engine, with emphasis on mullite.

Silicon Carbide Whiskers - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; Los Alamos National Laboratory Contact George Hurley, 505-667-9498

- Develop beta-SiC whiskers for composite research utilizing a SiC whisker growth furnace.

Dispersion Toughened Silicon Carbide - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact V.J. Tennery, 615-574-5123

- Identify SiC matrix dispersed particle system(s) having superior high temperature fracture toughness and fracture strength to monolithic ceramics.

Si_3N_4 - Metal Carbide Composite - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact Mark Janney, 615-574-4281; GTE Laboratory Contact S.T. Bulzan, 617-890-8460

- Develop high toughness, high strength, refractory ceramic matrix composites which are amenable to low cost, near-net-shape forming for application as structural components in advanced gas turbine engines.

Si_3N_4 - SiC Whisker Composite - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact T.N. Tiegs, 615-574-5173; AiResearch Casting Co. Contact Hun Yen, 213-618-7449

- Develop high toughness, high strength refractory ceramic matrix composites amenable to low cost near-net-shape processing for AGT applications.

Si_3N_4 Matrix Transformation-Toughened Si_3N_4 - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact T.N. Tiegs, 615-574-5173; Rocketdyne Contact Harry Carpenter, 818-710-3828

- Develop with toughness, high strength refractory ceramic matrix composites amenable to low-cost, near-net-shape forming for application in advanced heat engines.

Advanced Transformation-Toughened Oxides - DOE Contact Robert B. Schulz, 202-252-8055; AMMRC Contact R.N. Katz, 617-923-5415; University of Michigan Contact T.Y. Tien, 813-764-9449

- Develop improved transformation-toughened ceramics for application in adiabatic diesel engines.

Improved Transformation-Toughened Ceramics - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact P.F. Becker, 615-574-5157; Norton Co. Contact L.A. Ebel, 617-853-1000, ext. 2351

- Develop transformation-toughened ceramics for adiabatic diesel applications which exhibit high toughness and high strength at temperatures up to 1000 degrees C which can be pressureless sintered to full density.

Injection Molded Composites - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- Develop an industrial process for forming whisker or particulate toughened ceramic composites to near-net-shape by injection molding.

<u>SiC Whisker Reinforced Ceramic</u> - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact P.F. Becher, 615-574-5157

- Develop ceramic matrix composites with increased critical fracture toughness without strength degradation for use in structural components in advanced high temperature diesel engines.

<u>Sol Gel Oxide Powder</u> - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact V.J. Tennery, 615-574-5123

- Develop improved transformation-toughened ceramic material, utilizing sol gel processes for adiabatic diesel application.

<u>Mullite-SiC Whisker Composite</u> - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact T.N. Tiegs, 615-574-5173; General Electric Contact S. Musikant, 215-354-3020

- Develop high toughness, high strength, refractory ceramic matrix composites, amenable to low cost near-net-shape forming for application as structural components in advanced automotive engines.

<u>Transformation-Toughened Ceramics</u> - DOE Contact Stephen J. Goguen, 202-252-8055; NASA LeRC Contact George M. Prok, 416-433-4000, ext. 981; General Electric Co. Contact Solomon Musikant, 215-354-3020

- Demonstrate the feasibility of applying transformation toughening to ceramics for application in advanced heat engines.

<u>Advanced Coating Technology AGT</u> - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- Develop an oxidation resistant, adherent coating for SiC and Si_3N_4 that will reduce contact stress among touching static parts.

- Procurement plan FY 1985 (University).

<u>CVD and Sol Gel ZrO_2</u> - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- Develop coatings which provide thermal wear, oxidation and corrosion protection to a variety of engine components. Goals include development of a ZrO_2-based coating having improved toughness, adhesion, and thermal insulating powers.

Development of Thermal Barrier Coatings - DOE Contact Stephen J. Goguen, 202-252-8055; NASA LeRC Contact M. Murray Bailey, 216-433-4000, ext. 5181; Allison Gas Turbine Co. Contact David L. Clingman, 317-242-4535

- Develop a thermal barrier coating with enhanced durability for application in advanced diesel engines.

ZrO_2-Cr_2O_3 Coating Evaluation - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact E.L. Long, Jr., 615-574-5172; Cummins Engine Co. Contact Thomas M. Yonushonis, 812-377-7078

- Improve the understanding of protective chromia coatings used as critical wear surfaces and insulation for metal components in adiabatic diesel engines.

Advanced Coating Technology Diesel - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- Develop adherent, wear-resistant refractory ceramic coatings on metal substrates for use on components of uncooled diesel engines.

Active Metal Brazing PSZ-Iron - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact V.J. Tennery, 615-574-5123

- Develop the technology base for preparing high reliability ceramic-to-metal joints for advanced heat engines.

- Identify, develop, and demonstrate materials and processes which, when used with selected structural ceramics and engine alloys, will produce ceramic-to-metal joints having long-term mechanical and phase stability in engine operating environments.

Ceramic-Metal Joints AGT - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- Develop the technology required to reliably join advanced gas turbines (AGT) ceramic rotor to the high temperature alloy rotor shafts.

Diesel Ceramic-Metal Joint Scale-Up - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- Extend the active metal brazing PSZ-iron technology to larger shapes and to mechanically characterize the joints under appropriate conditions of high temperatures and combustion product gaseous atmosphere.

Ceramic-Ceramic Joints AGT - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- Develop technology for strong reliable SiC/SiC and Si_3N_4/Si_3N_4 joints for application in the Advanced Gas Turbine.

Materials Development - Intermetallic Evaluation - DOE Contact Patrick L. Sutton, 202-252-8012; NASA LeRC Contact Joseph R. Stephens, 216-433-4000, ext. 6676; Case Western University Krishna Vedula, 216-368-4211

- Investigate intermetallic compounds as potential materials for advanced Stirling engines.

Cast Iron Alloy Containing Nonstrategic Elements - DOE Contact Patrick L. Sutton, 202-252-8012; NASA LeRC Contact C.M. Scheurman, 216-433-4000, ext. 5213; United Technologies Research Center Contact A. Giamei, 203-727-7172

- Identify a ferrous alloy for the automotive Stirling engine cylinder and regenerator housings which contains only nonstrategic materials.

Materials Properties, Behavior, Characterization, or Testing

High Temperature Coating to Reduce Contact Stress - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; Garrett Turbine Engine Co. Contact J. Schienle, 602-231-4666

- Develop zirconia coatings on silicon carbide and silicon nitride ceramics to reduce static contact stresses and resulting loss of strength in gas turbine structural parts.

Dynamic Interfaces - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact E.L. Long, Jr., 615-574-5172; Battelle Columbus Labs Contact Keith Dufrane, 614-424-4618

- Develop a generic understanding of the friction and wear behavior of material interfaces between monolithic ceramics and ceramic-coated alloys in which the materials experience motion with respect to each other as in the adiabatic diesel engine (piston ring and cylinder liner).

Friction and Wear Characteristics of Load Bearing Materials - DOE Contact Stephen J. Goguen, 202-252-8055; NASA LeRC Contact Howard G. Yacobucci, 216-433-4000, ext. 5331; Westinghouse R&D Center Contact David J. Boes, 412-256-9387

- Determine the friction and wear characteristics of materials considered as candidates for use in high efficiency heavy duty diesel engines.

Advanced Statistical Calculations - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact W.P. Eatherly, 615-574-5220

- Develop advanced statistical techniques to bring similar Weibull-associated distributions into a usable state of knowledge, if not in an algebraic form, then at least by Monte Carlo calculations.

Advanced Statistics Calculations - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact W.P. Eatherly, 615-574-5220; General Electric Research Lab Contact C.E. Johnson, 518-385-8649

- Develop advanced statistical techniques for describing and characterizing frequency distributions of strengths in realistic cases of multiple and time-dependent distributions.

Design Allowables Code - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; AMMRC Contact E.M. Lenoe, 617-923-5427

- Continue development and improvement of component failure and life estimating technology by developing a computer code for determining design allowables from experimental strength data.

Failure Analysis - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; National Bureau of Standards Contact Nancy J. Tighe, 301-921-2901

- Conduct microstructural analysis on structural ceramic specimens and components subject to severe and realistic environmental testing.

Ceramic Durability Evaluation - DOE Contact Saunders B. Kramer, 202-252-8012; NASA LeRC Contact Sunil Dutta, 216-433-4000, ext. 611; Garrett Turbine Engine Co. Contact K.W. Benn, 602-231-4373

- Assess the capability of ceramic materials to perform satisfactorily at temperatures and exposure times defined for automotive turbine

Characterization of Transformation-Toughened Ceramics - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; AMMRC Contact R.N. Katz, 617-923-5415

- Determine the effect of time-at-temperature on toughened oxide ceramics especially zirconia and alumina zirconia materials.

- Screen advanced and experimental toughened oxide ceramics.

Cyclic Fatigue of Toughened Ceramics - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact V.J. Tennery, 615-574-5123

- Design, fabricate, and evaluate a test system (grips and load train) and specimens for uniaxial fatigue characterization of improved ceramic materials.

Fracture Behavior of Toughened Ceramics - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact V.J. Tennery, 615-574-5123

- Characterize the high temperature strength and toughness of state-of-the-art structural ceramics for heat engine applications.

High Temperature Creep Evaluation - DOE Contact Patrick L. Sutton, 202-252-8012; NASA LeRC Contact R.H. Titran, 216-433-4000, ext. 398

- Evaluate the effects of brazing cycle and alloy composition or creep-rupture properties and Stirling engine operating temperatures.

Time-Temp Properties of Advanced Ceramics - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; AMMRC Contact R.N. Katz, 617-923-5415

- Characterize time dependent high temperature behavior of SiC and Si_3N_4 ceramics.

Experimental Life Testing - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; Ford Motor Co./AMMRC Contacts A.F. Mclean, 313-322-3855, R.N. Katz, 617-723-5415

- Develop a methodology for predicting time-to-failure of ceramic components under stress and high temperatures.

Alloy Properties in High Pressure Hydrogen - DOE Contact Patrick L. Sutton, 202-252-8012; NASA LeRC Contact R.H. Titran, 216-433-4000, ext. 398; IIT Research Institute Contact S. Bhattacharyya, 312-567-4192

- Assess the effects of high pressure hydrogen on creep properties of candidate Stirling engine alloys.

Structural Ceramics Corrosion/Erosion Studies - DOE Contact Robert B. Schulz, 202-252-8055; NASA LeRC Contact Carl S. Stearns, 216-433-4000, ext. 6826

- Determine the effects of fuel ingested impurities on structural ceramic materials under simulated gas turbine engine conditions.

Corrosion/Erosion Effects - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; NBS Contact Nancy J. Tighe, 301-921-2901

- Characterize the behavior of AGT materials subjected to corrosion by salts in combustion air and/or alternate fuels combined with erosion by combustion.

Environmental Effects in Toughened Ceramics - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact V.J. Tennery, 615-574-5123; University of Dayton Contact N.L. Hecht, 513-229-4341

- Determine the dynamic fatigue behavior of transformation-toughened ceramics (PSZ and DTA) as a function of temperatures and composition of the gaseous environment.

Static Behavior of Toughened Ceramics - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; University of Illinois Contact M.K. Ferber, 217-333-1770

- Determine strength degradation behavior of two types of toughened ceramics (PSZ SiC whisker reinforced alumina) as a function of time and temperature.

Static Fatigue of Toughened Ceramics - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact V.J. Tennery, 615-574-5123

- Determine fatigue life characteristics of PSZ and dispersion toughened Al_2O_3 as functions of temperature.

High Temperature Fracture Toughness Measurement - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact V.J. Tennery, 615-574-5123; University of Washington Contact R.C. Bradt, 206-543-2613

- Develop and demonstrate new improved techniques for determining fracture resistance of both monolithic structural ceramics and ceramic matrix composites at temperatures of 1400 degrees C.

High Temperature Tensile Testing - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; N.C. A&T University Contact J. Sankar, 919-379-7620

- Conduct high temperature uniaxial tensile testing of SiC and Si_3N_4.

Standard Tensile Test Development - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; National Bureau of Standards Contact Sheldon M. Wiederhorn, 301-921-2901

- Develop a standard method of tensile testing ceramic specimens at elevated temperatures.

Ceramic Component Technology - DOE Contact Saunders B. Kramer, 202-252-8012; NASA LeRC Contact Alex Vary, 216-433-4000, ext. 357

- Identify and develop NDE techniques for ceramic heat engine components.

Characterization Needs Assessment - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact Robert McClung, 615-574-4466

- Prepare a national assessment of the material characterization measurements and techniques needed for the manufacturing of reliable ceramic components.

Non-Destructive Characterization - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact V.J. Tennery, 615-574-5123

- Conduct non-destructive evaluation (NDE) development directed at identifying approaches for quantitative determination of conditions in ceramics that affect the structural performance.

International Exchange Agreement - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- The purpose of this task is to encourage international cooperation in the development of voluntary standards for structural ceramics.

NBS Standard Reference Material - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832; National Bureau of Standards Contact Allen Dragoo, 301-921-2842

- Develop standard reference material from the ceramic powder chosen by the U.S. consulting committee for the International Energy Agency (IEA) agreement.

Specimens and Hardware for IEA - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- Provide funding for procurement of specimens and hardware for Annex II of the IEA agreement.

Technical Support and Monitoring Contracts - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- This task provides expert technical support and technical program monitoring by cognizant researchers who support industrial and university subcontracts.

Technology Assessment and Planning - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- The purpose of this activity is to keep ORNL ceramic technology for advanced heat engines program plan current.

Technology Transfer - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- The purpose of this task is to facilitate the transfer of technology to private industry.

Device or Component Fabrication, Behavior, or Testing

Advanced Gas Turbine Engine Technology (AGT-100) - DOE Contact Saunders B. Kramer, 202-252-8012; NASA LeRC Contact P. Kerwin, 216-433-4000, ext. 770; GM/Allison/Pontiac Contact H.E. Helms, 317-242-5335

- Develop an advanced technology base applicable to a competitive automotive gas turbine engine.

Advanced Gas Turbine Engine Technology (AGT-101) - DOE Contact Saunders B. Kramer, 202-252-8012; NASA LeRC Contact Robert C. Evans, 216-433-4000, ext. 770; Garrett/Ford Contact E.E. Strain, 602-231-2797

- Develop an advanced technology base applicable to a competitive automotive gas turbine engine.

Instrumentation and Facilities

HTML Pre-Operational Support - DOE Contact Anne Marie Zerega, 202-252-8053; ORNL Contact V.J. Tennery, 615-574-5123

- Provide pre-operational support for the high temperature materials laboratory (HTML) in FY 1985.

Capital Equipment for Advanced Materials Development Program - DOE Contact Robert B. Schulz, 202-252-8055; ORNL Contact D. Ray Johnson, 615-576-6832

- Purchase capital equipment for the advanced materials development project.

OFFICE OF SOLAR HEAT TECHNOLOGIES

	FY 1984	FY 1985
Office of Solar Heat Technologies Grand Total	$ 4,792,000	$ 4,750,000
Active Heating and Cooling Division	$ 2,033,000	$ 2,455,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,463,000	$ 1,515,000
Influence of Combined Stresses on Degradation of Polymeric Cover-plate Materials	$ 320,000	$ 300,000
Thin Film Materials Research	300,000	625,000
Sorption Studies of Desiccant Materials	123,000	120,000
Heat and Mass Transfer Analysis of Advanced Dehumidifiers	173,000	300,000
Desiccant Materials Contamination Research	78,000	0
Research on Liquid Desiccant Materials	144,000	100,000
Open Cycle Absorption Chiller Research	225,000	0
Solar Collector Materials Exposure Testing	100,000	70,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 220,000	$ 620,000
Low Cost Process for the One Step Synthesis of U.V. Inhibitor	50,000*	395,000*
Development of Improved Desiccant Materials	170,000	225,000
Device or Component Fabrication, Behavior, or Testing	$ 350,000	$ 320,000
Research and Development on Stainless Steel Thin Material Collectors	350,000	320,000
Passive and Hybrid Solar Energy Division	$ 1,220,000	$ 600,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 905,000	$ 400,000
Optical Switching Apertures	$ 225,000	100,000
Optical Switching Materials	185,000	100,000
Transparent Insulating Materials	150,000	100,000

* This is a Small Business Innovation Research Program project which is managed by this office.

	FY 1984	FY 1985
Passive and Hybrid Solar Energy Division (Continued)		
Materials Preparation, Synthesis, Deposition, Growth, or Forming (Continued)		
Phase Change Thermal Storage Materials	$ 265,000	$ 100,000
Selective Opaque Coatings	80,000	0
Materials Properties, Behavior, Characterization, or Testing	$ 315,000	$ 200,000
Daylight Enhancement	$ 140,000	$ 100,000
Low-Emittance, High-Transmittance Materials	130,000	100,000
Selective Transmittance Materials	45,000	0
Solar Thermal Technology Division	$ 1,539,000	$ 1,695,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 750,000	$ 880,000
Silver/Polymer Reflector Research	$ 402,000	$ 275,000
Polymer Synthesis and Characterization	348,000	605,000
Materials Properties, Behavior, Characterization, or Testing	$ 789,000	$ 815,000
Ceramic Materials Research	$ 362,000	$ 375,000
High Temperature Thermal Fluids/Containment	192,000	245,000
High Temperature Windows	150,000	75,000
High Temperature Materials - Solar-Caused Degradation	85,000	120,000

OFFICE OF SOLAR HEAT TECHNOLOGIES

Active Heating and Cooling Division

This program funds R&D projects with industry and academic institutions directed towards the development of cost-effective, reliable and publicly acceptable active solar heating and cooling systems. A major emphasis of the program is to ensure that the information derived from these projects is made available to all of the members of the solar research, manufacturing and construction communities who will benefit from it.

Materials Properties, Behavior, Characterization, or Testing

Influence of Combined Stresses on the Degradation of Polymeric Coverplate Materials - DOE Contact John Goldsmith, 202-252-8171; NBS Contact David Waksman, 301-921-3114

- Characterization of moisture degradation mechanisms occuring in polymeric glazing materials.
- Comparison of microstructural and engineering properties of cover materials and investigation of micro-level changes used to detect materials degradation.
- Prediction of service life of polymeric materials through development of mathematical models for use with short-term accelerated aging test data.

Thin Film Materials Research - DOE Contact John Goldsmith, 202-252-8171; SAN Operations Office Contact Robert LeChavalier, 415-273-6362

- Identification of appropriate polymeric glazing materials, absorber laminates and adhesives and fabrication techniques to make a practical, durable and low cost thin film collector.

Sorption Studies of Desiccant Materials - DOE Contact John Goldsmith, 202-252-8171; SERI Contact Frederica Zangrando, 303-231-1761

- Measure adsorption/desorption characteristics of promising desiccant materials as a function of physical properties, geometry, and operating environment.

Heat and Mass Transfer Analysis of Advanced Dehumidifiers - DOE Contact John Goldsmith, 202-252-8171; SERI Contact Ahmad Pesaran, 303-231-7636

- Extend, improve, and validate the solid-side resistance model of packed dehumidifier to more advanced, cost-effective dehumidifier geometries for incorporation in performance prediction and design tools.

Desiccant Materials Contamination Research - DOE Contact John Goldsmith, 202-252-8171; SERI Contact Terry Penney, 303-231-1751

- Experimentally determine the influence of airborne contaminants on solid desiccant performance/degradation.

Research on Liquid Desiccant Materials - DOE Contact John Goldsmith, 202-252-8171; ANL Contact Jack Parks, 312-972-4334

- Identify and evaluate candidate organic liquids on multi-component liquid mixtures for use in the Liquid Desiccants that can be regenerated by Liquid-Liquid Phase Separation (LIQDES-RELLPS) concept.

Open Cycle Absorption Chiller Research - DOE Contact John Goldsmith, 202-252-8171; San Operations Office Contact Robert LeChevalier, 415-273-6362

- Identify a suitable mixture of absorbent-refrigerant pairs for use in a high performance open cycle absorption system.

Solar Collector Materials Exposure Testing - DOE Contact John Goldsmith, 202-252-8171; LANL Contact Robert Jones, 505-667-6441

- Develop a database of information on the response of various solar collector materials to long-term exposure to solar radiation, elevated temperatures, and moisture.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Low Cost Process for the One Step Synthesis of U.V. Inhibitor - DOE Contact John Goldsmith, 202-252-8171; Helix Associates Contact Walther Heldt, 302-738-6581 *

- Development of a low cost one step synthesis of tetrahydroxybenzophenol for use as an additive to inhibit degradation of transparent films due to exposure to sunlight

Development of Improved Desiccant Materials - DOE Contact John Goldsmith, 202-252-8171; ANL Contact Anthony Fraioli, 303-972-7550

- Determine moisture adsorption/desorption characteristics of MNO_2 and MNO_2/Silica Gel desiccant materials.

- Development of methods to measure absorptive equilibrium rate data on MNO_2 and silica gel.

* Funded under SBIR Program.

Device or Component Fabrication, Behavior, or Testing

Research and Development on Stainless Steel Thin Material Collectors- DOE Contact John Goldsmith, 202-252-8171; BNL Contact William Wilhelm, 516-282-4708

- Development of a thin foil stainless steel/copper foil absorber-heat exchanger solar collector capable of withstanding temperatures above 150 degrees C.

Passive and Hybrid Solar Energy Division

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Optical Switching Apertures - DOE Contact Dave Pellish, 202-252-8110; SERI Contact Dave Benson, 303-231-1162

- Evaluate the feasibility of using solid state electrochromic coatings to control transmittance through apertures in passive solar heated buildings

Optical Switching Materials - DOE Contact Dave Pellish, 202-252-8110; LBL Contact Carl M. Lampert, 415-486-6093

- Research and synthesize new electrochromic materials with broad band and response characteristics. For example, NiO_x.

- Identify and synthesize potential compounds that exhibit photochromic or thermochromic properties.

- Also provides scientific coordination, materials analysis and guidance to DOE contractors.

Transparent Insulating Materials - DOE Contact Dave Pellish, 202-252-8110; LBL Contact Arlon Hunt, 415-486-5370

- Investigation of optical, thermal, and structural properties of silica aerogel

Phase Change Thermal Storage Materials - DOE Contact Dave Pellish, 202-252-8118; SERI Contact Dave Benson, 303-231-1162

- Solid state phase change materials (SS PMC's) are being studied for use in thermal energy storage components of passive solar heated buildings.

Selective Opaque Coatings - DOE Contact David Pellish, 202-252-8110; Los Alamos Contact Stan Moore, 505-667-2228

- A selective surface in conjunction with a single glazing has a performance comparable to a normal surface and double glazing.

- Development of coating cheaper than currently available involving the mixture of selective metallic flakes with a binder to produce a paint.

Materials Properties, Behavior, Characterization, or Testing

Daylight Enhancement - DOE Contact Dave Pellish, 202-252-8110; LBL Contact Mike Rubin, 415-486-7124

- Reduction of electric lighting requirements by development of light guide materials and systems which collect and transmit daylight

Low-Emittance, High-Transmittance Materials - DOE Contact Dave Pellish, 202-252-8110; LBL Contact Mike Rubin, 415-486-7124

- Development of next generation of low-emittance, high-transmittance coatings for the control of radiant heat transfer in buildings

Selective Transmittance Materials - DOE Contact Dave Pellish, 202-252-8110; LBL Contact Carl M. Lampert, 415-486-6093

- Determination of desirable angle selective properties and investigation of methods to produce angle selective growth structures

Solar Thermal Technology Division

Solar Thermal Technology is developing central receivers, parabolic dishes, and parabolic troughs to concentrate the sun's energy to produce electricity or industrial process heat. The combination of concentrated direct solar flux (to 2,000 suns) and high temperature (to 2000 degrees F) causes solar unique materials problems that are now being characterized in areas of heat transfer fluids, ceramics and windows. In addition, the solar-caused degradation of silvered polymers is also being studied with the objective being a highly reflective, environmentally stable, low cost reflector. The DOE contact is Frank Wilkins, 202-252-1684.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Silver/Polymer Reflector Research - SERI Contact Gordon Gross, 303-231-1222

- Develop understanding of degradation mechanisms in candidate polymer/silver combinations.

- Identify silvered polymers that have a useful life of 5-10 years, at least a 90% reflectance and low cost.

Polymer Synthesis and Characterization - SERI Contact Gordon Gross, 303-231-1222

- Modify polymers using two approaches - bulk stabilization and surface modification.

- Improve durability of polymers in solar thermal applications.

Materials Properties, Behavior, Characterization, or Testing

Ceramic Materials Research - SERI Contact Gordon Gross, 303-231-1222

- Determine the operating limits of ceramics in high temperature, high flux environments through math modeling and testing.

- Identify suitable ceramic materials for solar thermal applications, particularly in combination with molten carbonate salts (to 900 degrees C).

High Temperature Thermal Fluids/Containment - SERI Contact Gordon Gross, 303-231-1222

- Areas of study include corrosion mechanisms, oxidation, and the influence of absorption additives.

- Characterize heat transfer fluid and ceramic structural material combinations that can operate at temperatures to 1100 degrees C.

High Temperature Windows - Georgia Institute of Technology Contact Dr. Robert Cassanova, 404-894-3589

- Develop a coating (emphasis on boron-silica oxide polymer coating) that will inhibit devitrification of silica-based windows.

- Through testing identify a transparent refracting window capable of withstanding the solar, chemical, and environment of a receiver.

High Temperature Materials - Solar-Caused Degradation - University of Houston Contact Dr. Lorin Van Hull, 713-749-1154

- Conduct photo-corrosion studies of Fe, Al, ceramics.

- Acquire an understanding of photo-induced degradation in materials.

OFFICE OF SOLAR ELECTRIC TECHNOLOGIES

	FY 1984	FY 1985
Office of Solar Electric Technologies Grand Total	$23,645,000	$24,600,000
Photovoltaic Energy Technology Division	$23,600,000	$24,600,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$18,600,000	$19,800,000
Amorphous Silicon for Solar Cells	$ 7,500,000	$ 8,000,000
Polycrystalline Thin Film Materials for Solar Cells	3,200,000	3,600,000
Deposition of High Purity Polycrystalline Silicon from Silane in a Fluidized-Bed Reactor	1,200,000	700,000
Growth of Silicon Ribbons For Solar Cells	3,200,000	4,000,000
Deposition of III-V Semiconductors for High-Efficiency Solar Cells	3,500,000	3,500,000
Materials Properties, Behavior, Characterization, or Testing	$ 2,500,000	$ 3,000,000
Materials and Device Characterization	$ 2,500,000	$ 3,000,000
Device or Component Fabrication, Behavior, or Testing	$ 2,500,000	$ 1,800,000
High-Efficiency Crystal Silicon Solar Cells	$ 2,500,000	$ 1,800,000
Wind Energy Technology Division	$ 45,000	$ 0
Materials Properties, Behavior, Characterization, or Testing	$ 45,000	$ 0
Wood Composite Material Fatigue	$ 45,000	$ 0

OFFICE OF SOLAR ELECTRIC TECHNOLOGIES

Photovoltaic Energy Technology Division

The primary goal of the national photovoltaic program is to reduce the uncertainties surrounding photovoltaic technology, so that the private sector may make informed investment decisions in this area. Successful uncertainty reduction will require advances in several areas of materials technology. DOE Contact is Anthony Scolaro, 202-252-5548.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Amorphous Silicon for Solar Cells - SERI Contact Ed Sabisky, 303-231-1483

- Plasma enhanced CVD (glow discharge), thermal CVD, and sputtering techniques with long term goal of developing 12% efficient cells of area of 1000 cm^2.

Polycrystalline Thin Film Materials for Solar Cells - SERI Contact Allan Hermann, 303-231-1311

- Chemical and physical vapor deposition, electrodeposition, and sputtering techniques are being investigated for depositing stoichiometric films of CuInSe, CdTe, and Zn_3P_2.
- Large area (1000 cm^2) control of interlayer diffusion, lattice matching and stoichiometry for long-term enhancement of 15% efficient large area solar cells.

Deposition of High Purity Polycrystalline Silicon from Silane in a Fluidized-Bed Reactor - JPL Contact Andrew Morrison, 818-354-7200

- Deposition of semiconductor grade silicon from high purity silane in a fluidized bed reactor.
- Investigation of nucleation and growth of silicon particles and determination of impurities in deposited silicon.

Growth of Silicon Ribbon for Solar Cells - JPL Contact Andrew Morrison, 818-354-7200

- Investigation of high speed crystal growth stresses on ribbon formation and solar cell performance.
- Fundamental problems of ribbon growth.

Deposition of III-V Semiconductors for High-Efficiency Solar Cells- SERI Contact John Benner, 303-231-1396

- Deposition by CVD, LPE, and MBE of III-V's in order to study interfaces between layers and for precise control of thickness and uniformity.

- Long-term goal of 35% efficient concentrator cells and 20% and 100 cm^2 flat plate cells.

Materials Properties, Behavior, Characterization, or Testing

Materials and Device Characterization - SERI Contact Larry Kazmerski, 303-231-1115; JPL Contact Ram Kachare, 818-354-4583

- Surface and interface analysis, electro-optical characterization and cell performance evaluation.

- Critical material/cell parameters study of such things as impurities, layer mismatch and other defects using a wide variety of instruments.

Device or Component Fabrication, Behavior, or Testing

High-Efficiency Crystal Silicon Solar Cells - SERI Contact John Benner, 303-231-7299; JPL Contact Ram Kachare, 818-354-4583

- Investigation of new coatings and/or dopants and other treatment that reduce electron-hole recombination at cell surfaces or in the bulk.

- 18% efficient one sun crystal solar cell by end of FY 1984 and 20% by end of FY 1986.

Wind Energy Technology Division

The R&D work of the wind program emphasizes the attainment of reduction in the cost of energy from wind systems through testing of blades and other wind system components and systems. Improved materials and bond techniques would increase the assurance of adequate fatigue margins and reduce rotor weight, favorably affecting all other subsystems.

Materials Properties, Behavior, Characterization, or Testing

Wood Composite Material Fatigue - DOE Contact Peter Goldman, 202-252-1776; NASA Contact Art Birchenough, 216-433-4000, ext. 5207

- Characterization of static and cyclic fatigue properties of laminated Douglas fir veneer wood composite materials.

- Data on wood grade, moisture content, butt joint gap, lamination clamping pressure, and test temperatures and humidity levels collected.

OFFICE OF RENEWABLE TECHNOLOGY

	FY 1984	FY 1985
Office of Renewable Technology Grand Total	$ 1,307,000	$ 1,590,000
Geothermal and Hydropower Technologies Division	$ 1,235,000	$ 1,360,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 425,000	$ 550,000
High Temperature Elastomers for Dynamic Sealing Applications	$ 100,000	$ 125,000
Advanced Materials for Lost Circulation Control	75,000	75,000
Pitting Resistant Steels	50,000	50,000
In-Situ Conversion of Drilling Fluids into Cements	25,000	30,000
Geothermal Waste Utilization and Disposal	100,000	170,000
Materials for Non-Metallic Heat Exchangers	75,000	100,000
Materials Properties, Behavior, Characterization, or Testing	$ 290,000	$ 300,000
Corrosion Resistant Elastomeric Liners for Well Casing	$ 125,000	$ 150,000
Downhole Testing of High Temperature Geothermal Well Cements	100,000	100,000
Corrosion in Binary Geothermal Systems	65,000	50,000
Device or Component Fabrication, Behavior, or Testing	$ 60,000	$ 50,000
High Temperature Cathodic Protection Systems	$ 60,000	$ 50,000
Instrumentation and Facilities	$ 460,000	$ 460,000
Field Tests of Advanced Monitoring Instruments	$ 185,000	$ 185,000
Particle Measurement In-Line Instrument	275,000	275,000

OFFICE OF RENEWABLE TECHNOLOGY

	FY 1984	FY 1985
Energy From Municipal Waste Division	$ 72,000	$ 230,000
Materials Properties, Behavior, Characterization, or Testing	$ 72,000	$ 230,000
Refuse Derived Fuel (RDF) Binder Research	$ 72,000	$ 230,000

Geothermal and Hydropower Technologies Division

The primary goal of the geothermal materials program is to ensure that the private sector development of geothermal energy resources is not constrained by the availability of technologically and economically viable materials of construction. This requires the performance of long-term high risk GHTD-sponsored materials R&D.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

High Temperature Elastomers for Dynamic Sealing Applications - DOE Contact A. D. Allen, 202-252-5335; BNL Contact L.E. Kukacka, 516-282-3065

- Chemical modification of previously developed and tested Y-267 EPDM 260 degrees C static seal material for use in dynamic sealing applications.

- Optimization of EPDM formulations for use in critical high cost applications such as in downhole drill motors and open-hole packers.

Advanced Materials for Lost Circulation Control - DOE Contact A. D. Allen, 202-252-5335; BNL Contact L.E. Kukacka, 516-282-3065

- Hydrothermally stable and pumpable chemical systems are being investigated for use as lost circulation control materials in geothermal well drilling operations.

Pitting Resistant Steels - DOE Contact R. LaSala, 202-252-8077; BNL Contact D. van Rooyen, 516-282-4050

- Studies of the mechanism whereby high corrosion resistance is obtained through alloying of stainless steels with molybdenum combined with nitrogen.

In-Situ Conversion of Drilling Fluids into Cements - DOE Contact A. D. Allen, 202-252-5335; BNL Contact L. E. Kukacka, 516-282-3065

- Studies of high temperature interactions between the constituents of drilling muds, reactive solid additives and chemical fluids.

Geothermal Waste Utilization and Disposal - DOE Contact R. LaSala, 202-252-8077; BNL Contact L.E. Kukacka, 516-282-3065

- Studies of methods for utilizing waste constituents as raw materials for cementitious binders or as nonleachable fillers in composites that can be used for general construction purposes.

- Analyses of biochemical techniques for concentrating and subsequent removal of heavy metals from waste.

Materials for Non-Metallic Heat Exchangers - DOE Contact R. LaSala, 202-252-8077; BNL Contact L.E. Kukacka, 516-282-3065

- Development of corrosion resistant metallic and silicon carbide-filled composites which have thermal conductivities in the range of stainless steels.

Materials Properties, Behavior, Characterization, or Testing

Corrosion Resistant Elastomeric Liners for Well Casing - DOE Contact R. LaSala, 202-252-8077; BNL Contact L.E. Kukacka, 516-282-3065

- Investigation of high temperature chemical coupling systems for bonding elastomeric liners to carbon steel well casing.

- Data on corrosion resistance of Y-267 EPDM-lined carbon steel casing for comparison with those for high chrome and nickel alloys.

Downhole Testing of High Temperature Geothermal Well Cements - DOE Contact R. LaSala, 202-252-8077; BNL Contact L. E. Kukacka, 516-282-3065

- Characterization of promising high temperature well cements under placement and downhole environmental conditions duplicating most of the well completion variables.

- Preliminary screening tests on lightweight cement slurries.

Corrosion in Binary Geothermal Systems - DOE Contact R. LaSala, 202-252-8077; BNL Contact D. van Rooyen, 516-282-4050

- Quantitative corrosion data from laboratory and plant tests for metals presently used in binary plants and other more potentially resistive metals and nonmetals.

Device or Component Fabrication, Behavior, or Testing

High Temperature Cathodic Protection Systems - DOE Contact R. LaSala, 202-252-8077; BNL Contact D. van Rooyen, 516-282-4050

- Testing and characterization of high temperature electrochemical processes designed to cathodically protect the external surfaces of well casing and heat exchangers.

Instrumentation and Facilities

Field Tests of Advanced Monitoring Instruments - DOE Contact G. J. Hooper, 202-252-4153; PNL Contact D. W. Shannon, 509-376-3139

- Complete field tests of hydrothermal chemical instrumentation system developed for geothermal binary plants, and initiate similar tests on a geothermal flash plant.

Particle Measurement In-Line Instrument - DOE Contact G. J. Hooper, 202-252-4153; PNL Contact D. W. Shannon, 509-376-3139

- Development of in-line particle measurement instruments capable of measuring and characterizing solid material pumped into geothermal injection wells for use in hydrothermal power plants.

Energy from Municipal Waste Division

The goal of the Energy from Municipal Waste (EMW) Division is to provide the technical information base from which industry can develop future technologies for the recovery of liquid and gaseous fuels and other usable energy products and materials from municipal solid waste, and to increase the energy efficiency of municipal wastewater treatment processes. DOE contact is Christopher Kouts, 202-252-1697.

Materials Properties, Behavior, Characterization, or Testing

Refuse Derived Fuel (RDF) Binder Research - Argonne National Laboratory Contact Ole Ohlsson, 312-972-5593

- Identification and testing of chemical binders that will enhance the storability and overall material integrity of densified RDF.

- Identification of alternative methods of densifying RDF.

- Economic evaluation of the applications of identified binders and alternative densification methods vis-a-vis existing technology.

OFFICE OF ENERGY RESEARCH

	FY 1984	FY 1985
Office of Energy Research Grand Total	$153,619,384	$154,579,000
Office of Basic Energy Sciences	$126,229,000	$134,361,000
Division of Materials Sciences	$125,120,000	$133,055,000
Metallurgy and Ceramics	$ 48,830,000	$ 49,510,000
Structure of Materials	$ 18,420,000	$ 18,645,000
Mechanical Properties	8,030,000	8,300,000
Physical Properties	9,940,000	9,580,000
Radiation Effects	5,660,000	5,370,000
Engineering Materials	6,780,000	7,615,000
Solid State Physics	$ 62,910,000	$ 69,900,000
Neutron Scattering	$ 18,490,000	$ 21,290,000
Experimental Research	32,560,000	35,875,000
Theoretical Research	5,070,000	5,390,000
Particle-Solid Interactions	2,000,000	2,090,000
Engineering Physics	4,790,000	5,255,000
Materials Chemistry	$ 13,380,000	$ 13,645,000
Chemical Structure	$ 3,100,000	$ 3,150,000
Engineering Chemistry	4,080,000	4,070,000
High Temperature and Surface Chemistry	6,200,000	6,425,000
Division of Engineering and Geosciences	$ 1,109,000	$ 1,306,000
Materials Properties, Behavior, Characterization, or Testing	$ 609,600	$ 691,000
Damage Accumulation by Crack Growth under Combined Creep and Fatigue	$ 56,000	$ 56,000
Electrochemical Wear Mechanism and Deposit Formation in Lubricated Systems	66,000	93,000
Engineering Analysis of Elastic-Plastic Fracture	165,000	175,000
Continuous Damage Theory	41,000	43,000
Loss Characteristics of Cord-Rubber Composites	60,000	75,000
A Study of the Chemical Mechanism in Lubrication	50,000	60,000

OFFICE OF ENERGY RESEARCH (Continued)

		FY 1984		FY 1985
Office of Basic Energy Sciences (Continued)				
Division of Engineering and Geosciences (Continued)				
Materials Properties, Behavior, Characterization, or Testing (Continued)				
Effects of Crack Geometry and Near-Crack Material Behavior on Scattering of Ultrasonic Waves for QNDE Applications		55,000		59,000
Crack-Tip Fields for Materials with Exponential-Law Creep Behavior at High Stress		67,000		0
Mechanical Interactions of Rough Surfaces		100,000		130,000
Device or Component Fabrication, Behavior, or Testing	$	170,000	$	145,000
Improvement of Reliability of Welding by In-Process Sensing and Control	$	170,000	$	145,000
Instrumentation and Facilities	$	330,000	$	470,000
Crack Characterization With Ultrasonic NDE	$	110,000	$	110,000
High Frequency Transducers		20,000		110,000
A Composite, Multiviewing Transducer		200,000		250,000
Office of Health and Environmental Research	$	858,000	$	868,000
Division of Physical and Technological Research	$	858,000	$	868,000
Materials Properties, Behavior, Characterization or Testing	$	858,000	$	868,000
Development of Mercuric Iodide and Other New Concepts for the Detection and Spectroscopy of Ionizing Radiation	$	250,000	$	260,000

OFFICE OF ENERGY RESEARCH (Continued)

	FY 1984	FY 1985
Office of Health and Environmental Research (Continued)		
Division of Physical and Technological Research (Continued)		
Materials Properties, Behavior, Characterization, or Testing (Continued)		
Semiconductor Radiation Detector Technology	$ 360,000	$ 360,000
Avalanche Photodiodes for Positron Emission Tomography	248,000	248,000
Office of Fusion Energy	$ 21,780,000	$ 19,350,000
Materials Properties, Behavior, Characterization, or Testing	$ 9,610,000	$ 8,310,000
Alloy Development for Irradiation Performance (ADIP)	$ 5,080,000	$ 4,270,000
Damage Analysis and Fundamental Studies (DAFS)	2,490,000	1,990,000
Special Purpose Materials (SPM)	790,000	1,100,000
Tritium Breeding Materials	1,100,000	800,000
Analysis and Evaluation	150,000	150,000
Device or Component Fabrication, Behavior, or Testing	$ 5,970,000	$ 5,140,000
Plasma Materials Interaction and High Heat Flux Component Development Programs	$ 5,970,000	$ 5,140,000
Instrumentation and Facilities	$ 6,200,000	$ 5,900,000
Radiation Facilities Operation	$ 4,200,000	$ 3,900,000
Operation of Oak Ridge Research Reactor	2,000,000	2,000,000
Small Business Innovation Research Program*	$ 4,752,384	**
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 1,591,591	
Rapidly Solidified, Spherical, Fine Ceramic Powders	$ 49,670	

* This includes both Phase I and Phase II Awards in FY 1984.

** FY 1985 funding levels are not available because awards change annually.

	FY 1984	FY 1985
Small Business Innovation Research Program (Continued)		
Materials Preparation, Synthesis, Deposition, Growth, or Forming (Continued)		
Brazing of Machinable Glass-Ceramics	48,649	
Wear-Resistant Ferrous Metal Matrix Composites for Municipal Solid Waste (MSW) Processors	49,921	
Horizontal Growth of Silicon Sheet via Edge-Supported Pulling (ESP) from a Melt Contained in a Cold Crucible	285,019	
Fabrication of Amorphous Metallic Films and Coatings for Industrial Applications Using High-Energy Ion Beam Mixing	495,202	
Growth of BaF_2 Crystals by the Heat Exchanger Method (HEM) With Enhanced Fast Component for Scintillator Applications	49,751	
Growth of Bismuth Germanate ($Bi_2Ge_3O_{12}$, (BGO) Using the Heat Exchanger Method (HEM)	417,522	
Superplastic Forging of Structural Ceramics	50,000	
Titanium Nitride Coating of High-Speed Steel and Carbide Metal Cutting Tools Using Fluid Bed Furnace Technology	49,580	
Reduction of Surface Recombination in Silicon Solar Cells	49,173	
Shape Memory Alloy Seals for Geothermal Applications	47,104	
Materials Properties, Behavior, Characterization, or Testing	$ 1,715,107	
Eddy Current Non-Destructive Evaluation of Laser-Glazed Metallic Surfaces	$ 49,873	
Processing and Characterization of Silicon Carbide-Aluminum Oxycarbide Ceramics	49,983	
Containerless Sinter/Hot Isostatic Pressing (HIP) of a SIAlON	49,952	
Evaluation of Metal-Matrix Composites Based on Fe-Nd-B Alloys for Improved Permanent Magnets	48,608	
Rapidly Solidified Magnetic Alloys for High-Frequency, High-Power Applications	50,000	

		FY 1984	FY 1985
Small Business Innovation Research Program (Continued)			
Materials Properties, Behavior, Characterization, or Testing (Continued)			
ODS Tungsten Carbide-Cobalt		49,718	
"In-Situ" Evaluation of Electrocatalytic Materials with a Surface-Impedance Technique		50,000	
Fracture Mechanics Investigations of Grinding of Ceramics		215,976	
Mathematical Modeling of Electrochemistry of Stress Corrosion Cracking	$	331,735	
An Investigation to Determine the Commercial Feasibility of "In-Situ" Cu-Nb Composites for High-Strength, High-Conductivity Applications		350,000	
High Temperature and/or High-Speed Thickness Gauging of Metals		469,262	
Device or Component Fabrication, Behavior or Testing	$	946,136	
Superconducting Magnetic Shields for Neutral Beam Injectors		49,818	
Development of a New Process for the Production of Very Fine Filamentary Superconducting Nb-Ti Composite		50,000	
Method and Device for Non-Destructive Inspection of Noibium to Improve Superconductivity		50,000	
Improvement of Carbon Foils and Applications		306,464	
Research on Advanced Cell Designs for High-Efficiency Flat-Plate Applications		489,854	
Instrumentation and Facilities	$	499,550	
Extreme Ultraviolet and Soft X-Ray Instrumentation for Microcharacterization of Materials		499,550	

OFFICE OF ENERGY RESEARCH

The Director of Energy Research is responsible for three major outlay programs: Basic Energy Sciences, High Energy and Nuclear Physics, and Magnetic Fusion Energy. The Director of Energy Research also advises the Secretary on DOE physical research programs, the Department's overall energy research and development programs, university-based education and training activities, grants, and other forms of financial assistance. The Director also carries out additional duties assigned to the Office related to basic and advanced research, and monitors the well-being and management of the multiprogram laboratories under the jurisdiction of the Department.

Four multiprogram and seven single-purpose laboratories are administratively assigned to the Office of Energy Research. The multiprogram facilities are Argonne National Laboratory, Oak Ridge National Laboratory, Brookhaven National Laboratory, and Lawrence Berkeley Laboratory. The single-purpose or specialized laboratories are the Bates Linear Accelerator Facility at the Massachusetts Institute of Technology, the Ames Laboratory at the Iowa State University, the Fermi National Accelerator Laboratory, the Notre Dame Radiation Laboratory, the Princeton University Plasma Physics Laboratory, the Michigan State University Plant Research Laboratory, and the Stanford Linear Accelerator Center. The multiprogram laboratories conduct significant research activities for other DOE programs (e.g., Conservation, Nuclear, etc.) and other Federal agencies, while the seven specialized laboratories are funded almost totally by the Office of Energy Research.

The Office of Energy Research conducts materials research in the following offices and divisions:

Office of Basic Energy Sciences: Division of Engineering and Geosciences; Division of Materials Sciences

Office of Fusion Energy

Small Business Innovation Research Program

Office of Health and Environmental Research: Division of Physical and Technologies Research

Office of Basic Energy Sciences

Division of Materials Sciences

This basic research program has several roles. One is to increase the understanding of materials properties, behavior, and phenomena in those classes of materials that either presently or in the future might be important to the mission of the Department of Energy. Another concerns the development of new forefront analytical instruments and facilities that are used to probe the structure and behavior of matter. Thus this program carries a major responsibility for many of the nation's premier research facilities including several neutron sources, a synchrotron radiation source, processing facilities, and frontier electron microscopes. Some of the materials research has a specific relationship to an identified energy technology (e.g., photovoltaic phenomena for solar energy conversion, fast-ion diffusion for solid electrolytes in fuel cells and batteries, etc.); some is related to many energy technologies simultaneously (e.g., hydrogen embrittlement, corrosion, high temperature structural metals and ceramics, etc.); and some important to fundamental understanding of new experimental and theoretical research tools.

This research is conducted at DOE laboratories, universities, and to a lesser extent at industrial laboratories by metallurgists, ceramists, solid state physicists, and materials chemists in about 100 different institutions.

There are three subprograms:

- Metallurgy and Ceramics seeks to understand the synergistic relationship between properties/behavior, structure, and processing parameters of materials.

- Solid State Physics is concerned with understanding the interactions of electrons, atoms, and defects and their role in determining the structure and properties of condensed matter.

- Materials Chemistry focuses on understanding the chemical properties of materials and their relationship to composition, structure, and specimen environment.

The DOE contact for this Division is Dr. Louis Ianniello, 301-353-3427. For specific detailed information, the reader is referred to DOE publication Materials Sciences Programs Fiscal Year 1984 (DOE/ER-0143/2 dated September 1984). This publication contains: summaries of all funded programs at DOE laboratories; summaries of all funded grant programs in universities and private sector organizations; summaries of all Small Business Innovation Research programs; Collaborative Research Centers (descriptive information); cross-cutting indices: investigators, materials, techniques, phenomena, environment. Limited copies may be obtained by calling 301-353-3428.

Division of Engineering and Geosciences

Materials Properties, Behavior, Characterization, or Testing

Damage Accumulation by Crack Growth Under Combined Creep and Fatigue - DOE Contact Oscar P. Manley, 301-353-5822; Battelle-Columbus Laboratories Contact C.E. Jaske, 614-424-4417

- Objective is to develop and evaluate methods for assessing creep/fatigue crack growth under inelastic straining

- A fracture-mechanics approach implementing the J-integral for fatigue and the C*-integral for creep is being employed

- Experimental studies will test Type 316 stainless steel and modified 9Cr-1Mo steel at various temperatures: 538, 593, and 649 degrees C

Electrochemical Wear Mechanism and Deposit Formation in Lubricated Systems - DOE Contact Oscar P. Manley, 301-353-5822; Electrochemical Technology Corp. Contact T.R. Beck, 206-632-5965

- Objective is to measure and determine the importance of electrokinetic- or zeta- corrosion and deposit formation in lubricated rolling and sliding systems

- Approach is to compare measurements of wear for rolling and sliding lubricated systems to calculate zeta corrosion rates based on extensions of the valve wear model

Engineering Analysis of Elastic-Plastic Fracture - DOE Contact Oscar P. Manley, 301-353-5822; Idaho National Engineering Laboratory Contact W.G. Reuter, 208-526-0111

- The objective of this project is to improve design and analytical techniques for predicting the integrity of flawed structural components. Research is primarily experimental with analytical evaluation guiding the direction of experimental testing. Tests are conducted on a modified ASTM A-710 material exhibiting a range of fracture toughness but essentially constant yield and ultimate tensile strength.

- Metallographic techniques are used to measure crack tip opening displacement for comparison with analytical models. Laser interferometry and infrared thermography will be used to evaluate and quantify the deformation in the crack region.

Continuous Damage Theory - DOE Contact Oscar P. Manley, 301-353-5822; University of Illinois Contact D. Krajcinovic, 312-996-7000

- Research centers on the phenomenological description of the nucleation and growth of microdefects in a metallic solid and their influence on the mechanical response.

- Study will include the investigation of the interaction of viscuous effects (reflecting boundary slip) and the brittle effects (growth of microcracks). Problems in creep rupture and fatigue will be considered using the continuum damage model developed.

Loss Characteristics of Cord-Rubber Composites - DOE Contact Oscar P. Manley, 301-353-5822; University of Michigan Contact S.K. Clark, 313-764-4256

- First task will be data acquisition on the loss characteristics of cord-rubber composites under both uniaxial and multiaxial stress states, including the effects of prestrain, frequency, strain amplitude and temperature in the assessment of the visco-elastic properties of the materials.

- The rolling loss of a pneumatic tire will be analyzed using the viscoelastic properties obtained in the first task, together with finite element codes suitable for the problem. Theoretical results will be compared against measured values.

<u>A Study of the Chemical Mechanism in Lubrication</u> - DOE Contact Oscar P. Manley, 301-353-5822; National Bureau of Standards Contact S.M. Hsu, 301-921-3113

- The nature and extent of influence of chemical reactions in the contact zone on friction and wear will be studied. Surface topography of worn surfaces will be characterized to predict oil film thickness under different speed, load ranges in a NBS-developed four-ball wear tester.

- Micro-asperity temperatures and the wear film temperatures of the oil film will be calculated using Archard-Jaeger equations as well as finite-element analysis techniques.

- A theoretical model linking elastohydrodynamic theories to tribo-chemical rate constants with material properties will be attempted to predict lubrication effectivness a priori.

<u>Effects of Crack Geometry and Near-Crack Material Behavior on Scattering of Ultrasonic Waves for QNDE Applications</u> - DOE Contact Oscar P. Manley, 301-353-5822; Northwestern University Contact J.D. Achenbach, 312-491-5527

- This project is concerned with applications of the scattered field approach to the detection of a cracklike flaw, and to the determination of its location, size, shape and orientation. Interior, as well as surface-breaking and near-surface cracks, are considered.

- Usual mathematical modeling of ultrasonic wave scattering by cracks is adjusted to account for several typical characteristics of fatigue and stress-corrosion cracks, and the environment of such cracks.

- Local anisotropy and inhomogeneity due to near-tip voids, and the effect of a zone of plastic deformation near a crack tip will also be investigated.

<u>Crack-Tip Fields for Materials With Exponential-Law Creep Behavior at High Stress</u> - DOE Contact Oscar P. Manley, 301-353-5822; University of Pennsylvania Contact - John L. Bassani, 215-898-5632

- This research is concerned with elastic-viscoplastic analyses of cracks under creep conditions, with particular emphasis on the influence of the assumed stress dependence on the creep strain-rate, where the total strain rate is taken as the sum of linear elastic and hyperbolic-sine-creep rates.

- The crack-tip fields under plane strain Mode I conditions will be analyzed.

<u>Mechanical Interactions of Rough Surfaces</u> - DOE Contact Oscar P. Manley, 301-353-5822; SKF Industries, Inc. Contact J.I. McCool, 215-265-1900

- This project is concerned with the development of fundamental information and the resolution of a number of issues that impact on the design of mechanical systems in which surface microtopography per se or events which occur on the microgeometric scale play a critical role.

- An apparatus designed and constructed by SKF is used to obtain optical interferograms of the lubricated contact of rough surfaces along with measurements of traction transmitted under conditions of combined rolling, sliding, and spinning.

- Guideline and techniques will be developed for the digital processing of surface roughness data generated in analog form by a stylus profile instrument.

<u>Device or Component Fabrication, Behavior, or Testing</u>

<u>Improvement of Reliability of Welding by In-Process Sensing and Control</u> - DOE Contact Oscar P. Manley, 301-353-5822; MIT Contact K. Masubuchi, 617-255-6820

- The main focus of this project is to develop closed-loop control of welding variables in a cost-effective approach to improving weld quality.

- Ultimate goal is to implement a geometry control system on a mechanized welding system, and provide one formal framework for implementation of welding control.

<u>Instrumentation and Facilities</u>

<u>Crack Characterization With Ultrasonic NDE</u> - DOE Contact Oscar P. Manley, 301-353-5822; Idaho National Engineering Laboratory Contact J.A. Seydel, 208-526-0111

- The purpose of this research is to develop the instrumentation and analytical models that can predict and identify the frequency dependence of the amplitude and phase of ultrasonic echoes from defects.

- The approach treats the transducer/media/defect combination as a linear system which allows separation of the individual contributions to the signal detected at the transducer.

High Frequency Transducers - DOE Contact Oscar P. Manley, 301-353-5822; Stanford University Contact G.S. Kino, 415-497-0205

- A new theory has been developed for cross-coupling in acoustic transducer arrays used for acoustic imaging. The entirely new theoretical technique finds application in acoustic devices for NDT, medical and sonar arrays, as well as electromagnetic and antenna arrays.

A Composite, Multiviewing Transducer - DOE Contact Oscar P. Manley, 301-353-5822; Iowa State University Contact D.O. Thompson, 515-294-5320

- Demonstration of a composite multiviewing NDE transducer
- Approach uses recent advances in ultrasonic scattering and inversion theories.
- Reconstruction protocol fits acquired data to an "equivalent" ellipsoid (3 axes and 3 angles)

Office of Health and Environmental Research

The Office of Health and Environmental Research supports a broad multidisciplinary program in basic and applied life sciences research for the purpose of achieving a comprehensive understanding of the health and environmental effects associated with energy technologies. Research is conducted to characterize and measure energy-related hazards, study transport and transformations in the environment, determine the biological and ecological response and define the potential impact on human health. In addition, new applications of nuclear science and energy technologies are developed for use in the diagnosis and treatment of human disease. Materials interests are primarily in development of sensors for radiation and chemical detection.

Division of Physical and Technological Research

The Physical and Technological Research Division conducts physical, chemical, and instrumentation research related to the health and environmental aspects of energy technology development. Included are support of physical and chemical characterization studies, atmospheric sciences research, research on measurement and dosimetry techniques, and fundamental radiation biophysics.

Materials Properties, Behavior, Characterization or Testing

Development of Mercuric Iodide and Other New Concepts for the Detection and Spectroscopy of Ionizing Radiation - DOE Contact G. Goldstein, 301-353-5348; University of Southern California Contact G. Huth, 213-822-9184

- Mercuric iodide and other semiconductor compounds are studied as radiation detectors. Research focuses on the basic physics of the detection process and on detector design.

Semiconductor Radiation Detector Technology - DOE Contact G. Goldstein, 301-353-5348; LBL Contact F. S. Goulding, 415-486-6432

- Semiconductor materials, primarily germanium and silicon, are studied as radiation detectors. Research includes crystal growth and purification, measurement of materials properties, and signal processing.

Avalanche Photodiodes for Positron Emission Tomography - DOE Contact G. Goldstein, 301-353-5348; Radiation Monitoring Devices Contact G. Entine, 617-926-1167

- Silicon avalanche devices are fabricated and tested as solid state photosensors. Research focuses on defining the proper surface preparation technique and on the electrical properties of the photodiode.

Office of Fusion Energy

Fusion Materials Research - Definition of the Materials in Fusion Energy Development

The ultimate economics of fusion energy, like most other energy systems, will depend on the materials required for the system. Fusion materials research separates naturally into two classes of problems: those associated with interaction of plasma with the materials and those associated with the interaction of fusion neutrons with the materials. Both involve basic and applied research. The former are near-term problems which must be solved to advance plasma confinement research; the latter problems are more fundamental to the ultimate success of fusion as an energy source.

The last decade of research, using available nuclear test facilities, has revealed that there are materials which could withstand the nuclear environment of a fusion reactor with reasonable system economics and relatively modest waste disposal requirements. However, studies have also shown that it is important to improve the conomics of these systems and to reduce the need for long-term waste disposal of fusion materials even further through the development of specialized materials. The future fusion materials program must include both the basic research on fundamental new materials and the development of the new technology required for testing those materials.

Objective

The objective of the Fusion Materials Program is to develop the necessary structural, plasma-interactive, breeding, low activation, and special purpose materials to support present and future fusion plasma experiments and to form the foundation for a reliable, economic, and environmental assessment of fusion energy.

I. The objective of the Plasma Interactive Materials (PMI) and High Heat Flux Materials and Component Development (HHF) Programs are to provide the necessary materials and technological support for fusion plasma experiments as they progress to longer pulse length, higher temperatures and densities, and limited tritium operation.

II. Eighty percent of the energy of the deuterium-tritium reaction is released in the form of high energy (14.1 MeV) neutrons and the influence of those radiation fields on materials is profound. The objectives of the (neutron) Radiation Interaction Materials Program elements are to provide the foundation of knowledge and the development and understanding of new or improved materials required to evaluate, design, construct, and operate future fusion devices considering, especially, the interaction of that high energy neutron irradiation on the materials. In addition to the general functional requirements of materials, this program topic has the further special objective to develop materials that would have sufficiently reduced neutron induced radioactivity to significantly shorten or eliminate the burden of long-term (>100 years) waste management -- a primary program objective to make fusion a more attractive energy option.

Organization and "Projects"

The fusion materials research program is managed by the Reactor Technology Branch in the Division of Development and Technology of the Office of Fusion Energy. It is structured around the two major technical issues that are specific to fussion--plasma interactive materials, and neutron radiation interactive materials. These are organized into eight sub-elements (or projects in the context of this report). These sub-elements of the program are each guided by technical level task groups drawn from laboratory, university, and industrial participants. Each task group is claimed by a laboratory program manager in cooperation with a DOE counterpart.

Materials Properties, Behavior, Characterization, or Testing

Alloy Development for Irradiation Performance (ADIP) - DOE Contact T.C. Reuther, 301-353-4963; ORNL Contact A. Rowcliffe, 615-576-5057

- The scope of the ADIP program covers R&D on structural alloys and is focused on neutron irradiation efforts. Principal materials are developmental variations of austenitic stainless and 9-12Cr ferritic/martensitic starts and vanadium alloys. Reduced activation alloys are a priority development goal.

Damage Analysis and Fundamental Studies (DAFS) - DOE Contact T.C. Reuther, 301-353-4963; Hanford Engineering Development Laboratory Contact D.G. Doran, FTS 444-3187

- The scope of the DAFS program is to establish the mechanistic basis to evaluate and project to the effect of the fusion radiation environment from currently available irradiation facilities, to do dosimetry and damage analysis and in general to establish the fundamental response of materials to the fusion environment.

Special Purpose Materials (SPM) - DOE Contact M.M. Cohen, 301-353-4253; ORNL Contact J.L. Scott, FTS 624-4834

- The scope of SPM covers radiation effects on magnet system materials (superconductor, stabilizer, insulator) ceramic applications for insulators, diagnostics, etc., Be for neutron multipliers, etc.

Tritium Breeding Materials - DOE Contact M.M. Cohen, 301-353-4253; ANL Contact C.E. Johnson, FTS 972-7533

- The scope of the Tritium Breeding Materials Program is focused on establishing the properties, behavior, and tritium breeding and release characteristics of lithium bearing oxides. It includes in-reactor and post-irradiation studies and laboratory preparations and characterization.

Analysis and Evaluation - DOE Contact T.C. Reuther, 301-353-4963; McDonnell Douglas Astronautics Co. Contact J. Davis, FTS 314-234-4826

- The scope of the Analysis and Evaluation program is to provide a bridge between the materials and design communities. This task develops and publishes the Materials Handbook for Fusion Energy Systems.

Device or Component Fabrication, Behavior, or Testing

Plasma Materials Interaction and High Heat Flux Component Development Programs - DOE Contact M.M. Cohen, 301-353-4253; Sandia Contact W. Gusster, 415-422-1648

- The strategy of the PMI and HHF programs are to develop and maintain a basic long range technological capability which can be utilized by all confinement communities. Focusing of this technology is accomplished through performance of specific component development projects on present and future confinement facilities and experiments. This program represents a vital resource utilized by all confinement concepts.

Instrumentation and Facilities

Radiation Facilities Operation - DOE Contact M.M. Cohen, 301-353-4253; Lawrence Livermore Contact C. Henning, FTS 532-0235

- This task covers the U.S. share of the joint U.S./DOE and Japanese operations of RTNS-II, or 14 MeV DT neutron source.

Operation of Oak Ridge Research Reactor - DOE Contact T.C. Reuther, 301-353-4963; ORNL Contact J.L. Scott, FTS 624-4834

- This task covers the operating cost of the ORR for Energy Research users.

Small Business Innovation Research Program

The Small Business Innovation Research (SBIR) program, now completing its second year in 1984, was established in compliance with the Small Business Innovation Development Act of 1982, Public Law 97-219.

As prescribed in the legislation, the program is designed for implementation in a three-phase process, with Phase I determining, insofar as possible, the scientific or technical merit and feasibility of ideas proposed for investigation, The period of performance in this initial phase is relatively brief, typically about 6 months, and the awards are limited to $50,000. Phase II is the principal research or research and development effort, and the awards are as high as $500,000 for work to be performed in periods of up to 2 years. Under Phase III, commercial applications of the research or research and development are pursued by small businesses with non-Federal capital or, alternatively, Phase III may involve follow-on non-SBIR Federal contracts for products or processes desired by the Government.

The selections for awards were made on scientific and technical merit, using the specific evaluation criteria listed in the solicitation. Conclusions were reached on the basis of detailed reports returned by reviewers drawn from DOE laboratories, universities, private industry, and government. Where several proposals were judged to be of approximately equal technical merit, preference was given to those proposals that had demonstrated third phase, non-Federal capital commitments.

The work described in the abstracts represents high-risk research, but the potential benefits are also high if the objectives are met. The DOE contact for all the projects is Dr. B. Chalmers Frazer, 301-353-3054.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Rapidly Solidified , Spherical, Fine Ceramic Powders - Marko Materials Contact Ranjan Ray, 617-663-2210

- Determination of the feasibility of making rapidly solidified ceramic powders using a unique new concept resulting in spherical powders less than 3 micrometers in average diameter.

Brazing of Machinable Glass-Ceramics - Materials and Medical Components, Inc. Contact Harold N. Barr, 301-730-7800

- Investigation of the metallizaton of machinable glass-ceramics by the low-temperature sputter deposition of thin film active metals, which will then permit brazing of ceramic-to-metal and ceramic-to-ceramic assemblies for electronic and mechanical applications.

Growth of BaF_2 Crystals by the Heat Exchanger Method (HEM) with Enhanced Fast Component for Scintillator Applications - Crystal Systems Contact Chandra P. Khattak, 617-745-0088

- Adaptation of the Heat Exchanger Method (HEM) for the growth of BaF_2 crystals.

- Crystal growth experiments will be tailored to evaluate the effect of impurities, crystal quality, size and crystal growth parameters on the scintillation properties of BaF_2.

Shape Memory Alloy Seals for Geothermal Applicaitons - Memory Metals Contact Dewa Adnyana, 203-358-0437

- Application of shape memory alloy seals (Ni-Ti alloys) to geothermal systems

- Optimization of seal design and fabrication methods

Wear-Resistant Ferrous Metal Matrix Composites for Municipal Solid Waste (MSW) Processors - Waste Energy Technology Corporation Contact David B. Spencer, 617-275-6400

- Determination of the technical feasibility of producing ferrous metal/ceramic composites by high technology, direct-casting methods -- termed rheocasting and compocasting -- resulting in material which will combine the strength and impact-resistance properties of iron with the abrasion-resistance properties of ceramic materials.

Horizontal Growth of Silicon Sheet Crystals via Edge-Supported Pulling (ESP) from a Melt Contained in a Cold Crucible - Ceres Corporation Contact Joseph F. Wenckus, 617-667-3000

- Explore the feasibilty and scale-up of the horizontal growth of silicon sheet ctystals using the edge-supported pulling (ESP) process from silicon melts contained in an RF-coupled cold crucible.

Fabrication of Amorphous Metallic Films and Coatings for Industrial Applications Using High-Energy Ion Beam Mixing - Universal Energy Systems, Inc. Contact Peter Pronko, 513-426-6900

- Development of stable amorphous metallic alloy coatings by energetic ion beam processing which will exhibit superior properties with respect to corrosion pitting and surface erosion in fluid dynamic and electrohydrodynamic environments.

Growth of Bismuth Germanate ($Bi_4Ge_3O_{12}$, BGO) Using the Heat Exchanger Method (HEM) - Crystal Systems Contact Chandra P. Khattak, 617-745-0088

- Establishment of technology for economic growth of large, high-quality BGO crystals for nuclear and high-energy physics applications.

Superplastic Forging of Structural Ceramics - Jupiter Technologies Contact Prakash Panda, 607-257-4514

- Ascertain the feasibility of superplastic forming of engineering ceramic materials, namely, silicon nitride, and glass-ceramic/silicon carbide-fiber composites.

- CAD/CAM techniques will be developed and applied.

Titanium Nitride Coating of High-Speed Steel and Carbide Metal Cutting Tools Using Fluid Bed Furnace Technology - Procedyne Corporation Contact Joseph E. Japka, 201-249-8347

- Study of the fesability of using fluid bed technology for putting a hard titanium nitride coating on carbide and steel tools to determine optimum coating conditions and the characteristics of the TiN coating.

Reduction of Surface Recombination in Silicon Solar Cells - Spire Corporation Contact Mark B. Spitzer, 617-275-6000

- Investigation of growth of epitaxial layers of zinc sulfide on high-efficiency solar substrates by chemical vapor deposition.

- Research will result in a means of lowering the surface recombination of silicon of silicon solar cells and make possible the production of solar cells of greatly increased efficiencies.

Improvement of Carbon Foils and Applications - Arizona Carbon Foil Company Contact Stanley Bashkin, 602-621-6814

- Object is to make improved carbon and carbon-hydrogen foils, to develop a neutral-density filter for the near-infrared spectral region, to make a proton detector useful for high proton energies and beam currents, and to protect surfaces from both abrasion and corrosive action.

Materials Properties, Behavior, Characterization, or Testing

Eddy Current Nondestructive Evaluation of Laser-Glazed Metallic Surfaces - American Research Corporation of Virginia Contact Russell J. Churchill, 703-731-0655

- Application of eddy current nondestructive evaluation (NDE) techniques to achieve control of surface layers and to identify defects.

- Anticipated result is a research tool for monitering and controlling the depth of melt and characterizing defects in surface layers and adjacent substrate materials.

Processing and Characterization of Silicon Carbide-Aluminum Oxycarbide Ceramics - Ceramatec Contact Raymond A. Cutler, 801-486-5071

- Characterization ot the microstructure and mechanical properties of the sinterable $SiC-Al_2OC$ Materials to determine if they are candidates for use in heat engines, cutting tools, wear parts, and other high-temperature components.

Containerless Sinter/Hot Isostatic Pressing (HIP) of a SIAlON - Gorham International Inc. Contact Andrew C. Nyce, 207-892-2216

- Determination of the feasibility of fully densifying a 92wt% Si_3N_4 + 6wt% Y_2O_3 + 2wt% Al_2O_3 SIAlON via sinter/HIP processing.

Evaluation of Metal-Matrix Composites Based on Fe-Nd-B Alloys for Improved Permanent Magnets - KJS Associates Contact Reinhold M. W. Strnat, 513-879-0114

- Improvement of a class of high-energy permanent magnets now under development: heat-bonded composites of hard magnetic alloy powders in a ductile metal matrix.

- Exploration of the applicability of Sn/Pb-solder bonding to iron neodymium-boron alloys.

Rapidly Solidified Magnetic Alloys for High-Frequency, High-Power Applications - Micromaterials Technology Contact Richard F. Cheney, 717-888-6505

- Fabrication of of amorphous alloys of low magnetoelastic coupling and compare their performance with that of commercially available magnetostrictive amorphous compostions.

ODS Tungsten Carbide-Cobalt - Technical Research Associates Contact Guy B. Alexander, 801-582-8080

- Improvement of the properties of WC-Co alloys, and thus improvement of the life of such alloys in cutting tools, mining tools, etc.

"In-Situ" Evaluation of Electrocatalytic Materials with a Surface-Impedance Technique - Energy Conversion Devices Contact William M. Ayers, 201-231-9060

- Development of an "in-situ" surface characterization technique to evaluate electrocatalytic materials, utilizing the propagation of high-frequency surface electromagnetic waves (SEW) along, rather than perpendicular to, the electrocatalyst surface.

Fracture Mechanics Investigations of Grinding of Ceramics - Ceramic Finishing Company Contact Henry P. Kirchner, 814-238-4270

- Determination of the relative importance of crushing and chipping alongside the track as a result of lateral cracking, as mechanisms of material removal, for various material properties and grinding conditions.

Mathematical Modeling of Electrochemistry of Stress Corrosion Cracking - Electrochemical Technology Corporation Contact Theodore R. Beck, 206-632-5965

- Reformulation and testing of SCC model, formulation of SCC models for iron and nickel alloys, and formulation of a model for concentration of anions in an occluded anode site.

An Investigation to Determine the Commercial Feasibility of "In-Situ" Cu-Nb Composites for High-Strength, High-Conductivity Applications - Supercon, Inc. Contact James Wong, 617-655-0500

- Optimization of the high-strength, high-conductivity properties of multi-element "in-situ" composites and increasing of the quantity of material fabricated.

High-Temperature and/or High-Speed Thickness Gauging of Metals - Materials Engineering Associates Contact Bruce W. Maxfield, 509-375-0663

- Evaluation of improved, rugged, reliable Electromagnetic Acoustic Wave Transducer (EMAT) designs for the generation and detection of longitudinal and shear waves up to 2000 degrees F.

Device or Component Fabrication, Behavior, or Testing

Superconductiong Magnetic Shields for Neutral Beam Injectors - Applied Sciences Consultants, Inc. Contact Ahmad Waleh, 415-497-7450

- Conduct a feasibility study of the design, material characteristics, strength analysis, fabrication techniques, subscale test definitions, and economics of the superconducting shielding technique.

Development of a New Process for the Production of Very Fine Filamentary Superconducting Nb-Ti Composite - Supercon, Inc. Contact James Wong, 617-655-0500

- Development of a new manufacturing method for the production of multifilamentary superconducting niobium-titanium wire with very large numbers of fine filaments.

Method and Device for Non-Destructive Inspection of Niobium to Improve Superconductivity - Sonoscan, Inc. Contact Lawrence K. Kessler, 312-766-7088

- Devlopment of a non-destructive test device to inspect niobium plates and niobium welds for defects causing its superconducting porperties to be quenched.

- Investigation of the feasibility of acoustic microscopy for locating critical size defects (50-500 m), and differentiating critical from noncritical defects.

Research on Advanced Cell Designs for High-Efficiency Flat-Plate Applications - Spire Corporation Contact Mark B. Spitzer, 617-275-6000

- Phase II comprises research on the fabrication of Prototype large-area cells. In addition, Phase II research addresses reduction of process cost, and includes application of the cell design and fabrication process to fabrication of solar cells made from a number of present-day Si sheet materials.

Instrumentation and Facilities

Extreme Ultraviolet and Soft X-Ray Instrumentation for Microcharacterization of Materials - Altex Corporation Contact Herbert Pummer, 312-372-3440

- Development of a prototype laser system that delivers a tunable, high-quality pulse of about 10psec duration in the range < 450 to 700nm.

OFFICE OF NUCLEAR ENERGY

	FY 1984	FY 1985
Office of Nuclear Energy Grand Total	$130,892,000	$126,648,000
Office of Converter Reactor Deployment	$ 5,865,000	$ 7,020,000
High Temperature Reactor Development Division	$ 5,865,000	$ 7,020,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 600,000	$ 695,000
Fuel Process Development	$ 600,000	$ 695,000
Materials Properties, Behavior, Characterization, or Testing	$ 6,401,000	$ 6,325,000
Fuel Materials Development	$ 585,000	$ 510,000
Fuel Development and Testing	650,000	920,000
Graphite Development	635,000	1,095,000
Graphite Development and Testing	635,000	845,000
Metals Technology Development	1,030,000	1,225,000
Structural Materials Development	660,000	660,000
Advanced Gas Reactor Materials Development	1,070,000	1,070,000
Office of Terminal Waste Disposal and Remedial Action	$ 12,100,000	$ 9,700,000
Division of Storage and Treatment Projects	$ 12,100,000	$ 9,700,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 2,600,000	$ 2,500,000
Technical Support to West Valley Demonstration Project	$ 2,600,000	$ 2,500,000
Materials Properties, Behavior, Characterization, or Testing	$ 6,900,000	$ 6,700,000
Materials Characterization Center Testing of West Valley Formulation Glass	$ 0	$ 200,000
Nuclear Waste Treatment	6,900,000	6,500,000

	FY 1984	FY 1985
Device or Component Fabrication, Behavior, or Testing	$ 2,600,000	$ 500,000
West Valley Joule Heated Ceramic Melter Design and Fabrication	$ 2,000,000	$ 0
Special Waste Form Lysimeter for Arid Regions	400,000	250,000
Special Waste Form Lysimeter for Humid Regions	200,000	250,000
Office of Uranium Enrichment	$ 55,229,000	$ 77,708,000
Device or Component Fabrication, Behavior, or Testing	$ 55,229,000	$ 77,708,000
Gaseous Diffusion: Barrier Quality	$ 1,770,000	$ 1,073,000
Gaseous Diffusion: Barrier Science	1,010,000	875,000
Gaseous Diffusion: Materials and Chemistry Support	2,865,000	2,291,000
Advanced Gas Centrifuge: Set V	34,584,000	33,469,000
Atomic Vapor Laser Isotope Separation Process Separator Development	15,000,000	40,000,000
Office of Breeder Reactor Programs	$ 57,698,000	$ 32,220,000
Office of Special Nuclear Projects	$ 1,105,000	$ 2,105,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 755,000	$ 1,705,000
Development of Improved Thermoelectric Materials	$ 0	$ 850,000
Development of an Improved Process for the Manufacture of DOP-26 Iridium Alloy Blank	350,000	525,000
Carbon Bonded Carbon Fiber Insulation Manufacturing Process Development and Product Characterization	405,000	330,000
Materials Properties, Behavior, Characterization, or Testing	$ 350,000	$ 400,000
Characterization of State-of-the-Art Thermoelectric Device/Materials and Exploratory Studies of Rare Earth Sulfide Thermoelectric Materials	$ 350,000	$ 400,000

OFFICE OF NUCLEAR ENERGY (Continued)

	FY 1984	FY 1985
Office of Space Reactor Projects	$ 1,400,000	$ 2,485,000
Office of Breeder Technology Projects	$ 55,193,000	$ 27,630,000
Fuels and Core Materials Division	$ 46,893,000	$ 22,930,000
Materials Properties, Behavior, Characterization, or Testing	$ 46,893,000	$ 22,930,000
Core Systems: Mixed Oxide Fuel - Reference Core	$ 1,720,000	$ 0
Mixed Oxide Fuel - Extended Life	2,515,000	0
Mixed Oxide Fuel - Long Life	7,248,000	12,450,000
Fuel Blanket	265,000	0
Absorber - Boron Carbide	475,000	0
Fuel Support Technology	2,869,000	0
Alloy Development	3,415,000	0
Component Fabrication or Testing for Safe Automated Facility	14,193,000	10,480,000
Powder Operations	2,639,000	0
Pellet Operations	3,390,000	0
Fuel Pin Operations	1,547,000	0
Process Support	2,704,000	0
Engineering, Testing, and Evaluation	3,913,000	0
Materials and Structures Division	$ 8,300,000	$ 4,700,000
Materials Properties, Behavior, Characterization, or Testing	$ 8,300,000	$ 4,700,000
High Temperature Structural Design, Mechanical Property Design Data, Tribology, Coolant Technology, Fabrication, Handbook, and Advanced Alloy Development	8,300,000	4,700,000
Office of Naval Reactors	$ 60,000,000*	$ 60,000,000*
Reactor Material Division	$ 60,000,000*	$ 60,000,000*

* Approximate.

OFFICE OF NUCLEAR ENERGY

The Office of Nuclear Energy conducts research projects in the Office of Converter Reactor Development, the Office of Terminal Waste Disposal and Remedial Action, the Office of Uranium Enrichment, the Breeder Reactors Program, and the Office of Naval Reactors. Summarized below are the areas of research in which the Department is currently engaged.

- Conducts the Light Water Reactor R&D program to improve the operation and availability of LWR's, extending plant lifetimes, enhancing plant safety (utilizing Three Mile Island information, as appropriate) and improving plant licensability, and plans and carries out R&D to provide base technology in High Temperature Reactors.

- Conducts R&D programs which support the development of converter reactors to exploit state-of-the-art and encouraging technologies to meet future requirements. This includes advanced LWRs's, HIGR's, and innovative LMR's.

- Develops advanced Breeder Reactor Technology to determine the optimum economic, environmental, and safety qualities in plants, systems, and components preparatory to commercial application in the power plant market.

- Conducts programs to develop and apply Advanced Nuclear System technology to space and terrestial application requirements including defense applications.

- Conducts the Naval Reactor Program to meet the nation's military requirements.

- Conducts programs to fulfill the Federal Government's responsibility for providing uranium enrichment services and for supporting low-level waste management and waste technology development.

- Conducts programs to fulfill the department's responsibilities for remedial action to protect public health and safety or to fulfill specific legislative requirements.

- Determines obstacles which stand in the way of increased use of Nuclear Energy and the steps needed to overcome them and implements other programs as directed by the Secretary.

Office of Converter Reactor Deployment

The overall mission of this office is to undertake activities which will resolve technical and institutional obstacles to the further deployment of converter reactors by private industry. This office includes the following divisions: High Temperature Reactor Development, Light Water Reactor

Projects, Nuclear Regulation and Safety, and Nuclear Reactor Economics and Financing. The major materials interests of this office include those required for the following reactor applications: fuels, fuel cladding, moderators, structural components, and heat exchangers.

Division of High Temperature Reactor Development

The objective of this division is to develop the base technology, systems concepts, and reactor designs which will permit the Government, in cooperation with utilities and private industry, to commercialize the High Temperature Reactor. The materials interests of this division include those required for the development of coated particles fuels, graphite moderator and reflector blocks, graphite core support blocks and posts, pre-stressed concrete reactor vessels, thermal barrier pads and insulation, and heat exchanger tubing and tube sheets. DOE contact is J.E. Fox, 301-353-4162.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Fuel Process Development - GA Technologies Contact E.O. Winkler, 619-455-4200

- Production of depleted and enriched uranium oxycarbide microspheres.
- Coating of microspheres with multiple ceramic layers of pyrolytic carbon and silicon carbide.

Materials Properties, Behavior, Characterization, or Testing

Fuel Materials Development - GA Technologies Contact O.M. Stansfield, 619-455-2895

Fuel Development and Testing - ORNL Contact M.J. Kania, 615-576-4856

- Fabrication, testing, and evaluation of irradiation experiments; development of post-irradiation examination equipment and methods.
- Evaluation of fuel performance and development of fission product release mechanism and models; development of fuel kernel and coating production specifications.

Graphite Development - GA Technologies Contact H. Jones, 615-455-2360

Graphite Development and Testing - ORNL Contact W. Eatherly, 615-576-5220

- Selection, characterization, and qualification of graphite materials; evaluation of high temperature corrosion resistance and mechanical properties (tensile, creep, fatigue, fracture mechanics, etc.)
- Fabrication, testing, and evaluation of irradiation experiments; development of high strength, oxidation resistant graphites with high resistance to irradiation damage.

Metals Technology Development - GA Technologies Contact D. Roberts, 619-455-2560

Structural Materials Development - ORNL Contact P. Rittenhouse, 615-574-5103

- Selection, characterization, and qualification of high temperature alloys; evaluation of effects of exposures in simulated environments on mechanical properties (creep, fatigue, fracture mechanics).
- Development of the data base and correlations required for qualification; development of welding procedures and evaluation of weldment properties.

Advanced Gas-Reactor Materials Development - GE Contact O.F. Kimball, 518-385-1427

- Selection and evaluation of candidate high temperature alloys; evaluation of effects of exposures in simulated environments on mechanical properties (tensile, impact, creep, fatigue).
- Generation of a data base for development of design criteria and code qualification rules for temperatures above 760 degrees C (1400 degrees F).

Office of Terminal Waste Disposal and Remedial Action

Division of Storage and Treatment Projects

The mission of the Division of Storage and Treatment Projects is to facilitate development of a reliable national system for managing low-level waste and to develop acceptable technologies for the treatment and immobilization of nuclear fuel cycle and special types of radioactive waste.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Technical Support to West Valley Demonstration Project - DOE Contact J.A. Turi, 301-353-4728; PNL Contact H.C. Burkholder, 509-375-2860

- Provide technical assistance in supernate treatment and borosilicate glass formulation for West Valley Demonstration Project waste.

Materials Properties, Behavior, Characterization, or Testing

Materials Characterization Center Testing of West Valley Formulation Glass - DOE Contact H.F. Walter, 301-353-5510; PNL Contact J.E. Mendel, 509-375-2905

- Evaluate, using various MCC test methods, samples of glass having the expected composition of West Valley borosilicate glass incorporating high-level waste.

Nuclear Waste Treatment - DOE Contact J.B. Zorn, 301-353-4728; PNL Contact H.C. Burkholder, 509-375-2860

- Develop acceptable technologies for treatment and immobilization of waste from the nuclear fuel cycle and special waste.

Device or Component Fabrication, Behavior, or Testing

West Valley Joule Heated Ceramic Melter Design and Fabrication - DOE Contact J.A. Turi, 301-353-4728; PNL Contact H.C. Burkholder, 509-375-2860

- Design and fabricate a liquid fed joule heated ceramic melter capable of making about 0.8 cubic meters per day of borosilicate glass incorporating West Valley high-level waste.

Special Waste Form Lysimeter for Arid Regions - DOE Contact J.L. Smiley, 301-353-4728; EG&G Idaho Contact - E. Jennrich, 208-526-9490

- Conduct waste form leaching tests in a field facility in order to determine typical source terms generated by commercial solidified low-level waste in an arid climate
- Identify the chemical and physical processes that control the concentrations of radionuclides in the surrounding soil
- Determine methods for representing the source term boundary conditions for transport models

Special Waste Form Lysimeter for Humid Regions - DOE Contact J.L. Smiley, 301-353-4728; EG&G Idaho Contact E. Jennrich, 208-526-9490

- Conduct waste form leaching tests in a field facility in order to determine typical source terms generated by commercial solidified low-level waste in a humid climate
- Identify the chemical and physical processes that control the concentration of radionuclides in the surrounding soil
- Compare radionuclid emigration from solidified commercial low-level waste in order to evaluate the benefits of solidification

Office of Uranium Enrichment

The goal of the uranium enrichment program is to meet the requirements of domestic and foreign customers and the United States Government for uranium enrichment services in an economical, reliable, safe, and environmentally acceptable manner. The Office of the Deputy Assistant Secretary for Uranium Enrichment, reporting to the Assistant Secretary for Nuclear Energy, is responsible for the management of DOE resources to attain the program goal. Uranium Enrichment is composed of four major offices: Marketing and Business Operations, Operations and Facility Reliability, Enrichment Expansion Projects, and Advanced Technology Projects. Operations and Facility Reliability is responsible for oversighting all aspects of the Gaseous Diffusion Plants including the electrical power contracts which are a major cost element. The Enrichment Expansion Projects Office is responsible for construction of the Gas Centrifuge Enrichment Plant (GCEP) at Portsmouth, Ohio, and the procurement and installation of baseline centrifuges and other plant process equipment. Advanced Technology Projects is responsible for all research/development/demonstration of a higher capacity Advanced Gas Centrifuge and the Atomic Vapor Laser Isotope Separation Process. Both of these advanced processes are now being critically evaluated to determine which will be the recommended enrichment technology for further development and potential future deployment.

Revenues received by DOE for the enrichment of uranium are retained and used for the specific purposes of offsetting costs incurred by the Department in providing uranium enrichment service activities as authorized by Section 201 of Public Law 95-238, not withstanding the provisions of Section 3617 of the Revised Statutes (31 USC 484). The sum appropriated is reduced as uranium enrichment revenues are received during a fiscal year so as to result in a final fiscal year appropriation estimated at $0. Total obligations for all uranium enrichment activities in FY 1984 was 1.94 billion dollars and is expected to be 1.83 billion dollars in FY 1985.

Uranium as found in nature contains about seven-tenths of 1 percent uranium 235 which is fissionable. The remainder is essentially uranium 238 which is nonfissionable. The fissionable characteristics of uranium 235 make it desirable to enhance its concentration for use as nuclear fuel. Light water reactors typically require uranium 235 concentrations in the 2 to 4 percent range. Presently uranium is enriched to the desired uranium 235 product assay levels in gaseous diffusion plants located at Oak Ridge, Tennessee; Portsmouth, Ohio; and Paducah, Kentucky. These plants were built in the 1940's and 1950's and were operated initially to satisfy defense requirements for uranium 235. They are now operated primarily to provide enrichment services to domestic and foreign utility customers. In these plants, the Department enriches customer-provided natural uranium in the uranium 235 component for a fee which recovers the cost of providing the services. The Department is the sole provider of enrichment services in the United States. The specific statutory authority which established this role is the Atomic Energy Act of 1954, as amended.

Materials activities within the Office of Uranium Enrichment are varied and, for the most part, especially the test results, classified Restricted Data. The following summarizes most of these activities for the purpose of this report. The total outlay in FY 1984 was $55,229,000 and in FY 1985, due to the Technology Decision, about $77,708,000 will be expended. The DOE contact is A.P. Litman, 301-353-5777.

Materials Activities

Gaseous Diffusion: Barrier Quality

- Studies of the short- and long-term changes in the separative capability of the diffusion barrier.

- Methods to recover and maintain barrier quality and demonstration in the production facilities.

Gaseous Diffusion: Barrier Sciences

- Work on barrier theory is performed and assistance is given to the barrier quality activities.

Gaseous Diffusion: Materials and Chemistry Support

- Characterization of contaminant-process gas cascade reactions, physical/chemical properties of UF_x substances, corrosion of materials, failure analyses, trapping technology, alternative materials replacement.

Advanced Gas Centrifuge: Set V

- Development of an Advanced Gas Centrifuge (AGC), designated as Set V, the goal of which is to design and qualify a machine capable of producing 600 separative work units (SWU) of enriched uranium per machine-year.

Atomic Vapor Laser Isotope Separation Process Separator Development

- Utilization of the differences in the electronic spectra of atoms of uranium isotopes to induce the selective absorption required for isotopic separation.

- Development of an AVLIS plant module point design, fully supported by experimental results, which will produce enriched uranium at low cost in accordance with the uranium enrichment enterprise.

- Coating development for various substrates to contain uranium and development/demonstration of engineering subcomponents.

Office of Breeder Reactor Programs: Office of Special Nuclear Projects

The Office of Special Nuclear Projects is responsible for the development, system safety, and production of radioisotope thermoelectric generators (RTG) and dynamic power systems for NASA and DoD space and terrestrial applications and advancing base technologies for these power systems. Thus, applied materials research programs are supported in the areas of thermoelectric materials and devices, high temperature heat source materials, materials systems compatibility, and safety related materials characterization and testing.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Development of Improved Thermoelectric Materials for Space Nuclear Power Systems - DOE Contact W. Barnett, 301-353-3097; General Electric Co., Space Systems Division Contact P. Gorsuch, 215-354-5047

- An optimization study of Si-Ge type thermoelectric alloys is being conducted. Key variables include alloy and dopant additions, processing parameters, and structure control. Goal is an average Figure of Merit, Z, of 1×10^{-3} per degree C from 300 to 1000 degrees C.

- Exploratory studies of potential advanced refractory thermoelectric materials, namely beta boron and boron carbide, are being conducted.

Development of an Improved Process for the Manufacture of DOP-26 Iridium Alloy Blank - DOE Contact W. Barnett, 301-353-3097; ORNL Contact R. Heestand, 615-574-4352

- A consumable arc melt/extrusion route process is being developed for the production of DOP-26 iridium alloy sheet.

Carbon Bonded Carbon Fiber (CBCF) Insulation Manufacturing Process Development and Product Characterization - DOE Contact W. Barnett, 301-353-3097; ORNL Contact W. Eatherly, 615-574-5220

- This program is aimed at improved process control systems, optimization of process parameters, and accommodation of a new type carbon fiber for the manufacture of CBCF, carbon bonded carbon-fiber thermal insulation.

Characterization of State-of-the-Art Thermoelectric Device/Materials and Exploratory Studies of Rare Earth Sulfide Thermoelectric Materials - DOE Contact W.J. Barnett, 301-353-3097; Iowa State University Contact B. Beaudry, 515-294-1366

- This program is concerned with the evaluation and characterization of state-of-the-art Si-Ge/GaP and other "improved" silicon-germanium type thermoelectric materials.

Office of Space Reactor Projects

Investigation of fundamental material properties and resolution of compatibility issues are critical for the successful development of space nuclear reactor power systems. Feasibility of using refractory metals in a reactor concerns the material transport fluid/cladding/fuel chemical interaction. Knowledge of the creep strength, ductility, fracture toughness, and fabricability of refractory alloys is an important factor in the selection of materials for the reactor system. The effects of fast neutron irradiation on their mechanical behavior are also important factors for this selection. The candidate structural materials include molybdenum, niobium, tantalum, and tungsten-based alloys.

One objective is the measurement of the high temperature creep strength and the DBTT of refractory alloy, wrought and weldment specimens, for use in early structural alloy selection decisions. A second objective is to analyze the available high temperature creep data for candidate refractory alloys.

Office of Breeder Technology Projects

Fuels and Core Materials Division

The applied research and development technology activities, conducted at several national laboratories, industrial organizations, universities, and through bilateral and trilateral technology programs and exchanges with foreign nations, relate to current and advanced reactor systems. The scope of these activities include the following areas: fucl cycles; design and performance of high quality core components for fuels, blanket, and control systems; development of the structural materials used in these components and systems; development and demonstration of equipment, processes, and procedures for fabricating, processing, handling, and producing mixed oxide bearing fuels, materials, and components; sodium technology; standards and quality assurance; assuring a reliable high quality economical fuel supply for LMR's; destructive and non-destructive testing, examination, and evaluation of core components and the facilities and capabilities for conducting such examinations; responsibility for engineering and supporting facilities; associated safety, safeguards, and non-proliferation; maintaining competent capabilities in the several contractor organizations that conduct the pertinent R&D activities and programs. These activities are responsive to the administration's policies and goals and, to the DOE programs that support them.

In-reactor and out-of-reactor property evaluations are being conducted on core materials, clad/ducts, fuels and absorber materials. Through irradiation testing in FFTF and EBR-II, the Fuels and Core Materials Program is developing, qualifying, and verifying the use of reference, improved and advanced mixed oxide fuels and boron carbide absorbers, including full size driver and blanket fuel, and absorber element pins and assemblies--same for carbide fuels. Fabrication development, evaluation, qualification, and verification (raw material processing, melting, hot working, cold working, and finishing) are conducted on reference, improved, and advanced alloys including in-reactor qualification of pins, ducts, and assemblies; surveillance assemblies of reference materials now in FFTF Core 1. Improved and advanced materials are being tested for use in future cores. The DOE contact is Dave Nulton, 301-353-5004.

Materials and Structures Division

The objectives of the Materials and Structures Division are to develop procedures that will assure economic and safe components and systems while providing designers with sufficient flexibility in components and systems design to facilitate optimization. Materials being evaluated are low alloy and stainless steels as well as ferrous superalloys. Major areas include materials characterization, radiation effects, mechanical properties, joining methods, non-destructive testing, tribology, corrosion and wear, and materials data documentation. The DOE contact is Nick Grossman, 301-353-3405.

Office of Naval Reactors: Materials R&D Program

The Materials Research and Development Program is in the Reactor Materials Division under the Deputy Assistant Secretary for Naval Reactors. The program supports the development and operation of improved and longer life reactors and pressurized water reactor plants for naval nuclear propulsion.

The objective of the materials program is to develop and apply in operating service materials capable of use in the high power density and long life required of naval ship propulsion systems. This work includes irradiation testing of reactor fuel, poison, and cladding materials in the Advanced Test Reactor at the Idaho National Engineering Laboratory. This testing and associated examination and design analysis demonstrates the performance characteristics of existing materials as well as defining the operating limits for new materials.

Corrosion, mechanical property, and wear testing is also conducted on reactor plant structural materials under both primary reactor and secondary steam plant conditions to confirm the acceptability of these materials for the ship life. This testing is conducted primarily at two Government laboratories - Bettis Atomic Power Laboratory in Pittsburgh and Knolls Atomic Power Laboratory in Schenectady, New York.

One result of the work on reactor plant structural material is the issuance of specifications defining the processing and final product requirements for materials used in naval propulsion plants. These specifications also cover the areas of welding and non-destructive testing.

Funding for this materials program is incorporated in naval projects jointly funded by the Department of Defense and the Department of Energy. This funding amounts to approximately $60 million in FY 1984 including over $28 million as the cost of irradiation testing in the Advanced Test Reactor. The Naval Reactors Contact is Robert H. Steele, FTS 557-5565.

OFFICE OF DEFENSE PROGRAMS

	FY 1984	FY 1985
Office of Defense Programs Grand Total	$18,690,000	$19,855,000
Office of Inertial Fusion	$ 1,000,000	$ 1,000,000
Fusion Research Division	$ 1,000,000	$ 1,000,000
Device or Component Fabrication, Behavior, or Testing	$ 1,000,000	$ 1,000,000
Target Fabrication	$ 1,000,000	$ 1,000,000
Office of Military Applications	$17,690,000**	$18,855,000
Solid State Sciences Directorate, 1100	$ *	$ 2,550,000
Ion Implantation and Radiation Physics Research Department, 1110	$ *	$ 750,000
Materials Properties, Behavior, Characterization, or Testing	$ *	$ 750,000
Ion Implantation Studies for Friction and Wear	$ *	$ 250,000
Silicon-Based Radiation Hardened Microelectronics	*	500,000
Condensed Matter and Surface Science Department, 1130	$ *	$ 1,150,000
Materials Properties, Behavior, Characterization, or Testing	$ *	$ 1,150,000
Shock Chemistry	$ *	$ 500,000
Initiation of Granular Explosives	*	350,000
Strained-Layer Superlattices for IR Detectors	*	300,000

* At the time of publication, FY 1984 funding levels were not submitted.

** At the time of publication, FY 1984 funding levels were not submitted for portions of this office.

	FY 1984	FY 1985
Solid State Research Department, 1150	$ *	$ 650,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ *	$ 550,000
Materials Growth by MOCVD	$ *	$ 150,000
Materials Growth by MBE	*	300,000
Conducting Organic Materials	*	100,000
Materials Properties, Behavior, Characterization, or Testing	$ *	$ 100,000
Passivation of Semiconductor Grain Boundaries and Defects	$ *	$ 100,000
Organic and Electronic Materials Department, 1810	$ 1,760,000	$ 1,870,000
Chemistry of Organic Materials Division, 1811	$ 350,000	$ 400,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 200,000	$ 250,000
Polysilanes, Photoresists, and Non-Charring Dielectrics	$ 100,000	$ 150,000
Sulfonated Aromatic Polysulfones	100,000	100,000
Materials Properties, Behavior, Characterization, or Testing	$ 150,000	$ 150,000
Radiation Hardened Dielectrics	$ 150,000	$ 150,000
Physical Chemistry and Mechanical Properties of Polymers Division, 1812	$ 610,000	$ 670,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 350,000	$ 300,000
Effects of Material and Processing Variables on the Mechanical and Thermal Expansion Behavior of Graphite/Epoxy and Kelvar/Epoxy Composites	$ 350,000	$ 300,000

* At the time of publication, FY 1984 funding levels were not submitted.

		FY 1984		FY 1985
Physical Chemistry and Mechanical Properties of Polymers Division, 1812 (Continued)				
Materials Structure and Composition	$	210,000	$	320,000
The Chemical Characterization of Plasma Deposited Thin Films	$	100,000	$	150,000
Materials Structure and Properties by NMR Spectroscopy		60,000		70,000
Electron and Photon Stimulated Desorption From Organic Surfaces		50,000		100,000
Materials Properties, Behavior, Characterization, or Testing	$	50,000	$	50,000
Surface Chemistry and Bond of Plasma-Aminated Polyaramid Filaments	$	50,000	$	50,000
Physical Properties of Polymers Division, 1813	$	500,000	$	500,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$	100,000	$	100,000
Microcellular Foams for X-ray Laser	$	100,000	$	100,000
Materials Properties, Behavior, Characterization, or Testing	$	400,000	$	400,000
Cure Kinetics of Thermosets by DSC	$	100,000	$	100,000
Creep Rupture of Kelvar Composites		300,000		300,000
Electronic Property Materials Division, 1815	$	300,000	$	300,000
Materials Properties, Behavior, Characterization, or Testing	$	300,000	$	300,000
High Electric Field Varistors	$	100,000	$	100,000
Microelectronic Aluminum Metallizations		100,000		100,000
High Resistivity Thin Film Polycrystalline Silicon		100,000		100,000

	FY 1984	FY 1985
Materials Characterization Department, 1820	$ 770,000	$ 1,240,000
Analytical Chemistry Division, 1821	$ 300,000	$ 350,000
Instrumentation and Facilities	$ 300,000	$ 350,000
Development of Automated Methods for Chemical Analysis	$ 300,000	$ 350,000
Electron Optics and X-Ray Analysis Division, 1822	$ 240,000	$ 350,000
Materials Properties, Behavior, Characterization, or Testing	$ 80,000	$ 80,000
Thermomechanical Treatment of U Alloys	$ 80,000	$ 80,000
Instrumentation and Facilities	$ 160,000	$ 270,000
Advanced Methods for Electron Optical, X-Ray, and Image Analysis	$ 160,000	$ 270,000
Surface Chemistry and Analysis Division, 1823	$ 230,000	$ 240,000
Instrumentation and Facilities	$ 230,000	$ 240,000
Advanced Methods for Surface and Optical Analysis	$ 230,000	$ 240,000
Thermophysical Properties Division, 1824	$ 0	$ 300,000
Instrumentation and Facilities	$ 0	$ 300,000
Design and Fabrication of a Gamma-Ray Attenuation Spectrometer	$ 0	$ 150,000
Infrared Reflectometer Development	0	150,000
Metallurgy Department, 1830	$ 3,025,000	$ 3,935,000
Cleaning and Coating Technology Division, 1831	$ 400,000	$ 1,005,000

	FY 1984	FY 1985
Metallurgy Department, 1830 (Continued)		
Cleaning and Coating Technology Division, 1831 (Continued)		
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 170,000	$ 410,000
Plasma Deposition of Amorphous Metal Alloy	$ 40,000	$ 130,000
Electrophoretically-Deposited Coatings	10,000	110,000
Near-Net-Shape Processing of Nickel-based Alloys	120,000	150,000
High Temperature Semiconductors	0	20,000
Materials Structure and Composition	$ 70,000	$ 40,000
Surface Structure Modification of Coating Morphology Using Ion Bombardment	$ 70,000	$ 40,000
Materials Properties, Behavior, Characterization, or Testing	$ 130,000	$ 440,000
Optical Diagnostics for Metallurgical Processing	$ 130,000	$ 440,000
Device or Component Fabrication, Behavior, or Testing	$ 30,000	$ 115,000
Plasma Removal of Metal Oxides	$ 30,000	$ 115,000
Physical Metallurgy Division, 1832	$ 930,000	$ 1,030,000
Materials Properties, Behavior, Characterization, or Testing	$ 930,000	$ 1,030,000
Toughness of Ductile Alloys	$ 330,000	$ 350,000
Analytical Electron Microscopy of Engineering Alloys	150,000	150,000
Friction and Wear of Modified Surfaces	200,000	230,000
Alloy Deformation Response and Constitutive Modeling	250,000	300,000

	FY 1984	FY 1985
Process Metallurgy Division, 1833	$ 905,000	$ 1,115,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 170,000	$ 75,000
Vacuum Arc Remelting	$ 170,000	$ 75,000
Materials Properties, Behavior, Characterization, or Testing	$ 170,000	$ 100,000
Toughness of Inertia Welds	$ 120,000	$ 60,000
Metallurgical Characterization of TiCode 12 Resistance Welds	50,000	40,000
Device or Component Fabrication, Behavior, or Testing	$ 515,000	$ 865,000
Aluminum Laser Welding	$ 50,000	$ 80,000
Low Temperature, Solid-State Welds of Copper	30,000	60,000
Dissimilar Metal Welds	60,000	120,000
Welding of Nickel-Based Alloys	150,000	225,000
Plasma Arc Welding	75,000	230,000
Laser Welding	150,000	150,000
Instrumentation and Facilities	$ 50,000	$ 75,000
Electrode Gap Controller	$ 50,000	$ 75,000
Surface Metallurgy Division, 1834	$ 790,000	$ 785,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 20,000	$ 80,000
Deposition of Amorphous Materials with a Dual Beam Ion System	$ 20,000	$ 80,000
Materials Properties, Behavior, Characterization, or Testing	$ 25,000	$ 25,000
Modification of Mechanical Properties by Ion Implantation	$ 25,000	$ 25,000

OFFICE OF DEFENSE PROGRAMS (Continued)

	FY 1984	FY 1985
Surface Metallurgy Division, 1834 (Continued)		
Device or Component Fabrication, Behavior, or Testing	$ 500,000	$ 500,000
Development of Materials for Magnetic Fusion Reactors	$ 500,000	$ 500,000
Instrumentation and Facilities	$ 245,000	$ 180,000
Ion Beam Reactive Deposition System	$ 175,000	$ 100,000
In-Situ Friction, Wear, and Electrical Contact Resistance System	70,000	80,000
Chemistry and Ceramics Department, 1840	$ 6,560,000	$ 6,960,000
Corrosion Division, 1841	$ 1,100,000	$ 1,200,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,050,000	$ 1,150,000
Corrosion	$ 1,050,000	$ 1,150,000
Ceramics Development Division, 1845	$ 2,960,000	$ 3,260,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 2,380,000	$ 2,580,000
Ceramic Processing	$ 2,380,000	$ 2,580,000
Materials Properties, Behavior, Characterization, or Testing	$ 580,000	$ 680,000
Fracture of Ceramics	$ 580,000	$ 680,000
Inorganic Materials Chemistry Division, 1846	$ 2,500,000	$ 2,500,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 2,500,000	$ 2,500,000
Glass and Glass-Ceramic Development	$ 2,500,000	$ 2,500,000

	FY 1984	FY 1985
Sandia National Laboratories - Livermore	$ 1,990,000	$ 2,300,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 350,000	$ 400,000
Powder Metallurgy	$ 200,000	$ 250,000
Advanced Electrodeposition Studies	150,000	150,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,440,000	$ 1,700,000
Helium Induced Crack Growth in Metals and Alloys	$ 600,000	$ 700,000
Welding Science and Technology	500,000	550,000
High Strength Martensitic Stainless Steels	90,000	100,000
Metal Forming	200,000	250,000
Composites: Stability and Compatibility	50,000	100,000
Instrumentation and Facilities	$ 200,000	$ 200,000
New Surface Spectroscopy	$ 200,000	$ 200,000
Lawrence Livermore National Laboratory	$ 3,585,000**	$ *
Materials Properties, Behavior, Characterization, or Testing	$ 3,345,000	$
Weld Molding	$ 250,000	$
Metal Deformation Modeling	150,000	
Liquid Pu Corrosion of Refractories	150,000	
High Temperature Carbon Fiber Study	75,000	
Structure-Property Relations of Polymers and Composites	50,000	
Pu Laser Welding	100,000	
Actinide Oxidation/Hydriding	100,000	
Surface Preparation for Coating and Joining	150,000	
Directed Energy Surface Modification	400,000	
Pu Sputtering	370,000	
Electrochemical Oxidation	900,000	
Adhesives Evaluation	200,000	
Electrochemical Corrosion Monitoring Techniques in Non-Condensing Environments	200,000	
Microstructure Research	250,000	

* Funding information was not provided.
** Funding figure does not include two of the projects.

		FY 1984		FY 1985
Lawrence Livermore National Laboratory (Continued)				
Instrumentation and Facilities	$	240,000**	$	*
Titium Facility Upgrade	$	*		
Weapons Database Development		240,000		
Building 235 Weapons Materials Research and Development Facility		*		
Los Alamos National Laboratory	$		$	

Input was not received at the time of publication.

* Funding information was not provided.
** Funding figure does not include two of the projects.

OFFICE OF DEFENSE PROGRAMS

The Assistant Secretary for Defense Programs directs the Nation's nuclear wepons research, development, testing, production, and surveillance programs. In addition, the Assistant Secretary coordinates a safeguards and security program to provide accountability and physical protection of special nuclear materials, including research and development for improvements, testing, evaluation, and implementation of safeguards systems. Additional responsibilities include management of the inertial fusion development and nuclear materials production programs, classification and declassification of sensitive weapons information, and analysis and coordination of international activities related to nuclear technology and materials.

Materials activities in Defense Programs are concentrated in the Offices of Inertial Fusion, Military Application, and Nuclear Materials Production.

Office of Inertial Fusion

Fusion Research Division

Target Fabrication - DOE Contact Carl B. Hilland, 301-353-3687; LNL Contact Richard Mah, 505-667-3238; KMS Fusion, Inc. Contact Timothy Henderson, 313-769-8500, ext. 302; Lawrence Livermore Contact Irving Stowers, 415-422-5343

- Targets filled with dueterim-tritium gas are irradiated with a laser or particle beam to produce a fusion burn.

Office of Military Applications

Solid State Sciences Directorate 1100

Ion Implantation and Radiation Physics Research, Department 1110

The mission of Department 1110 is to provide Sandia National Laboratories with a comprehensive research program and technology base in ion implantation, ion-solid microanalysis/channeling, defects in solids, and laser and electron beam annealing. The research is designed to enhance our fundamental understanding of the physical and chemical processes necessary to control the near-surface and interfacial regions of solids as well as to develop new techniques for the controlled modification and analysis of these near-surface and interfacial regions. A major aspect of the work is thus to develop an underlying understanding and control of defects, alloying processes, and the formation of metastable and amorphous phases. In addition, the mission of the department is to relate this knowledge to laboratory problems and needs in the development of advanced weapons and energy systems.

Materials Properties, Behavior, Characterization, or Testing

Ion Implantation Studies for Friction and Wear - DOE Contact Y. Song, 301-353-5350; Sandia Contacts D.M. Follstaedt, 505-844-2102; S.T. Picraux, 505-844-7681; L.E. Pope, 505-844-5041

- Ion implantation is used to modify the surface and near-surface regions of metals and these implantation-modified materials are evaluated for their improved friction and wear characteristics.

Silicon-Based Radiation Hardened Microelectronics - DOE Contact Y.Song, 301-353-5350; Sandia Contacts H.J. Stein, 505-844-6279; K.L. Brower, 505-844-6131

- Optical and electrical measurements, in conjunction with electron paramagnetic resonance and related techniques are used to determine the fundamental defect structures and materials properties required for radiation-hardened Si-based microelectronics.

Condensed Matter and Surface Science, Department 1130

The mission of Department 1130 is to provide the Laboratories with fundamental understanding and strong technology bases in the following areas: (1) shock wave and explosives physics and chemistry; (2) electronic structure and transport in solids; and (3) surface science. Current areas of emphasis include shock-induced solid state chemistry, shock initiation of heterogeneous explosives, electromechanical phenomena and phase transitions in ferroelectrics, electronic properties of compound semiconductor strained-layer superlattices, electronic properties of polycrystalline and amorphous semiconductors, defects and deep levels in semiconductors, the use of Auger lineshape analysis to study the sensitivity of chemical explosives, and the modification and control of the properties of surfaces.

Materials Properties, Behavior, Characterization, or Testing

Shock Chemistry - DOE Contact Y. Song, 301-353-5350; Sandia Contact R.A. Graham, 505-844-1931

- Both organic and inorganic solids are being investigated to determine the influence of molecular structure on shock-induced bond scission, and the influence of line and point defects on the observed enhanced, shock-induced solid state reactivity.

Initiation of Granular Explosives - DOE Contact Y. Song, 301-353-5350; Sandia Contact R.E. Setchell, 505-844-5459

- Experimental and theoretical efforts are being directed at developing a fundamental understanding of the mechanisms involved in the shock wave initiation and growth to detonation of heterogeneous granular explosives. Materials of current interest include hexanitrostilbene and PBX 9404.

Strained-Layer Superlattices for IR Detectors - DOE Contact Y. Song, 301-353-5350; Sandia Contact G.C. Osbourn, 505-844-8850

- Strained-layer superlattices based on the InAs/InSb/AlSb systems are being investigated as attractive alternatives to the difficult HgCdTe alloys for IR detector applications in the 8-12 micron and 3-5 micron wavelength ranges.

Solid State Research, Department 1150

Department 1150 supports the Laboratories by providing fundamental, theoretical, and experimental research on novel materials and phenomena. Projects include synthesis and characterization of new materials not available from other sources as well as extensive modeling of materials and material behavior of interest to a wide variety of weapons and energy initiatives.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Materials Growth by MOCVD - DOE Contact Y. Song, 301-353-5350; Sandia Contact R.M. Biefeld, 505-844-1556

- Growth of GaP/GaAsP strained layer superlattices (SLS's) both conventionally and modulation doped for application in a variety of typical and novel device structures.

Materials Growth by MBE - DOE Contact Y. Song, 301-353-5350; Sandia Contact T.J. Drummond, 505-844-9677

- The major efforts here center on the AlGaAs/AlAs system and the InGaAs system for material growth.

- New devices including bistable optical switches, rad-hard photodiodes and the first p-channel SLS MODFET have been grown.

Conducting Organic Materials - DOE Contact Y. Song, 301-353-5350; Sandia Contacts D.S. Ginley, 505-844-8863; P.J. Nigrey, 505-844-8985

- A variety of charge transfer organic superconductors and polymeric organic conductors are being synthesized.

Materials Properties, Behavior, Characterization, or Testing

Passivation of Semiconductor Grain Boundaries and Defects - DOE Contact Y. Song, 301-353-5350; Sandia Contact D.S. Ginley, 505-844-8863

- Study of the chemistry and kinetics of the passivation of polycrystalline silicon grain boundaries and defects with monatomic hydrogen.

Organic and Electronic Materials Department, 1810

Department 1810 provides support to Sandia projects through selection, development, and characterization of organic and electronic materials and associated manufacturing processes. Responsibilities span exploratory development through design, production, and stockpile life. The Department provides the Laboratories with knowledge and engineering data on properties and reliability of organic and electronic materials pertinent to our unique applications and conducts in-depth studies in order to understand and improve these properties. Department 1810 investigates unique and innovative approaches to applying organic materials to problems of interest at Sandia.

Chemistry of Organic Materials Division, 1811

Division 1811 supports the Laboratories in the area of chemistry of organic materials. It is responsible for selecting, formulating, and characterizing polymer films and coatings, adhesives, and resins for casting and molding as well as developing or synthesizing new organic materials for unique and innovative applications. This division coordinates aging and compatibility studies throughout the Laboratories. To accomplish these goals, the Division carries out in-depth chemical investigations to characterize the reaction chemistry of these materials which influence their formulation, processing, or aging.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Polysilanes, Photoresists and Non-Charring Dielectrics - DOE Contact Y. Song, 301-353-5350; Sandia Contacts J.M. Zeigler, 505-844-8728; L.A. Harrah, 505-844-6847

- Some alkyl substituted polysilanes undergo photolytic depolymerization- volatilization when irradiated with UV light. These new polymers are being investigated as potential positive-working non-solvent-developed photoresists for use in microelectronic circuit manufacture.

Sulforated Aromatic Polysulfones - DOE Contact Y. Song, 301-353-5350; Sandia Contacts C. Arnold, Jr., 505-844-8728; R.A. Assink, 505-844-6372

- Sulfonated aromatic polysulfones are being synthesized as stable ionic battery membranes. Stability and resistivity tests are underway.

Materials Properties, Behavior, Characterization, or Testing

Radiation Hardened Dielectrics - DOE Contact Y. Song, 301-353-5350; Sandia Contacts C. Arnold, 505-844-8728; S.R. Kurtz, 505-844-5436

- Polymer dielectrics are being developed that display a minimum radiation-induced conductivity (RIC). These materials will be used in capacitors and cables exposed to high dose-rate radiation so that little charge is lost due to RIC in this environment.

Physical Chemistry and Mechanical Properties of Polymers Division, 1812

The mission of Division 1812 is two-fold: to structurally and chemically characterize organic materials used in Sandia's applications and to characterize the mechanical properties of structural polymers. It is responsible for characterizing the molecular, electronic, and microphase structure of organic materials and their chemical reactivity toward the use environment as well as formulation of organic composites and adhesives. The Division carries out aging studies, compatibility studies, and coordinates these activities with designers and quality assurance staff. To support these programs, the division carries out in-depth studies on radiation chemistry, photochemistry, surface chemistry, and spectroscopy on polymeric systems.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Effects of Material and Processing Variables on the Mechanical and Thermal Expansion Behavior of Graphite/Epoxy and Kelvar/Epoxy Composites - DOE Contact Y. Song, 301-353-5350; Sandia Contact T.R. Guess, 505-844-5604

- The processing of high performance composites is being examined to determine the influence of process variables on dimensional and environmental stability of the finished parts. Formulations giving very low and controlled thermal expansion coefficients are sought for structural and electronic applications.

Materials Structure and Composition

The Chemical Characterization of Plasma Deposited Thin Films - DOE Contact Y. Song, 301-353-5350; Sandia Contact R. Buss, 505-844-7494

- Structural characterization of plasma deposited polymers are being carried out on thin films as a function of plasma characteristics, monomer structure, and deposition geometry. Dopants are being used to study the growth reactions during deposition. Materials and plasmas are characterized by a variety of spectroscopic techniques.

Materials Structure and Properties by NMR Spectroscopy - DOE Contact Y. Song, 301-353-5350; Sandia Contact R.A. Assink, 505-844-6372

- NMR studies are being used to characterize the microstructure and reaction kinetics of polymers and the transport characteristics of polymeric membranes. Magic angle spinning high resolution solid NMR spectroscopy is being used to define the structure of rigid polymers formed by plasma deposition. Fourier transform studies are being used to study the reaction kinetics of sol-gel materials. The mobility of the fluid phase in ion exchange resins is being studied by pulsed decay experiments.

Electron and Photon Stimulated Desorption From Organic Surfaces - DOE Contact Y. Song, 301-353-5350; Sandia Contact J.A. Kelber, 505-844-3408

- Electron and photon stimulated desorption from organic surfaces are being used to examine both the structure of surfaces and the fundamental mechanisms of radiation damage. These studies are being applied to problems in polymer adhesion and bulk radiation damage.

Surface Chemistry and Bond of Plasma-Aminated Polyaramid Filaments - DOE Contact Y. Song, 301-353-5350; Sandia Contact R.E. Allred, 505-844-5538

- Thermomechanical performance of polyaramide reinforced, resin-matrix composites often is limited by poor adhesion between the filaments and the matrix. We are studying methods to improve fiber-matrix adhesion by modifying the fiber surface to allow covalent chemical bonding to the matrix resin.

Physical Properties of Polymers Division, 1813

Division 1813 provides support to Sandia projects through selection, development, and processing of foams, elastomers, encapsulants, and molding compounds. It is responsible for characterizing the physical properties and aging behavior of these materials. This Division also carries out in-depth physical property studies when necessary in order to understand or improve these properties.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Microcellular Foams for X-Ray Laser - DOE Contact Y. Song, 301-353-5350; Sandia Contact P.B. Rand, 505-844-7953

- Ultra-low density (<0.005 g/cc) microcellular foams have been developed for the Narya pulsed-power-driven x-ray laser development program. These foams, which are molded into rods, have been successfully used in gas puff implosion experiments on the Proto-II accelerator.

Materials Properties, Behavior, Characterization, or Testing

Cure Kinetics of Thermosets by DSC - DOE Contact Y. Song, 301-353-5350; Sandia Contact M.R. Keenan, 505-844-6631

- Isothermal differential scanning calorimetry (DSC) has been used to obtain the cure kinetics of a commercial epoxy film adhesive. The kinetic model can be used to determine cure times and temperatures at lower temperatures. Good correlation was obtained with mechanical property measurements.

Creep Rupture of Kelvar Composites - DOE Contact Y. Song, 301-353-5350; Sandia Contact R.H. Ericksen, 505-844-8333

- We have found a variation in stress-rupture life of fibers from nominally identical Kevlar 49. There is evidence that long fiber life correlates with high initial modulus, a relationship that will provide further insight into microstructural features controlling stress-rupture.

Electronic Property Materials Division, 1815

Division 1815 provides support to Sandia programs through selection, development, and characterization of electronic materials. Responsibilities span exploratory development through design, production, and stockpiling. The Division also performs in-depth studies in order to understand material properties and associated electronic phenomena. Areas of activity include inhomogeneous materials, contacts to electronic materials, dielectrics, and special materials and processes.

Materials Properties, Behavior, Characterization, or Testing

High Electric Field Varistors - DOE Contact Y. Song, 301-353-5350; Sandia Contact G.E. Pike, 505-844-7562

- ZnO varistors are being prepared from fine powders precipitated from chemical solutions. This yields switching electric fields from 30 to 100 kV/cm.

Microelectronic Aluminum Metallizations - DOE Contact Y. Song, 301-353-5350; Sandia Contact J.S. Arzigian, 505-844-2465

- Thin film aluminum alloy metallizations for microelectronic applications are being developed and characterized for both their electromigration resistance and their compatibility with proposed VLSI circuit fabrication methods.

High Resistivity Thin Film Polycrystalline Silicon - DOE Contact Y. Song, 301-353-5350; Sandia W.K. Schubert, 505-846-2466

- We have gained an understanding of the roles of dopant diffusion and grain growth in determining the resistivity of ion implanted thin polycrystalline silicon films. The results have guided process development for high sheet resistance polysilicon used to make integrated circuit resistors.

Materials Characterization Department, 1820

Department 1820 performs chemical, physical, and thermophysical analyses of materials in support of weapons and energy programs throughout the Laboratories. The department also has the responsibility for the development of advanced analytical techniques to meet existing or anticipated needs. Consulting and process reviews are other important functions of the department.

Analytical Chemistry Division, 1821

The Analytical Chemistry Division 1821 is responsible for performing chemical analyses in support of weapon and energy programs at Sandia. The division is equipped to analyze a variety of samples such as gases, liquids, solutions, solids, organics, inorganics, glasses, alloys, ceramics, and geological materials. Analyses are performed by a variety of techniques using absorption and emission spectroscopy, gas chromatography, gas chromatography/mass spectrometry, ion chromatography, neutron activation analysis, electrochemistry, combustion, and classical methods of chemical analysis.

Instrumentation and Facilities

Development of Automated Methods for Chemical Analysis - DOE Contact Y.Song, 301-353-5350; Sandia Contact N.E. Brown, 505-844-2747

- New, highly automated methods for chemical analysis of a wide variety of materials are being developed. These include a new automated inductively coupled plasma emission spectroscope for trace analysis, an automated optical densitometer, an automated high performance liquid chromatograph, and an automated multichannel electronic recording emission spectrometer.

Electron Optics and X-Ray Analysis Division, 1822

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Thermomechanical Treatment of U Alloys - DOE Contact Y.Song, 301-353-5350; Sandia Contact K.H. Eckelmeyer, 505-844-7775

- Thermomechanical treatments of uranium alloys are being investigated as a means of improving properties and ease of processing. Methods have been found for significantly reducing the quench severity required in U-Ti alloys, and for simultaneously increasing yield strength and ductility in U-0.75%Ti.

Instrumentation and Facilities

Advanced Methods of Automated Electron Optical, X-Ray, and Image Analysis - DOE Contact Y.Song, 301-353-5350; Sandia Contact W.F. Chambers, 505-844-6163

- Advanced methods of automated electron and x-ray instrumental analysis are being developed to improve resolution, accuracy, and efficiency. Improvements in in-situ electron diffraction analysis are a recent accomplishment. A new system in advanced centralized image analysis has been initiated. Plans are to interface this system with several optical and electron optical instruments.

Surface Chemistry and Analyses Division, 1823

The Surface Chemistry and Analyses Division 1823 provides analytical surface and optical analyses of materials in support of Sandia programs throughout the Laboratories. In addition, staff members in the division engage in advanced materials research and in research funded by specific weapons or energy programs which can be uniquely investigated using their expertise. Specific techniques employed within the division include Auger spectroscopy, x-ray photoelectron spectroscopy, low energy ion scattering and secondary ion mass spectroscopies, energetic ion analysis methods, fluorescence and Raman spectroscopies, dispersive and Fourier transform infrared spectroscopies.

Instrumentation and Facilities

Advanced Methods for Surface and Optical Analysis - DOE Contact Y. Song, 301-353-5350; Sandia Contact J.A. Borders, 505-844-8855

- Recent accomplishments include improvements in the multivariate least squares software package for quantitative Fourier transform infrared spectroscopy and improved software for automated data acquisition and reduction for the laser Raman microprobe system.

Thermophysical Properties Division, 1824

The mission of Division 1824 is the measurement and analysis of thermal and optical properties of engineering materials in support of Sandia's weapons and energy programs. Capabilities include thermal conductivity and diffusivity measurements, calorimetry, densitometry, dilatometry, optical reflectance, optical emittance, and ellipsometry.

Instrumentation and Facilities

Design and Fabrication of a Gamma Ray Attenuation Spectrometer - DOE Contact Y. Song, 301-353-5350; Sandia Contact W.D. Drotning, 505-844-7934

- A new system based on attenuation of monochromatic gamma rays from a radioactive isotopic source is being designed and built to analyze special materials for a strategic defense initiative program. This is a nondestructive method that will yield quantitative elemental analysis.

Infrared Reflectometer Development - DOE Contact Y. Song, 301-353-5350; Sandia Contact H.L. Tardy, 505-846-6548

- A new infrared reflectometer has been designed and will be constructed in FY 85 and FY 86. This system will be used in support of a strategic defense initiative program and for reentry systems.

Metallurgy Department, 1830

Department 1830 selects, develops, and characterizes the non-electronic behavior of all metals and processes that may be needed to meet systems and components requirements. Responsibilities span exploratory development through design, production, and stockpile life. If either current or anticipated demands cannot be met by commercially-available metals and processes, Department 1830 is responsible for the necessary development. Understanding mechanisms of alloy bulk and surface behavior provides the basis for alloy and process development and increases the confidence of predictions of behavior. Surface treatment and coating processes receive special emphasis because of the close coupling of the surface and "bulk" behavior.

Cleaning and Coating Technology Division, 1831

Division 1831 conducts basic and applied research in two areas: (1) cleaning and contamination control; and (2) coatings. Coating research is currently being conducted in the areas of plasma deposition, chemical vapor deposition, electrophoretic deposition, and sputtering. In addition, this Division provides support for design engineers in the specification of processes and transfer of technology involving cleaning and coating.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Plasma Deposition of Amorphous Metal Alloys - DOE Contact Y.Song, 301-353-5350; Sandia Contact A.K. Hays, 505-844-9996

- Amorphous metal alloys composed of Ni, P and C have been produced by decomposing $Ni(CO)_4$ and PH_3. The microstructure, electron transport properties, and corrosion response of these alloys is very different from their rapidly-solidified counterparts.

Electrophoretically-Deposited Coatings - DOE Contact Y. Song, 301-353-5350; Sandia Contact D.J. Sharp, 505-844-8604

- Electrophoretically-deposited coatings are being developed for two applications: (1) as electrically insulating coatings on large, irregularly-shaped objects; and (2) as IEMP hardeners on electronic component packages.

Near-Net-Shape Processing of Nickel-Based Alloys - DOE Contact Y. Song, 301-353-5350; Sandia Contact A.W. Mullendore, 505-844-6833

- Initial experiments have been carried out to produce Ni from the chemical vapor deposition of $Ni(CO)_4$. The mechanical properties of this material have been determined.

High Temperature Semiconductors - DOE Contact Y. Song, 301-353-5350; Sandia Contact A.W. Mullendore, 505-844-6833

- Single crystals of boron carbide have been grown using a chemical vapor deposition process. These specimens have been studied (i.e., electron transport properties have been measured) to determine the applicability of boron-based compounds for use as high temperature semiconductors.

Materials Structure and Composition

Structure Modification of Coating Morphology Using Ion Bombardment - DOE Contact T. Song, 301-353-5350; Sandia Contact D.J. Sharp, 505-844-1647

- Ion bombardment of films during sputter deposition has been used to obtain Be films with very small grain size and low surface roughness. This technique is generally applicable for obtaining films with a fine-grained morphology from substances that would otherwise have a preferred orientation for growth.

Materials Properties, Behavior, Characterization, or Testing

Optical Diagnostics for Metallurgical Processing - DOE Contact Y. Song, 301-353-5350; Sandia Contact H.C. Peebles, 505-844-1647

- Emission spectroscopy has been used to investigate laser light absorption during plume formation that occurs during a laser welding process. The particular system studied was Nd:YAG laser welding of aluminum.

Device or Component Fabrication, Behavior, or Testing

Plasma Removal of Metal Oxides - DOE Contact Y. Song, 301-353-5350; Sandia Contact R.R. Sowell, 505-844-1038

Physical Metallurgy Division, 1832

The mission of the Physical Metallurgy Division 1832 is to provide the characterization and understanding of the properties of metals and alloys. This includes the selection of alloys and the conduct of research in alloy design and thermo-mechanical effects on material behavior. Sophisticated mechanical testing capabilities are part of this Division, and extensive use is made of the analytical capabilities at Sandia.

Materials Properties, Behavior, Characterization, or Testing

Toughness of Ductile Alloys - DOE Contact Y. Song, 301-353-5350; Sandia Contacts R.J. Salzbrenner, 505-844-5041; J.A. VanDenAvyle, 505-844-1016

- Elastic-plastic fracture toughness (J_{IC}) is being studied to determine if it can be used as the basis for structural design. This includes a study of both the experimental techniques used to measure toughness and the application of the parameter in computer code calculations. The correlation between microstructure and toughness is also examined. Current emphasis is on the study of ductile cast iron for nuclear material shipping casks.

Analytical Electron Microscopy of Engineering Alloys - DOE Contact Y. Song, 301-353-5350; Sandia Contact A.D. Romig, 505-844-8358

- The capability to establish quantitatively the chemical concentrations with high resolution in the transmission electron microscope has progressed remarkably recently. The focus here has been to develop techniques which allow complex engineering alloys to be examined by this method by microscope modifications and the use of Monte Carlo simulations. Uranium alloys and stainless steels are currently under study.

Friction and Wear of Modified Surfaces - DOE Contact Y. Song, 301-353-5350; Sandia Contacts R.J. Bourcier, 505-844-6638; A.D. Romig, 505-844-8358

- Novel techniques such as laser glazing and ion implantation have been applied to surfaces requiring good wear resistance. The metallurgy of the near-surface regions produced by these (or more traditional) techniques is poorly understood and the mechanisms for enhanced wear resistance are not known. This is being addressed using finite element computer modeling of modified materials and microstructural examination.

Alloy Deformation Response and Constitutive Modeling - DOE Contact Y. Song, 301-353-5350; Sandia Contacts W.B. Jones, 505-844-4026; R.J. Bourcier, 505-844-6638

- Computational prowess has grown to the extent that more complex models of alloy deformation behavior can now be used in finite element codes. The development of microstructurally-based constitutive models is being sought through the use of both uniaxial and biaxial mechanical testing at ambient and elevated temperatures. Stainless steels have been chosen as the focus of this effort.

Process Metallurgy Division, 1833

The Process Metallurgy Division supports the Laboratories by selecting, characterizing, and developing metallurgical processes needed in the manufacture of components and systems. The objective is to provide process definition and control by understanding the mechanisms which operate. Attention is devoted toward structure-property modifications that occur during manufacturing processes. Principal processes currently under study include laser welding, arc welding (GTA and Plasma), brazing, soldering, vacuum induction melting, vacuum arc remelting, and casting techniques for metal-ceramic composites.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Vacuum Arc Remelting - DOE Contact Y. Song, 301-353-5350; Sandia Contact F.J. Zanner, 505-844-7073

- Vacuum arc remelting is being studied with the objective of reducing inhomogeneities and defects in structural alloys and uranium alloys. Variable melt rates have been related to oxide films on the surface of the melt.

Materials Properties, Behavior, Characterization, or Testing

Toughness of Inertia Welds - DOE Contact Y. Song, 301-353-5350; Sandia Contact G.A. Knorovsky, 505-844-1109

- The fracture toughness of alloy steel inertia welds is being determined. Excessive weld energies have been found to reduce fracture toughness of HP 9-4-20/AISI 4330V inertia welds.

Metallurgical Characterization of TiCode 12 Resistance Welds - DOE Contact Y. Song, 301-353-5350; Sandia Contact G.A. Knorovsky, 505-844-1109

- The effect of resistance upset welding on the microstructure and mechanical properties of titanium alloy TiCode 12 was evaluated. Since no unique phases or microstructures were found that are not in the base material, upset welding does not appear to be deleterious with respect to mechanical or corrosion properties.

Device or Component Fabrication, Behavior, or Testing

Aluminum Laser Welding - DOE Contact Y. Song, 301-353-5350; Sandia Contact M.J. Cieslak, 505-846-7500

- The role of vaporization during laser welding on composition, mechanical properties, and hot cracking of aluminum alloys is being studied. Convective fluid flow is believed to contribute to the large losses of magnesium observed.

Low Temperature, Solid-State Welds of Copper - DOE Contact Y. Song, 301-353-5350; Sandia Contact F.M. Hosking, 505-844-8401

- Solid-state welding and solid-liquid interdiffusion techniques have been evaluated for joining copper flex circuits in the 373-450 K range. High quality welds were produced with the use of indium and indium-silver alloy interlayers.

Dissimilar Metal Welds - DOE Contact Y.Song, 301-353-5350; Sandia Contact M.J. Cieslak, 505-846-7500

- Fusion welding procedures for dissimilar welds are being developed with emphasis on avoidance of hot-cracking. A Nb(C,N) phase was found to form in the weld metal of 15-5 PH/HP 9-4-20 welds during the terminal transient stage of solidification and is the cause of hot-cracking.

Welding of Nickel-Based Alloys - DOE Contact Y. Song, 301-353-5350; Sandia Contacts M.J. Cieslak, 505-846-7500; G.A. Knorovsky, 505-844-1109

- The mechanisms of hot-cracking during the fusion welding of both solid solution strengthened and precipitation strengthened nickel-based alloys is under study. Hot-cracking in Hastelloys C-22 and C-276 and Inconel 718 appears to be related to solidification segregation resulting in formation of topologically-close-packed phases.

Plasma Arc Welding - DOE Contact Y. Song, 301-353-5350; Sandia Contacts P.W. Fuerschbach, 505-846-2464; J.L. Jellison, 505-844-6397

- Variable polarity plasma arc welding of aluminum is under development. Significantly narrower welds have been produced in thin aluminum sheet than can be achieved with gas tungsten arc welding.

Laser Welding - DOE Contact Y. Song, 301-353-5350; Sandia Contact J.L. Jellison, 505-844-6397

- Both pulsed and CW laser welding is being developed for application to component closures. Mechanisms of beam-plume interactions are being evaluated for various material-process combinations. These results, along with a new understanding of the roles of reflectivity and convection, are being incorporated into models of the processes.

Instrumentation and Facilities

Electrode Gap Controller - DOE Contact Y. Song, 301-353-5350; Sandia Contact F.J. Zanner, 505-844-7073

- Instrumentation for monitoring and maintaining the electrode gap during vacuum arc remelting is being developed. A control algorithm based on an inverse relationship between electrode gap and the frequency of drop shorts is being tested.

Surface Metallurgy Division, 1834

Surface Metallurgy Division 1834 is concerned with the influence of surface and near-surface regions to the engineering application of materials. Basic and applied research is conducted to understand and control deposition processes for reproducible surface modification and to correlate surface properties (composition, structure, and stress) with friction, wear, and electrical contact resistance. Controlled deposition of amorphous materials by sputtering, reactive ion beam deposition of compound films, low-pressure plasma spraying, and surface modification by ion implantation are techniques used to tailor surface properties. This Division also supports design and component groups in areas where surface properties are critical.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Deposition of Amorphous Materials with a Dual Beam Ion System - DOE Contact Y. Song, 301-353-5350; Sandia Contact J.K.G. Panitz, 505-844-8604

- A dual beam ion system has been developed to sputter-deposit films onto selected substrates. Concurrent ion bombardment with inert and reactive gas ions increases the adhesive strength of the deposited film.

Materials Properties, Behavior, Characterization, or Testing

Modification of Mechanical Properties by Ion Implantation - DOE Contact Y. Song, 301-353-5350; Sandia Contact L.E. Pope, 505-844-5041

- The dual implantation of titanium and carbon into stainless steels produces an amorphous layer; the amorphous layer reduces both friction and wear. The effects of implantation species on friction and wear are being explored.

Device or Component Fabrication, Behavior, or Testing

Development of Materials for Magnetic Fusion Reactors - DOE Contact Y. Song, 301-353-5350; Sandia Contact M.F. Smith, 505-846-4270

- Materials used in magnetic confined fusion energy devices experience severe environments. A low-pressure plasma spray process has been developed to deposit ceramic/metal coatings. The coatings are being considered for first wall surfaces or for graded thermal expansion layers.

Instrumentation and Facilities

Ion Beam Reactive Deposition System - DOE Contact Y. Song, 301-353-5350; Sandia Contact D.E. Peebles, 505-844-1647

- A system has been constructed for reactive ion beam deposition of compound films. The mechanism of compound film formation will be characterized for TiN and then complex film deposition of compounds not readily obtained by current methods will be studied.

In-Situ Friction, Wear, and Electrical Contact Resistance Systems - DOE Contact Y. Song, 301-353-5350; Sandia Contacts L.E. Pope, 505-844-5041; D.E. Peebles, 505-844-1647

- An in-situ friction, wear, and electrical contact resistance device has been assembled in a scanning Auger system. Surface analytical measurements are made in wear tracks without exposure to ambient environments, because exposure can mask compositional measurements. The correlation between surface composition and measured experimental parameters is determined.

Chemistry and Ceramics Department, 1840

Department 1840 supports Sandia weapons and energy programs by selecting, developing, and characterizing ceramics glasses and glass ceramics. The department also supports the Laboratories through the study of metallurgical corrosion and oxidation. Electrochemistry constitutes a major element of these studies. Initiative is taken to stimulate advanced weapons and energy related concepts by providing new materials and developing prototype components.

Corrosion Division, 1841

Division 1841 personnel performs research to understand and control the corrosion and oxidation of metals, and they also characterize gas-metal reactions involving species such as hydrogen and ammonia. Corrosion research is directed toward: (a) developing new and improved materials; (b) defining boundaries for applying existing materials; and (c) performing failure analyses. Emphasis is on understanding the mechanistic nature of corrosion processes. The Division maintains expertise in the areas of: corrosion by aqueous and non-aqueous electrolytes; corrosion by gases; stress corrosion cracking; gas-metal interactions, including scattering, adsorption, and desorption; and electrodeposition.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Materials Synthesis - DOE Contact Y. Song, 301-353-5350; Sandia Contact T. Guilinger, 505-846-9833

- We are developing new techniques to electrodeposit aluminum. Present electroplating techniques require the use of toxic and/or highly flammable solvents, and very elaborate facilities such as dry boxes. We have begun research to develop a simplified process that uses relatively non-toxic and low flammability solvents, and which are less moisture-sensitive.

Materials Properties, Behavior, Characterization, or Testing

Corrosion - DOE Contact R. Cooper, 505-887-0586; Sandia Contact R. Diegle, 505-846-3450

- Titanium alloys, particularly TiCode 12 (Ti-0.8% Ni-0.3% Mo), are being evaluated in bedded salt and subseabed environments as nuclear waste containers.

Ceramics Development Division, 1845

Division 1845 is responsible for supporting laboratory programs involving glass- or ceramic-to-metal seals and other uses of glass or ceramics in moderate temperature environments. Expertise in the division includes the following areas: fracture surface analysis of brittle materials; seal design and fabrication processes; and glass and ceramic properties, i.e., strength, electrical conductivity. The division also maintains an active materials development program to formulate new glass or glass ceramics to meet particular requirements, e.g., corrosion resistance or high thermal expansion.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Glass and Glass Ceramic Development - DOE Contact Y. Song, 301-353-5350; Sandia Contacts S.M. Monroe, 505-844-3258; K. Keefer, 505-846-0322

- High expansion phosphate based glasses have been developed for sealing to Al, Cu, and stainless steels. The chemical durability has been improved to the point that the glasses compare favorably to many silicate glasses.

- A transformation toughened glass ceramic has been developed wherein a metastable ZrO_2 phase is precipitated in a glass matrix.

Materials Properties, Behavior, Characterization, or Testing

Fracture of Ceramics - DOE Contact Y. Song, 301-353-5350; Sandia Contacts R.E. Loehman, 505-846-2537; T.J. Headley, 505-844-4787

- The role of P_2O_5 as a nucleating agent in glass ceramics was revealed through an experimental study using TEM and XRD to identify crystalline phases present. The analysis showed that certain crystallographic orientations of lithium phosphate crystals were sites for epitaxial growth of major silicate crystalline phases.

Inorganic Materials Chemistry Division, 1846

Division 1846 has responsibility for relating the chemical properties of inorganic materials to their application in a variety of SNL weapons, energy, and reactor safety programs. The Division has programs in the chemical preparation of glasses and ceramics including sol-gel chemistry of glasses for coatings and monolithic structure and electroactive ceramic powders, precipitation of ion exchangeable transition metal oxides for catalysts, rad-waste and thin-film capacitors, and solution stabilization to yield homogeneous, monodispersed structural and electronic ceramics. The Division also has programs to study the properties and survivability of inorganic materials in reactive environments, e.g., solvent (aqueous, acidic and basic, corrosive) dissolution of inorganic glasses, ionic conductivity of high temperature electrolytes, and the physical and chemical properties, especially thermal stability, of inorganic materials at high temperature.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Glass and Glass/Ceramic Development - DOE Contact Y. Song, 301-353-5350; Sandia Contact R. Quinn, 505-844-1933

- A glass has been developed for use in Li/So_2 batteries. This glass was developed to resist the environment of Li batteries for five years. A model of Li under potential deposition was proposed and used to define a glass chemistry resistant to attack.

Ceramic Processing - DOE Contact Y. Song, 301-353-5350; Sandia Contact R. Dosch, 505-844-1565

- High purity homogeneous PZT powders have been prepared by sol-gel chemistry techniques. The total mixture has been co-precipitated to insure homogeneity. The most important element is considered to be the ZrO_2 and most of the efforts have focused on this component.

- ZnO varistor material has been prepared by sol-gel chemistry techniques. High purity material and doped materials have been prepared and are being evaluated.

Powder Metallurgy - DOE Contact Y. Song, 301-353-5350; Sandia Contacts J.A. Brooks, 415-422-2051; J.E. Smugeresky, 415-422-2910; R.M. Allen, 415-422-2861

- The relationship between strength, toughness, microstructure, and fracture modes of blended elemental powder metallurgy (P/M) titanium alloys is being studied to optimize properties for near-net-shape processing applications.

Advanced Electrodeposition Studies - DOE Contact Y. Song, 301-353-5350; Sandia Contacts R.W. Carling, 415-422-2206; J.E. Farmer, 415-422-3418; H.R. Johnson, 415-422-2822

- Engineering applications, technology development, and basic studies are being pursued in the area of electrodeposition of metal from both aqueous and non-aqueous media.

Helium Induced Crack Growth in Metals and Alloys - DOE Contact Y. Song, 301-353-5350; Sandia Contacts S.L. Robinson, 415-422-2209; S.H. Goods, 415-422-3274; J.E. Costa, 415-422-2352

- The effect of helium on the low temperature mechanical properties of fcc metals is being investigated experimentally. Tritium decay is used to introduce helium into metals without introducing radiation damage into the metal.

Welding Science and Technology - DOE Contact Y. Song, 301-353-5350; Sandia Contacts J.A. Brooks, 415-422-2051; J.C. Lippold, 415-422-2686; J.E. Smugeresky, 415-422-2910

- Developing a science-based methodology for designing, analyzing, and obtaining welding processes, in order to control microstructure and thereby improve the performance of welded joints.

High Strength Martensitic Stainless Steels - DOE Contact Y. Song, 301-353-5350; Sandia Contacts J.A. Brooks, 415-422-2051; N.R. Moody, 415-422-2622

- The physical metallurgy and mechanical property microstructure relationships are being studied for three martensitic precipitation-hardened stainless steels (PH13-8, PH15-5, and Custom 450).

Metal Forming - DOE Contact Y. Song, 301-353-5350; Sandia Contacts J. Lipkin, 415-422-3115; T.C. Lowe, 415-422-3187; J.B. Woodard, 415-422-3115

- Development of advanced materials models, interfacing these models with finite element codes, measurement of materials properties needed for the models, and experimental verification of the code results.

Composites: Stability and Compatibility - DOE Contact Y. Song, 301-353-5350; Sandia Contacts J.B. Woodard, 415-422-3115; B.C. Odegard, 415-422-2789

- Characterization of outgassing, measurement of coefficient of moisture expansion, and investigation of galvanic corrosion when in contact with specific metals.

New Surface Spectroscopy - DOE Contact Y. Song, 301-353-5350; Sandia Contacts L.A. West, 415-422-2475; M.R. McClellan, 415-422-2598

- High Resolution Electron Energy Loss Spectroscopy (HREELS) is being developed by this laboratory as a sensitive means for probing gas-solid interactions.

Materials Properties, Behavior, Characterization, or Testing

Weld Molding - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contacts K.W. Mahin, E. Flower, 415-423-0740

- Develop a general weld model for the prediction of penetration and distortion in fusion welds. The material under investigation is 304 SST.

Metal Deformation Modeling - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contacts E. Flower, K.W. Mahin, 415-423-1572

- Develop LLNL existing finite element methods (FEM) codes (NIKE/DYNA) to accurately predict metal deformation during a forming operation.

- Coupling of the "refined" mechanical code with the "refined" thermal code to improve the predictions of metal flow during fabrication.

Liquid Pu Corrosion of Refractories - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact J.E. Hanafee, 415-422-6928

- Study of the relative corrosion resistance of refractory oxides W, Ta, Nb, V, Mo, and Ti to attack by molten plutonium in the temperature range of 800 to 1200 degrees C.

- Use of immersion tests of refractory metal coupons into molten plutonium and measuring weight loss after post immersion leaching, to determine dissolution rate.

High Temperature Carbon Fiber Study - DOE Contact Y. Song, 301-353-5350; Lawrence Liver Contact J.R. Kolb, 415-422-7060

- For the study of how carbon fibers degrade under thermolytical conditions, all the tests to 2500 degrees C have been completed.

Structure-Property Relations of Polymers and Composites - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact J.R. Kolb, 415-422-7060

- Emphasis is on reliability theory for polymeric materials and modeling of the mechanical behavior of low density materials.

- The failure modes of very low density materials are being investigated.

Pu Laser Welding - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact Haskell Weiss, 415-422-6268

- Welds have been made in pure plutonium materials and crack fine joints have been achieved without pre-heat.

Actinide Oxidation/Hydriding - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact C. Colmenares, 415-422-6352

- The kinetics and detailed mechanism of the reaction of uranium with dry oxygen, oxygen-free water vapor, and oxygen-water vapor mixtures are being studied using thermogravimetric electron paramagnetic resonance, positron annihilation spectroscopy, and surface-sensitive analysis techniques.

- A critical review of classified and unclassified literature on the subject of plutonium hydriding will be prepared.

Surface Preparation for Coating and Joining - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact D.M. Makowiecki, 415-422-8007

- Investigating the effect of various in-situ surface cleaning processes on the adhesion of vapor deposited metal coatings on metal substrates.

Directed Energy Surface Modification - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contacts E.N. Kaufmann, R.G. Musket, 415-423-2640

- The use of energetically implanted ions of solute element and the use of laser or electron beam irradiation for rapid controllable melting and cladding are being investigated for applications to surface property enhancement.

Pu Sputtering - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact H.F. Rizzo, 415-422-6369

- Study to explore the glass forming ability of various elements with plutonium by sputtering. Composite targets of Fe, Ta, V, Os, and Si with plutonium have been sputtered and the resulting binary coating compositions are being examined by x-ray and metallographic techniques.

Electrochemical Oxidation - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact R.R. McGuire, 415-422-7792

- Explore the electrochemical oxidation of nitrogen tetroxide (N_2O_4) to nitrogen pentoxide (N_2O_5) in 100% nitric acid.

Adhesives Evaluation - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact D.M. Hoffman, 415-422-7759

- Short-term screening tests of segmented polyurethane adhesion, chemical structure, and molecular architecture are being used to select candidate adhesives for longer-term reliability evaluation.

Electrochemical Corrosion Monitoring - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact J. Truhan, 415-422-6925

- Extending of AC and DC electrochemical techniques to study corrosion processes in gaseous environments containing humidity.

- Currently applying AC techniques to drier environments and mixed gases.

Microstructure Research - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact Tomas Hirschfeld, 415-422-6364

- Project focuses on a basic research effort and a feasibility demonstration effort run in parallel.

- Study concentrates on the effects of size scale on physiochemical and engineering processes and uses them to create guidelines for work in the micro domain.

Instrumentation and Facilities

Tritium Facility Upgrade - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contacts P.C. Souers, 415-422-1301; M. Holda, 415-423-7240

- The Tritium Facility Upgrade consists of two parts: a clean-up system and an office/mechanical technician shop addition.

Weapons Database Development - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contacts T.M. Quick, D.D. Jackson, 415-422-8005

- Development of a computer database system to facilitate the analysis of stockpile life data to better assess the current condition of the stockpile and predict its probable future condition.

Building 235 - Weapons Materials Research and Development Facility - DOE Contact Y. Song, 301-353-5350; Lawrence Livermore Contact J.D. Balser, 415-422-8063

- A new facility under construction at LLNL will be dedicated to the development of advanced materials for weapons applications.

OFFICE OF FOSSIL ENERGY

	FY 1984	FY 1985
Office of Fossil Energy Grand Total	$10,779,000	$ 7,071,000
Office of Technical Coordination	$ 6,463,000	$ 5,141,000
Advanced Research and Technology Development Program	$ 6,463,000	$ 5,141,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 1,226,000	$ 915,000
Evaluation of the Feasibility of Pressure Quenching to Produce Hard Metastable Materials	$ 130,000	$ 0
Development of Refractory Composites with High Fracture Toughness	135,000	35,000
Short Fiber Reinforced Structural Ceramics	250,000	260,000
Silicon Carbide Powder Synthesis	50,000	0
Ceramic Fabrication and Microstructure Development	200,000	0
Fabrication of Fiber-Reinforced Composites by CVD Infiltration	225,000	340,000
Transfer of CVD Infiltration Technology to Industry	56,000	100,000
Development of Advanced Fiber Reinforced Ceramics	180,000	180,000
Materials Structure and Composition	$ 270,000	$ 0
Design of Low Alloy Steels for Thick-Walled Pressure Vessels	270,000	0
Materials Properties, Behavior, Characterization, or Testing	$ 3,014,000	$ 2,335,000
Technical Monitoring of Coal Gasification Subcontracted Materials Projects for the AR&TD Fossil Energy Materials Program	$ 40,000	$ 40,000
Assessment of Materials Needs for Advanced Steam Cycle Pulverized Coal Plants	10,000	0
Microstructure and Micromechanical Response in Austenitic Stainless Steel Overlays on Low Alloy Steel Plate	0*	0

* Prefunded in FY 1983

Office of Technical Coordination (Continued)

Advanced Research and Technology Development Program (Continued)

Materials Properties, Behavior, Characterization, or Testing (Continued)

	FY 1984	FY 1985
The Fatigue Behavior of Chromium-Containing Ferritic Steels at Elevated Temperatures	$ 0*	$ 0
Transformation, Metallurgical Response and Behavior of the Weld Fusion and Heat Affected Zone in Cr-Mo Steels for Fossil Energy Applications	80,000	100,000
Development of Iron and Nickel Aluminides	200,000	200,000
Hydrogen Attack in Cr-Mo Steels at Elevated Temperatures	170,000	0
Analysis of Hydrogen Attack on Pressure Vessel Steels	90,000	120,000
Deformation and Fracture of Low Alloy Steels at High Temperature	105,000	100,000
Evaluation of 3 Cr-1.5 Mo Steel in a Simulated Coal Conversion Environment	0*	80,000
Creep Rupture of High-Chromium Alloys in Mixed-Gas Environments	95,000	115,000
Biaxial Stress-Rupture of Alloys in Coal Gasification Atmospheres	170,000	0
Corrosion of Alloys for Internals and Heat Exchangers in Mixed-Gas Environments	120,000	110,000
Screening and Study of Behavior of Materials Subjected To Combined Erosion and Corrosion	209,000	0
Corrosion of Alloys in FBC Systems	120,000	110,000
A Mechanistic Study of Low-Temperature Corrosion on Materials in the Coal Combustion Environment	0*	140,000
Hot Corrosivity of Coal Conversion Products on High-Temperature Alloys	75,000	80,000
Erosion in Dual-Phase Microstructures	100,000	0
Evaluation of Advanced Materials for Slurry Erosion Service	225,000	225,000
Mechanisms of Erosion-Corrosion in Coal Combustion Environments	200,000	215,000

* Prefunded in FY 1983

Office of Technical Coordination (Continued)

Advanced Research and Technology Development Program (Continued)

Materials Properties, Behavior, Characterization, or Testing (Continued)

	FY 1984	FY 1985
Study of Particle Rebound Characteristics and Material Erosion at High Temperature	$ 80,000	$ 80,000
High-Temperature Creep Behavior of Refractory Bricks	110,000	100,000
Investigation of the Effect of Slag Penetration on the Mechanical Properties of Refractories	165,000	135,000
Corrosion of Refractories in Slagging Gasifiers	160,000	125,000
High Temperature Applications of Structural Ceramics	265,000	260,000
Mechanical Behavior of Structural Ceramics	225,000	0
Device or Component Fabrication, Behavior, or Testing	$ 1,395,000	$ 1,346,000
"Materials and Components in Fossil Energy Applications" Newsletter	135,000	105,000
Microstructural Control to Improve Properties of Weldments in Chromium-Molybdenum Steels	0*	0
Electroslag Welding of Pressure Vessel Steels	0*	0
Three-Dimensional Residual Stress Characterization of Thick Plate Weldments with Advanced Instrumentation and Methodologies	0*	0
Investigation of the Mechanisms of Molten Salt Corrosion of Candidate Materials for Molten Carbonate Fuel Cells	210,000	225,000
Oxide Electrodes for High-Temperature Fuel Cells	300,000	226,000
Studies of Materials Erosion in Coal Conversion and Utilization Systems	300,000	350,000
Mechanisms of Galling and Abrasive Wear	145,000	135,000

* Prefunded in FY 1983

	FY 1984	FY 1985
Office of Technical Coordination (Continued)		
Advanced Research and Technology Development Program (Continued)		
Device or Component Fabrication, Behavior, or Testing (Continued)		
Thermomechanical Modeling of Refractory Brick Linings for Slagging Gasifiers	$ 125,000	$ 125,000
Alkali Attack of Coal Gasifier Refractory Linings	90,000	90,000
Thermodynamic Properties and Phase Relations for Refractory-Slag Reactions in Slagging Coal Gasifiers	90,000	90,000
Instrumentation and Facilities	$ 558,000	$ 545,000
Management of the AR&TD Fossil Energy Materials Program	353,000	340,000
Development of Nondestructive High-Temperature Erosion Monitoring System	85,000	0
Development of Nondestructive Evaluation Techniques for Structural Ceramics	120,000	205,000
Office of Surface Coal Gasification	$ 1,065,000	$ 860,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 490,000	$ 470,000
Protective Coatings and Claddings: Application Evaluation	$ 190,000	$ 180,000
Electroslag Component Casting	300,000	290,000
Materials Properties, Behavior, Characterization, or Testing	$ 405,000	$ 205,000
Plant Material Surveillance Tests	$ 100,000	$ 0
Slagging Gasifier Refractories: Application Evaluation	130,000	95,000
Advanced Pressure Vessel Materials Technology	175,000	110,000

OFFICE OF FOSSIL ENERGY (Continued)

	FY 1984	FY 1985
Office of Surface Coal Gasification (Continued)		
Device or Component Fabrication, Behavior, or Testing	$ 170,000	$ 185,000
Ceramic Fabrication/Application Technology	170,000	185,000
Office of Oil, Gas, Shale, and Coal Liquids	$ 143,000	$ 0
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 125,000	$ 0
Coating Studies for Coal Conversion	$ 125,000	$ 0
Materials Properties, Behavior, Characterization, or Testing	$ 18,000	$ 0
Assessment of Materials Selection and Performance for Coal Liquefaction Plants	$ 0*	$ 0
Materials Review and Support for the SRC-I Liquefaction Project	0	0
Coal Liquefaction Pilot Plant Materials Testing and Failure Analysis	0	0
Elastomer Test Program	18,000	0
Office of Coal Utilization	$ 1,554,000	$ 1,070,000
Fuel Cells Program	$ 760,000	$ 260,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 760,000	$ 260,000
Electrode Surface Chemistry	$ 150,000	$ 200,000
Development of Ternary Alloy Cathode Catalysts for Phosphoric Acid Fuel Cells	460,000	60,000
Organometallic Catalysts for Primary Phosphoric Acid Fuel Cells	150,000	0

* Prefunded in FY 1983

	FY 1984	FY 1985
Fuel Cells Program (Continued)		
Materials Properties, Behavior, Characterization, or Testing	$ 0	$ 0
Molten Carbonate Fuel Cell and Stack Technology Development	$ 0	$ 0
Molten Carbonate Fuel Cell Component Technology Development	0	0
Alternative Molten Carbonate Fuel Cell Cathodes	0	0
Device or Component Fabrication, Behavior, or Testing	$ 0	$ 0
High Temperature Solid Oxide Electrolyte Fuel Cell Power Generation System	$ 0	$ 0
Advanced Fuel Cell Research	0	0
Magnetohydrodynamics Program	$ 794,000	$ 810,000
Materials Properties, Behavior, Characterization, or Testing	$ 794,000	$ 810,000
MHD Materials Development, Testing, and Evaluation	$ 100,000	$ 30,000
UTSI MHD Development Testing	594,000	680,000
MHD Heat and Seed Recovery Technology	100,000	100,000

OFFICE OF FOSSIL ENERGY

The mission of the Fossil Energy Program is to develop technologies that will increase domestic production of oil and gas or that will permit the Nation to shift from oil or gas to more abundant coal. Specifically, the Fossil Energy role is to develop technologies to support the following objectives:

- Provide a capability to convert coal to liquid and gaseous fuels;
- Increase domestic production of coal, oil, and gas;
- Ensure that current and new facilities that burn coal can do so in an economically viable and environmentally acceptable manner; and
- Allow more efficient and more economically attractive utilization of fossil energy resources.

The Fossil Energy activity includes fourteen major programs, which are grouped under seven program offices. One of these seven is the Advanced Research and Technology Development Program of the Office of Technical Coordination, which is the central point of contact for inquiries from universities concerning the Fossil Energy program.

Project execution and technical monitoring are administered in five energy technology centers and selected national laboratories.

Office of Technical Coordination

Advanced Research and Technology Development Program

The objectives of the Advanced Research and Technology Development programs are to assess and identify long-range advanced research needs in coal processing, fossil fuels utilization and extraction, materials, components, and instrumentation; to provide oversight of on-going advanced research in fossil energy so as to ensure balance and proper priorities; to initiate and fund projects involving new, exploratory concepts or goal-oriented basic research; to manage the Materials Research and University Coal Research programs; and to provide policies for, and overview of, Fossil Energy-supported university activities. The Advanced Research and Technology Development program also is designed to provide an effective communications channel between the Fossil Energy program and academic institutions; to encourage these institutions to become involved in programs related to the DOE Fossil Energy mission; and to manage programs concerned with providing an adequate technical base for development of commercial construction materials and instrumentation for Fossil Energy pilot plants and demonstration plants.

The program supports workshops to identify research needs in all fossil energy technologies and manages selected training programs for faculty and students at Energy Technology Centers.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Evaluation of the Feasibility of Pressure Quenching to Produce Hard Metastable Materials - DOE Contact S.J. Dapkunas, 301-353-2784; R&D Associates Contact Richard Latter, 213-822-1715

- Design, building, and testing of a novel high-pressure press system to explore the scientific possibilities of" pressure quenching" of materials.

Development of Refractory Composites with High Fracture Toughness - DOE Contact S.J. Dapkunas, 301-353-2784; ANL Contacts W.A. Ellingson, D.R. Diercks, 312-972-5068

- Fabrication of refractories with improved thermal stock properties without sacrificing corrosion resistance.

Short Fiber Reinforced Structural Ceramics - DOE Contact S.J. Dapkunas, 301-353-2784; Los Alamos Contact G. Hurley, 505-667-5126

- Investigation of whisker reinforcement technology for producing structural ceramic composites of improved strength and fracture toughness.

Silicon Carbide Powder Synthesis - DOE Contact S.J. Dapkunas, 303-353-2784; ORNL Contact M.A. Janney, 615-574-4281

- Development of processes for synthesis of improved, highly pure, uniformly sinterable powders

Ceramic Fabrication and Microstructure Development - DOE Contact S.J. Dapkunas, 303-353-2784; ORNL Contact M.A. Janney, 615-574-4281

- Development of techniques for fabricating powders into dense monolithic ceramics and ceramic matrix composites with controlled microstructure for improved structural ceramics.

Fabrication of Fiber-Reinforced Composites by CVD Infiltration - DOE Contact S.J. Dapkunas, 301-353-2784; ORNL Contacts D.P. Stinton, A.J. Caputo, 615-574-4556

- Development of a ceramic composite having higher than normal toughness and strength (20 MPi + $m^{1/2}$ and 350 MP_a, respectively) yet retaining the tpyical ceramic attributes of refractories and high resistance to abrasion and corrosion.

Transfer of CVD Infiltration Technology to Industry - DOE Contact S.J. Dapkunas, 303-353-2784; ORNL Contact D.P. Stinton, A.J. Caputo, 615-574-4556

- Joint research and development program with Babcock and Wilcox Research Laboratories (B&W) will be conducted to transfer AR&TD-developed CVD infiltration technology to B&W.

Development of Advanced Fiber Reinforced Ceramics - DOE Contact S.J. Dapkunas, 301-353-2784; Georgia Institute of Technology Contact T.L. Starr, 404-894-3678

- Identification of new compositions and processing methods to improve the physical and mechanical properties of selected fiber reinforced ceramics, namely amorphous "fused" silica or modified silica glass, focusing on the development of fiber reinforced silica.

Materials Structure and Composition

Design of Low Alloy Steels for Thick-Walled Pressure Vessels - DOE Contact S.J. Dapkunas, 301-353-2784; University of California Contacts E.R. Parker, R.O. Ritchie, 415-642-0863

- Production of a modification of 2 1/4 Cr-1 Mo steel (Ni, Cr, Si, and Mr additions) to improve hardenability, toughness, and resistance to temper embrittlement.

Materials Properties, Behavior, Characterization, or Testing

Technical Monitoring of Coal Gasification Subcontracted Materials Projects for the AR&TD Fossil Energy Materials Program - DOE Contact S.J. Dapkunas, 301-353-2784; ANL Contact W. A. Ellingson, 312-972-5068

- Technical monitoring of subcontracts related to high-temperature gaseous corrosion, corrosion of refractories and ceramics, and nondestructive evaluation methods.

Assessment of Materials Needs for Advanced Steam Cycle Pulverized Coal Plants - DOE Contact S.J. Dapkunas, 301-353-2784; ORNL Contact P.L. Rittenhouse, 615-574-5103

- Assessment of the status of materials technology for advanced steam cycle pulverized coal plants.

- Identification of materials research and development which would permit the design, construction, and reliable operation of more efficient power plants.

Microstructural and Micromechanical Response in Austenitic Stainless Steel Overlays on Low Alloy Steel Plate - DOE Contact S.J. Dapkunas, 301-353-2784; University of Cincinnati Contact J. Moteff, 513-475-3096

- Establishing of correlations between the weld overlay process, postweld dent treatment, microstructure, micromechanical response, and macroscopic mechanical behavior.

The Fatigue Behavior of Chromium-Containing Ferritic Steels at Elevated Temperatures - DOE Contact S.J. Dapkunas, 301-353-2784; University of Connecticut Contact A.J. McEvily, 203-486-2941

- Study of the metallurgical and environmental effects of the fatigue behavior of chromium-containing ferritic steels.

Transformation, Metallurgical Response, and Behavior of the Weld Fusion and Heat Affected Zone in Co-Mo Steels for Fossil Energy Applications - DOE Contact S.J. Dapkunas, 301-353-2784; University of Tennessee Contact C.D. Lundin, 615-974-5310

- Development of fundamental information on the metallurgical behavior of the heat affected zone of welds in chromium-molybdenum alloys.

Development of Iron and Nickel Aluminides - DOE Contact S.J. Dapkunas, 301-353-2784; ORNL Contact C.T. Liu, 615-574-4459

- Design and testing of materials that will use Al_2O_3 as the main protective layer to prevent sulfidation attack and that will possess good mechanical properties at high temperatures.

Hydrogen Attack in Cr-Mo Steels at Elevated Temperatures - DOE Contact S.J. Dapkunas, 301-353-2784; Cornell University Contact Che-Yu Li, 607-256-4349

- Determination of the kinetics of nucleation and growth of methane bubbles on cavities in 2 1/4 Cr- 1 Mo steels at elevated temperatures under the influence of high pressure hydrogen and applied stress.

- Development of kinetic equations for estimating the number density and size distribution of grain boundary cavities as a function of time.

Analysis of Hydrogen Attack on Pressure Vessel Steels - DOE Contact S.J. Dapkunas, 301-353-2784; University of California Contact G.R. Odeth, 805-961-3525

- Developed physical models that describe the initiation and development of methane damage in carbon steel, C-Mi-Si steels, 2 1/4 Cr-1 Mo steel and weldments.

Deformation and Fracture of Low Alloy Steels at High Temperatures - DOE Contact S.J. Dapkunas, 301-353-2784; University of Illinois Contact D.L. Marriott, 217-333-7237

- Investigation of the microstructural changes and the mechanisms of damage accumulation that accompany, or arise from, high temperature deformation of a range of 2 1/4 Cr-1 Mo steels.

Evaluation of 3 Cr-1.5 Mo Steel in a Simulated Coal Conversion Environment - DOE Contact S.J. Dapkunas, 301-353-2784; Westinghouse Contact B.J. Shaw, 412-256-1201

- Development of a fracture mechanics characterization of candidate materials for coal gasification pressure vessels.

- Physical metallurgical evaluation of the various degradation processes observed in the basic characterization.

Creep Rupture of High-Chromium Alloys in Mixed Gas Environments - DOE Contact S.J. Dapkunas, 301-353-2784; ANL Contacts W.A. Ellingson, K. Natesan, 312-972-5068

- Experimentally evaluate the uniaxial creep rupture behavior of selected high-chromium alloys and weldments in mixed-gas environments.

- Correlation of the creep properties with the chemistry of exposure environment, temperature, and alloy chemistry

Biaxial Stress-Rupture of Alloys in Coal Gasification Atmospheres - DOE Contact S.J. Dapkunas, 301-353-2784; EG&G Idaho, Incorporated Contact G.R. Smolik, 208-526-8317

- Measurement of biaxial stress-rupture strength and ductility of type 310 stainless steel, alloy 800H, Haynes alloy 188m and Inconel 657.

Corrosion of Alloys for Internals and Heat Exchangers in Mixed-Gas Environments - DOE Contact S.J. Dapkunas, 301-353-2784; ANL Contact W.A. Ellingson, K. Natesan, 312-972-5068

- Corrosion experiments are being conducted by using thermogravimetric techniques in mixed-gas environments on selected alloys.

Screening and Study of Behavior of Materials Subjected to Combined Erosion and Corrosion - DOE Contact S.J. Dapkunas, 301-353-2784; Metal Properties Council, Incorporated Contact A.O. Schaefer, 212-705-7643

- Experiments are carried out at high temperature (to 900 degrees C) and pressure (to 0.7 MPi) to evaluate the effects of corrosive environments on erosion behavior.

Corrosion of Alloys in FBC Systems - DOE Contact S.J. Dapkunas, 301-353-2784; ANL Contacts W.A. Ellingson, K. Natesan, 312-972-5068

- Evaluation of the high temperature corrosion behavior of iron- and nickel-base alloys in varied gas environments.
- Evaluation of deposit-induced corrosion behavior of heat exchanger and gas turbine materials after exposure to multicomponent gas environments.
- Development of corrosion rate expressions for long-term extrapolation to component design lives.

A Mechanistic Study of Low-Temperature Corrosion on Materials In the Coal Combustion Environment - DOE Contact S.J. Dapkunas, 301-353-2784; GE Contact R.M. Johnson, 518-385-2873

- Develop a more detailed understanding of the corrosion morphology and interface chemistry on selected specimens after exposure to coal contaminants.
- Make thermochemical calculations to establish the range of conditions for stability of the alloy phases, corrosion products, and chemical compounds formed.

Hot Corrosivity of Coal Conversion Products on High-Temperature Alloys - DOE Contact S.J. Dapkunas, 301-353-2784; University of Pittsburgh Contact G.H. Meier, 412-624-5316

- Investigation of the corrosion reactions of the products of coal conversion (gasification and PFBC) with high-temperature alloys.

Erosion in Dual-Phase Microstructures - DOE Contact S.J. Dapkunas, 301-353-2784; Notre Dame Contact T.H. Kosel, 219-239-5642

- Investigation of mechanisms of material removed in dual-phase microstructures.

Evaluation of Advanced Materials for Slurry Erosion Service - DOE Contact S.J. Dapkunas, 301-353-2784; Battelle Columbus Contacts I.G. Wright, A.H. Clauer, 614-424-4377

- Collection of erosion data on several candidate valve trim materials under a range of slurry conditions.
- Development of a substitute erodent and liquid carrier combination.

Mechanisms of Erosion-Corrosion in Coal Combustion Environments - DOE Contact S.J. Dapkunas, 301-353-2784; ORNL Contact J.R. Keiser, 615-574-4453

- Evaluation of erosion-corrosion of alloys by microscopic techniques providing direct evidence of the erosion-corrosion modes of materials degradation.

Study of Particle Rebound Characteristics and Material Erosion at High Temperature - DOE Contact S.J. Dapkunas, 301-353-2784; University of Cincinnati Contact W. Tabakoff, 513-475-2849

- Development of a quantitative model that will facilitate the prediction of erosion in systems operating in particle-laden environments.

High-Temperature Creep Behavior of Refractory Bricks - DOE Contact S.J. Dapkunas, 301-353-2784; Iowa State Contact T.D. McGee, 515-294-9619

- Study of creep of refractories intended for use at higher temperatures and under more severe conditions than can be tolerated by refractory concretes.

Investigation of the Effect of Slag Penetration on the Mechanical Properties of Refractories - DOE Contact S.J. Dapkunas, 301-353-2784; NBS Contact S.M. Wiederhorn, 301-921-2901

- Evaluation of the effect of slag and microstructure on the fracture and deformation behavior of refractory materials.

- Development of a base of experimental data that can be used to model refractory degradation caused by slag penetration.

Corrosion of Refractories in Slagging Gasifiers - DOE Contact S.J. Dapkunas, 301-353-2784; ANL Contacts W.A. Ellingson, S. Greenburg, 312-972-5068

- Examination of the effects of slag and flux composition on the corrosion of alumina and chromia refractories.

High Temperature Applications of Structural Ceramics - DOE Contact S.J. Dapkunas, 301-353-2784; NBS Contacts E.R. Fuller, S.J. Schneider, 301-921-2901

- Characterization of high temperature failure and factors that influence their operation, aiming toward improving the properties of structural ceramics .

Mechanical Behavior of Structural Ceramics - DOE Contact S.J. Dapkunas, 301-353-2784; ORNL Contact P.F. Becher, 615-574-5157

- Correlation of mechanical properties of structural ceramics with their microstructure, crystal structure, microchemistry, and fabrication history.

- Determination of changes in flexural strength, fracture toughness, and supercritical crack growth as a function of exposure time to combustion products of fossil fuels at high temperatures.

Device or Component Fabrication, Behavior or Testing

Materials and Components in Fossil Energy Applications Newsletter - DOE Contact S.J. Dapkunas, 301-353-2784; ORO Contact E.E. Hoffman, 615-574-0735; Battelle Columbus Contact I.G. Wright, 614-424-4377

- Publish a newsletter addressing current developments in materials and components in fossil energy applications.

Microstructural Control to Improve Properties of Weldments in Chromium-Molybdenum Steels - DOE Contact S.J. Dapkunas, 301-353-2784; Combustion Engineering, Incorporated Contact E.W. Pickering, 615-752-7196

- Production and evaluation of shielded metal acr welds to determine the effects of composition of welding consumables and welding parameters on the microstructure and properties of the weldments.

Electroslag Welding of Pressure Vessel Steels - DOE Contact S.J. Dapkunas, 301-353-2784; Colorado School of Mines Contacts R.H. Frost, G.R. Edwards, 303-273-3777

- Characterization of the effects of process variables, including potential electrode composition and velocity, and flux composition.

Three Dimensional Residual Stress Characterization of Thick Plate Weldments with Advanced Instrumentation and Methodologies - DOE Contact S.J. Dapkunas, 301-353-2784; Penn State Contact C.O. Russel, 814-863-2843

- Characterization of the three-dimensional residual stress field in an approximately 30cm thick (12 in.) v-groove weldment of of 2 1/4 Cr-1 Mo steel.
- Evaluation of various postweld heat treatment techniques and schedules proposed for the fabrication of large pressure vessels.

Investigation of the Mechanisms of Molten Salt Corrosion of Candidate Materials for Molten Carbonate Fuel Cells - DOE Contact S.J. Dapkunas, 301-353-2784; ORNL Contact H.S. Hsu, 615-576-4810

- Studies of the corrosion mechanisms of the anode and cathode current collectors in NCFCs .

Oxide Electrodes for High Temperature Fuel Cells - DOE Contact S.J. Dapkunas, 301-353-2784; PNL Contacts J.L. Bates, D.D. Marchant, 509-375-2579

- Finding and developing highly electronically conducting oxides for use as cathodes in SOFCs.

Studies of Materials Erosion in Coal Conversion and Utilization Systems - DOE Contact S.J. Dapkunas, 301-353-2784; LBL Contact A.V. Levy, 415-486-5822

- Determination of the erosion-corrosion behavior of materials used in the flow passages of liquid slurries under conditions representative of those in coal liquefaction systems.

Mechanisms of Galling and Abrasive Wear - DOE Contact S.J. Dapkunas, 301-353-2784; NBS Contact K.J. Bhansoli, 301-921-2982

- Development of an understanding of the wear mechanisms of materials associated with valves in coal conversion systems.

Thermomechanical Modeling of Refractory Brick Linings for Slagging Gasifiers - DOE Contact S.J. Dapkunas, 301-353-2784; MIT Contact Orol Buyukozturk, 617-253-7186

- Study of the failure mechanisms of refractory-brick-lined coal gasification vessels under transient temperature loadings.

Alkali Attack of Coal Gasifier Refractory Linings - DOE Contact S.J. Dapkunas, 301-353-2784; Virginia Polytechnic Institute Contact J.J. Brown, Jr., 703-961-6777

- Investigation of the physical and chemical characteristics of alkali attack of coal gasifier linings under nonslagging conditions.

Thermodynamic Properties and Phase Relations for Refractory-Slag Reactions in Slagging Coal - DOE Contact S.J. Dapkunas, 301-353-2784; Penn State Contact Arnulf Muan, 814-865-7659

- Determination of the chemical constraints affecting the performance of refractory materials under experimental conditions corresponding to those prevailing in slagging gasifiers.

Instrumentation and Facilities

Management of the AR&TD Fossil Energy Materials Program - DOE Contact S.J. Dapkunas, 301-353-2784; ORNL Contacts R.A. Bradley, P.T. Carlson, 615-574-6094

- Management of the AR&TD Fossil Energy Materials Program under DOE approved guidelines.

Development of Nondestructive High-Temperature Erosion Monitoring System - DOE Contact S.J. Dapkunas, 301-353-2784; ANL Contacts W.A. Ellingson, K.J. Reimann, 312-972-5068

- Development of a reliable real-time, on-line, high-temperature system that will measure erosion wear.

Development of Nondestructive Evaluation Techniques for Structural Ceramics - DOE Contact S.J. Dapkunas, 301-353-2784; ANL Contacts W.A. Ellingson, D.S. Kupplman, 312-972-5068

- Study and development of acoustic and radiographic techniques and possibly nuclear magnetic resonance to characterize structural ceramics with regard to certain flaws.

Office of Oil, Gas, Shale, and Coal Liquids

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Coating Studies for Coal Conversion - DOE Contacts T.B. Simpson (HQ), 301-353-3913, S.R. Lee (PETC), 412-675-6137; ORNL Contact A.J. Caputo, 615-574-4566

- Development of chemically vapor deposited coatings which offer the hope of extending the life of valve trim materials in coal conversion applications.

- Erosion rates are being determined using an established test in order to evaluate whether these coatings appear promising for valve trim and other severe erosion environment fossil applications.

Materials Properties, Behavior, Characterization, or Testing

Assessment of Materials Selection and Performance for Coal Liquefaction Plants - DOE Contact J.A. Reafsnyder (ORO), 615-576-1051; ORNL Contact A.R. Olsen, 615-574-1753

- Collection, assessment, and compilation of materials selection and performance data for coal liquefaction pilot plants, including data from applicable research and development programs and other sources such as the American Petroleum Institute (API) and the National Association of Corrosion Engineers (NACE).

Materials Review and Support for the SRC-I Liquefaction Project - DOE Contact J.A. Reafsnyder (ORO), 615-576-1051; ORNL Contact A.R. Olsen, 615-574-1753

- Provide assistance in the review of contractor documents for materials selection; to review and provide input to materials testing and failure analysis plans; and to compile materials information for specific processing steps to assist designers in making appropriate materials choices.

Coal Liquefaction Pilot Plant Materials Testing and Failure Analysis - DOE Contacts T.B. Simpson (HQ), 301-353-3913, S.R. Lee (PETC), 412-675-6137; ORNL Contact J.R. Keiser, 615-574-4453

- Provide alloy screening data on the susceptibility to corrosion and stress-corrosion cracking of potential materials of construction for coal liquefaction plants.

Elastomer Test Program - DOE Contacts T.B. Simpson (HQ), 301-353-3913, S.R. Lee (PETC), 412-675-6137; ORNL Contact J.R. Keiser, 615-574-4453

- Testing of O-ring elastomers for use in coal liquids. Laboratory immersion tests are being performed at ORNL and in-plant testing is being performed at the Wilsonville Advanced Coal Liquefaction Research and Development Facility.

Office of Coal Utilization

Fuel Cells Program

The purpose of the Fuel Cells Program of the Office of Coal Utilization is to develop technology required to make fuel cells commercially viable. This involves reducing costs while increasing lifetime and performance. Typical materials issues include corrosion, both as it affects the cells under their operating potentials and as it affects contiguous ducts or manifolds; sintering of catalysts; development of low-cost manufacturing processes; and achieving requisite porosity distribution while maintaining structural integrity. Projects with no dollar figures are subtasks of singly funded, larger statements of work and no information on specific funding breakdowns is available for these tasks.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Electrode Surface Chemistry - DOE Contact W.J. Huber, 304-291-4663; LBL Contact P.N. Ross, 415-486-4000

- Synthesis of bimetallic catalysts by thermal annealing of platinum with refractory metals, refractory metal oxides, and refractory metal carbides.

Development of Ternary Alloy Cathode Catalysts for Phosphoric Acid Fuel Cells - DOE Contact W.J. Huber, 304-291-4663; Giner Contact V. Jalan, 617-899-7270

- Synthesis of binary and ternary platinum alloy catalysts, a few of which showed increased catalytic activity compared to platinum catalysts alone.

Organometallic Catalysts for Primary Phosphoric Acid Fuel Cells - DOE Contact W.J. Huber, 304-291-4663; ECO Contact F. Walsh, 617-964-7010

- Synthesis of several metal-cobalt-organic liquid type catalysts, which have shown increased catalytic activity compared to platinum catalysts.

Materials Properties, Behavior, Characterization, or Testing

Molten Carbonate Fuel Cell and Stack Technology Development - DOE Contact F.D. Gmeindl, 304-291-4751; United Technologies Corporation Contact A. Meyer, 203-727-2214

- Materials which maintain springiness under molten carbonate fuel cells (MCFC) operating conditions with temperatures up to about 700 degrees C are being evaluated for use in the construction of flexible flanges which maintain sealing pressures against electrolyte-filled ceramic matrices.

- Corrosion of 316 SS and other alloys are being studied in a MCFC cathode gas/molten carbonate film environment for the effects of heat and forming operations on the corrosion rate and the nature of the protective layer under normal operation of the fuel cell and under the stress of thermal cycling.

- ZrO_2 materials are being evaluated as gasket materials between gas manifolds and the MCFC stack.

Molten Carbonate Fuel Cell Component Technology Development - DOE Contact F.D. Gmeindl, 304-291-4751; Energy Research Corporation Contact H. Maru, 203-792-1460

- Improvement of anode creep resistance by filling the anode with lithium aluminate powders and improvement of porosity by controlling particle synthesis and improving the method of pressing and sintering the powders.

- Development of catalysts for reforming of methane in the anode compartment of the fuel cell.

- Development of a coating for separator plate materials that meets goals of overpotential and resistance to corrosion and spalling after thermal cycling.

Alternative Molten Carbonate Fuel Cell Cathodes - DOE Contact F.D. Gmeindl, 304-291-4751; ANL Contact R.D. Pierce, 312-972-4450

- Evaluation of ceramic materials (e.g., Li_2MnO_3, $LiFeO_2$, and ZnO) as possible alternatives to NiO for the cathode material for molten carbonate fuel cells because in-cell migration of NiO has been found to be excessive for long-term operation.

Device or Component Fabrication, Behavior, or Testing

High Temperature Solid Oxide Electrolyte Fuel Cell Power Generation System - DOE Contact C.M. Zeh, 304-291-4265; Westinghouse Electric Corporation R&D Center Contact W. Feduska, 412-256-1951

- Qualification of submodule performance prior to initiating development of a 5kW generator.

- Essential design features (sealless generator concept, temperature profiles, fuel and oxidant distribution) will be demonstrated in the submodule prior to design and fabrication of the 5kW generator.

- Diffusion studies to determine potential life limiting factors are underway.

Advanced Fuel Cell Research - DOE Contact C.M. Zeh, 304-291-4265; ANL Contact D.C. Fee, 312-972-8931

- Development of a fabrication process for a monolithic fuel cell design composed of a "honeycomb" of small 1- to 2-mm diameter cells.

Magnetohydrodynamics Program

Successful economic operation of commercial MHD power systems will depend to a large measure on the availability of reliable materials of construction, capable of extended service at MHD operating conditions. The primary objective of the Materials Program of the Office of MHD is the development of materials applicable to the unique operating environment of coal-fired MHD systems. Program effort is divided into two general categories: (1) research effort to provide a fundamental understanding of materials behavior and a basis for the development of particular materials properties for MHD systems; and (2) applied engineering development of MHD component materials.

Materials Properties, Behavior, Characterization, or Testing

MHD Materials Development, Testing, and Evaluation - DOE Contact T.W. Arrigoni, 412-675-5981; PNL Contact P.E. Hart, 504-375-2905

- Development of composite, multi-layered, high temperature electrodes of hafnium oxide/rare-earth oxides/indium oxides with improved thermal shock resistance.

UTSI MHD Development Testing - DOE Contact C.A. Thomas, 412-675-5731; University of Tennessee Space Institute Contact N.R. Johanson, 615-455-0631

- Evaluation of materials for use in MHD system superheaters and air heaters including Croloy, Inconel, and 304, 316, 446, and 26-1 stainless steels.

MHD Heat and Seed Recovery Technology - DOE Contact R.F. Sperlein, 412-675-5985; ANL Contact T. Johnson, 312-972-5964

- Investigation of critical factors affecting the formation and growth of seed/slag deposites in a coal-fired MHD steam plant.
- Simulated MHD channel exhaust gas was produced by burning a slurry of heating oil, potassium sulfate, and fly ash with preheated air.

Office of Surface Coal Gasification

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Protective Coatings and Cladding: Application/Evaluation - DOE Contact J.P. Carr, 301-353-5985; METC Contact J.M. Hobday, 304-291-4347; ANL Contact D.R. Diercks, 312-972-5032

- Experimental evaluation and thermodynamic analysis of metallic protective coatings for coal gasifier heat stream generators and super heaters
- Development of coating inspection methods

Electroslag Component Casting - DOE Contact J.P. Carr, 301-353-5985; METC Contact J.M. Hobday, 304-291-4347; ORNL Contact V.K. Sikka, 615-574-5112

- Development of ESC technology for use in coal conversion components such as valve bodies, pump housings, and pipe fittings with the aim of developing a sufficient data base to permit acceptance of ESC as an ASME Code material and transfer ESC process technology to private industry.

Materials Properties, Behavior, Characterization, or Testing

Plant Material Surveillance Test - DOE Contact J.P. Carr, 301-353-5985; METC Contact J.M. Hobday, 304-291-4347; Union Carbide Corporation Contacts A.O. Schaefer, 212-705-7693, E.J. Vesely, Jr., 212-705-7693

- Testing of construction materials in current gasification pilot plants for resistance to gasification environments

Slagging Gasifier Refractories: Application Evaluation - DOE Contact J.P. Carr, 301-353-5985; METC Contact J.M. Hobday, 304-291-4347; ANL Contact S. Greenberg, 312-972-5084

- Establishment of base technology on refractories which have been systematically selected for slagging gasifiers relative to corrosion resistance with emphasis on slag corrosion of medium-chromia and high-chromia refractories in acidic and base slags

Advanced Pressure Vessel Materials Technology - DOE Contact J.P. Carr, 301-353-5985; METC Contact J.M. Hobday, 304-291-4347; ORNL Contact R.W. Swindeman, 615-574-5108

- Advanced pressure vessel materials technology to permit more economical design and fabrication of large coal conversion vessels that will operate reliably and safely through their design lifetimes

Device or Component Fabrication, Behavior, or Testing

Ceramic Fabrication: Application Technology - DOE Contact J.P. Carr, 301-353-5985; METC Contact J.M. Hobday, 304-291-4347; ANL Contact T.E. Easler, 312-972-4250

- Testing of corrosion screening on a-SiC, NC-430, and CX-589, initially conducted for 200 h at 1250 degrees C in simulated medium-Btu gasification environments and longer term testing (500 h and 1000 h) on selected materials

PARAGRAPH DESCRIPTIONS

OFFICE OF ENERGY SYSTEMS RESEARCH

This office supports generic research of a long-term, high-risk, high-payoff nature aimed at stimulating innovation in conservation technology. The research is both broadly based and multi-sectoral, providing a technology base for the other conservation programs. The Office consists of three divisions: Energy Storage, Energy Conversion and Utilization Technologies (ECUT), and Electric Energy Systems.

Energy Storage Division

The principal function of the Energy Storage Division is to foster more efficient and more economical use of intermittent energy sources. A vital part of this R&D effort is the development of new and improved materials. Activities include materials development, fabrication, characterization and compilation of data bases. Described below are the materials R&D efforts of the four subprograms of the Division: Batteries and Electrochemistry; Chemical and Hydrogen Storage; Thermal Storage; and Mechanical Energy Storage.

1. Ceramics Research	FY 1984	FY 1985
	$1,400,000	$1,000,000

DOE Contact - A. Landgrebe, 202-252-1483
LBL Contact - E. Cairns, 415-486-5028
Sandia Contact - R. Clark, 505-844-6332

Sodium/sulfur and lithium/iron sulfide batteries operate at temperatures of several hundred degrees C. Materials for current collectors, separators, seals, and coatings to prevent corrosion are of concern. New superconducting ionic materials are being developed. Of special importance is the development of processing techniques to toughen beta alumina electrolytes and to make parts with more reproducible properties for use in sodium/sulfur batteries.

Keywords: Alloy Development, Alternate Materials, Corrosion, Joining Methods, Fast Ion Conductors and Solid Electrolytes, Batteries

2. Metals and Alloys	FY 1984	FY 1985
	$1,200,000	$900,000

DOE Contact - A. Landgrebe, 202-252-1483
LBL Contact - E. Cairns, 415-486-5028
Lawrence Livermore Contact - 415-422-8575

Aluminum alloys are being prepared and characterized for use as negative electrodes in aluminum/air batteries. Alloys of platinum are being studied for use as electrocatalysts in fuel cells and aluminum/air batteries.

Keywords: Alloy Development, Alternate Materials, Batteries

3. Organometallic Compounds

	FY 1984	FY 1985
	$ 400,000	$ 300,000

DOE Contact - A. Landgrebe, 202-252-1483
Eltech Systems Corporation Contact - L. Gestaut, 216-357-4041

Macrocyclic compounds of transition metals are being investigated for use as electrocatalysts for use as air electrodes in fuel cells, and in aluminum/air and iron/air batteries.

Keywords: Alternate Materials, Fuel Cells, Batteries

4. Polymers

	FY 1984	FY 1985
	$ 250,000	$ 180,000

DOE Contact - A. Landgrebe, 202-252-1483
LBL Contact - E. Cairns, 415-486-5028
Univ. of Pa. Contact - G.C. Farrington,

Electronically and ionically conducting polymers are being synthesized, prepared as films, and characterized for use as electrodes and electrolytes in storage batteries and fuel cells.

Keywords: Polymers, Fast Ion Conductors and Solid Electrolytes, Batteries

5. High Temperature Electrolysis

	FY 1984	FY 1985
	$ 450,000	$ 200,000

DOE Contact - M. Gurevich, 202-252-1507
Westinghouse R&D Center Contact - E. Buzzeli, 412-256-1952

Electrochemical cells employing yttria-stabilized zirconia solid electrolytes were evaluated in the electrolysis of steam at 800 - 1050 degrees C. Performance levels of 1.23 V at 300 mA/cm^2 were obtained with current efficiencies approaching 100%. Performance appears to be affected by cross-diffusion limitations as H_2/H_2O increases beyond 50%. This program utilizes technology developed under Westinghouse's solid oxide fuel cell program and a separate facility was built during FY 1984 to fabricate cells dedicated to the electrolysis program. The focus in FY 1985 will be on fully characterizing the polarization effects occurring mainly at the cathode correlating present theory with experimental results.

A parallel study is underway at the University of Illinois investigating the influence of electrode/solid oxide electrolyte microstructure and porosity on polarization behavior.

Keywords: Solid Oxide Electrolytes, Ceramics, Surface Characterization, Energy Storage and Conversion, Hydrogen Production

6. Hydrogen Embrittlement of Pipeline Steels

	FY 1984	FY 1985
	$ 120,000	$ 45,000

DOE Contact - M. Gurevich, 202-252-1507
Battelle Columbus Laboratories Contact - John Holbrook, 614-424-4347

Investigations at Battelle and Brookhaven have further quantified H_2 embrittlement effects on pipeline steels under expected operating conditions and have also identified gaseous additives that can inhibit these effects. Recent testing has shown that fatigue crack growth is accelerated in hydrogen especially under high stress conditions and that sustained load subcritical crack growth can be a problem if hard spots are present in the pipeline. Oxygen, sulfur dioxide and carbon monoxide have been shown to provide strong inhibition or elimination of the above effects. The current thrust of the Battelle work is aimed at fully defining the mechanism of inhibition with the goal of identifying more practical additives without inherent environmental or institutional problems.

Keywords: Metals, Fatigue, Hydrogen Effects, Energy Transmission

	FY 1984	FY 1985
7. Hydrogen Technology Evaluation Center	$ 300,000	$ 100,000

DOE Contact - M. Gurevich, 202-252-1507
BNL Contact - P.D. Metz, 516-282-4091

Over the past two years, BNL has established a test/simulation facility, which includes a 5 kW photovoltaic array, computer control data acquisition, and associated support equipment for evaluating hydrogen technology components and systems. The HTEC facility became fully operational during FY 1984 with an advanced 15 kW General Electric SPE electrolyzer installed and producing hydrogen. Steady state baseline tests were conducted and the computer/simulation model for evaluating system performance was developed and verified. A number of equipment and instrumentation problems were identified during installation and operation of the system which will probably require design modifications. An advanced technology metal hydride compressor developed by Ergenics, Incorporated was also installed in HTEC for a performance mapping conducted by the MIT Chemical Engineering Practice School Group working with BNL.

Keywords: Hydrides, Polymers, Energy Storage, Hydrogen Production

	FY 1984	FY 1985
8. Proton Conducting Electrolytes	$ 100,000	$ 100,000

DOE Contact - M. Gurevich, 202-252-1507
Brookhaven National Laboratory Contact - F. Salzano, 516-282-4458

The goal of this work is to develop proton-conducting electrolytes capable of operating in 300 - 600 degrees C temperature regime. The results of the study have identified a class of metal phosphates which show excellent promise as proton conductors. Hydrated phosphates of aluminum exhibit both stability and acceptable conductivity at temperatures up to 280 degrees C. Analyses suggest benefits derived from extended life of electrochemical modules and more effective interface with lower temperature heat source in water vapor electrolysis systems.

Keywords: Solid Electrolytes, Ceramics, Microstructure, Hydrogen Production

9. <u>Anode Depolarization Studies</u>

	FY 1984	FY 1985
	$ 120,000	$ 15,000

DOE Contact - M. Gurevich, 202-252-1507
Texas A&M University Contact - J. Bockris, 713-845-5335
Brookhaven National Laboratory Contact - F. Salzano, 516-282-4458
University of Virginia Contact - G. Stoner, 804-924-3277

The objective has been to investigate whether an anode depolarizing agent could be used to reduce the overvoltage required to produce hydrogen (to within the 1.0 volt range) at the same time producing an alternate (valuable) product at the anode. The original investigations looked at coal and coal derivatives as the depolarizing agent, but the activity or current densities achievable were extremely low to the point of being impractical. Texas A&M completed a study characterizing the anodic products and reaction kinetics.

The BNL work was directed at identifying redox couples that could provide a two-step reaction sequence to accomplish the desired depolarizing effect followed by selective oxidation of a suitable organic material. The specific system being studied is the oxidation of toluene to benzoic acid using the Ce (III)/Ce (IV) redox couple of the anodic products based on coal, coal derivatives and waste products.

The University of Virginia work is directed at the upgrading of hydrocarbons via the conversion of alkanes to alcohols in electrochemical reactions involving depolarizing agents. The work is currently focused on an acetic acid/sulfuric acid electrolyte system using propane as a depolarizing agent to help define the basic process and reaction sequence.

Keywords: Organics, Transformation, Hydrogen, Alternate Fuels

10. <u>Materials for Advanced High-Temperature Molten Salt Storage</u>

	FY 1984	FY 1985
	$ 106,000	$ 0

DOE Contact - M. Gurevich, 202-252-1507
SERI Contact - Werner Luft, 303-231-1823

Corrosion testing is being conducted on metal alloys that are candidates for barrier layers to protect internal insulation materials from 900 degrees C molten salt in thermal energy storage tanks. The metals and alloys tested include: Hastelloy N, Nickel-aluminate, Haynes 556, Inconel 600, Cabot 214, Nickel, and Incolloy 800. Coupons of the alloys were immersed in ternary eutectic lithium-sodium-potassium-cabonate for up to 67 days in controlled atmospheres containing either 0.4% or 20% carbon dioxide and about 1% and 19% oxygen, with the balance being nitrogen. Coupons were withdrawn at various intervals, and weight and dimensional changes measured. Metallographic analysis of cross-sections was made at 50X to 160X magnification. Severe corrosion or swelling was noted on most materials, except nickel, with 1% oxygen sparged through the salt. At 19% oxygen, the corrosion was much reduced for Inconel 800.

Keywords: Alloys, Metals, Corrosion, Alternate Fuels, Energy Storage, High Temperature Service

11. <u>Analysis of Zeolite Augmented Ice Storage</u>

	FY 1984	FY 1985
	$ 75,000	$ 10,000

DOE Contact - Rufus Shivers, 202-252-1476
Pacific Northwest Laboratory Contact - Landis Kannberg, 509-375-3919

A facility is being constructed to test the concept of using solar regenerated zeolites for augmenting the chill obtained from seasonally stored ice by using the heat of sublimation rather than simply the heat of fusion. The facility is being constructed at the New Mexico Solar Energy Institute and will involve the night time sublimation ice for generating chilled water for space cooling the next day. During the day the zeolite is dessicated by heating with solar energy. Testing includes evaluation of the cyclic absorptive capacity of several types of zeolites and the performance of various zeolites under widely varying operating conditions.

Keywords: Transformation, Microstructure, Diffusion

12. <u>Geochemical Stability of Sandstones</u>

	FY 1984	FY 1985
	$ 100,000	$ 50,000

DOE Contact - Rufus Shivers, 202-252-1476
Pacific Northwest Laboratory Contact - Landis Kannberg, 509-375-3919

Laboratory testing is being conducted to determine the effects of flow at 150 degrees C water of varying water quality through porous sandstones, primarily the Ironton/Galesville sandstone from St. Paul, Minnesota. The testing is being used to determine the degree and rate of changes in sandstone hydraulic and mechanical properties as a result of mineral dissolution and precipitation that occurs when hot chemically altered fluids flow through the sandstone. The testing is being conducted in conjunction with field testing at St. Paul, Minnesota. Results will be used to determine the degree and type of water treatments required to control geochemical alteration of rock properties.

Keywords: Strength, Microstructure, Cements

13. <u>Chemically Bonded Ceramic Heat Storage Materials</u>

	FY 1984	FY 1985
	$ 15,000	$ 0

DOE Contact - Imre Gyuk, 202-252-1508
MCA Inc. Contact - Dennis Brosnan, 803-843-6444

Conventional fired ceramic refractories for heat storage constitute 30% of a typical residential storage furnace cost principally because of the expensive energy intensive fabrication process required, i.e., firing temperature approximately 2000 degrees F. A much less expensive fabrication process, chemical bonded castable bricks, will be developed with heat storage characteristics equal to or greater than existing bricks. This will allow a U.S. industry to be developed because local raw materials

(North Carolina or Washington Olivine) can be used and low capital investment fabrication equipment can be utilized. Research consists of choice of bonding materials, optimum size distribution of the olivine, addition of iron oxide for increased density, and fabrication techniques for large monolithic segments with cast integral heating elements.

Keywords: Olivine, Materials Characteristics

14. Composite High Temperature Thermal Storage Media

	FY 1984	FY 1985
	$ 350,000	$ 150,000

DOE Contact - Imre Gyuk, 202-252-1508
IGT Contact - Randy Petri, 312-567-3985

Develop a prototype fabrication process for impregnating ceramic powder (MgO, $NaALO_2$, $LiAlO_2$) with carbonate salts (eutectic mixtures of Na, Ba, Li and K) to form a thermal storage pellet which retains some compressive strength (because of surface tension forces) when the salt is melted. This allows a packed bed, direct contact heat storage material with storage in latent as well as sensible heat. Physical and chemical studies are performed of the prototype pellets and thermal cycling to determine weight and strength loss over product life. Problems of powder size, method of fabrication, chemical reactions with heat exchange gases, strength, loss of weight, composite heat capacity, and safety and toxicity issues are addressed. It is expected that a pellet fabrication process to produce a successful 710 degrees C and possibly a 858 degrees C storage media will be developed.

Keywords: Composites, Materials Characteristics

15. Formation of Encapsulated Metallic Eutectic Thermal Storage Alloy

	FY 1984	FY 1985
	$ 90,000	$ 80,000

DOE Contact - Imre Gyuk, 202-252-1508
Ohio State University Contact - Prof. Robert Rapp, 614-422-2491

Develop a prototype fabrication process for encapsulating carbonate salt pellets with a metallic coating to form a thermal storage pellet which retains some compressive strength (because of tension forces) when the salt is melted. This allows a packed bed, direct contact heat storage material with storage in latent as well as sensible heat. Find an effective way of producing pellets in mass and of the right size and uniformity. Develop a pellet fabrication process to produce a storage media in the range of 700 - 800 degrees C.

Keywords: Composites, Materials Characteristics

16. Solid State Radiative Heat Pump

	FY 1984	FY 1985
	$ 125,000	$ 80,000

DOE Contact - Imre Gyuk, 202-252-1508
Lawrence Berkeley Laboratory Contact - Roland Otto, 415-486-5289

The objective of this project is to evaluate the feasibility of the solid state radiative heat pump concept. This concept employs a large-area thin-film semiconducting device to convert thermal energy to infrared heat radiation (heating), and vice versa (cooling), utilizing input electricity. The theoretical evaluation is to be based on the fundamental solid state physics of narrow-band semiconductors. Experimental research is to be focused on identification of promising materials and measurement of their relevant properties. One such material under investigation is indium antimonide (InSb). The approach is to start with an analysis of ideal photo-diode equations. For specific diode voltages, the radiative heat transfer can be calculated as a function of wavelength. Measurement of thermal radiation emission as a function of electric and magnetic field intensity and polarity will be carried out on the candidate semiconductor materials.

Keywords: Catalyst, Metals, Semiconductors, Microstructure, Transformation, Surface Characterization and Treatment, Energy Storage

17. <u>Use of Micro Particles as Heat Exchangers and Catalysts</u>

	FY 1984	FY 1985
	$ 75,000	$ 90,000

DOE Contact - Imre Gyuk, 202-252-1508
Lawrence Berkeley Laboratory Contact - Roland Otto, 415-486-5289

The focus of this project is on the issue of heat transfer between particles and gas since this was identified as important in understanding a broad range of energy storage and conversion systems. The first objective of the project was to investigate heat transfer mechanisms as a function of particle size and state of the gas. The goal of this study is to determine under what circumstances the particle temperature is moderately independent of the gas temperature and conversely those conditions when the particle temperature is "pinned" to the gas temperature. These two examples define the extremes in particle temperature and therefore delineate the range of applications of the process. Studies of the steady state heat fluxes in radiantly heated particle suspensions were initiated. Simplified analytic solutions of the heat transfer between very small particles and gas were formulated. These analytical solutions facilitated rapid evaluation of the factors influencing the steady state temperatures and heat transfer rates between radiantly heated particles and the gas. Experiments include using iron, iron oxide particles, and carbonaceous particles in conjunction with possible reversible gas phase energy storage reaction couples such as SO_2/SO_3.

Keywords: Catalyst, Metals, Semiconductors, Microstructure, Transformation, Surface Characterization and Treatment, Energy Storage

18. <u>Formation and Dissolution of Gas Clathrates</u>

	FY 1984	FY 1985
	$ 150,000	$ 80,000

DOE Contact - Imre Gyuk, 202-252-1508
ORNL Contact - Juan Carbajo, 615-574-3784

Study of the conditions required for cyclic formation and dissolution of gas clathrates for cool thermal energy storage for air conditioning applications. Specifically, gas clathrates of common refrigerants are under investigation so that residential and commercial heat pump cool storage with direct contact heat transfer between the refrigerant and the storage media (the clathrate) is achieved. This class of inclusion compounds can provide a "warm ice" which provides storage of cool at thermodynamically more efficient temperatures 15 - 20 degrees F above ice freezing temperature and with a latent heat of fusion approaching that of ice. In a laboratory scale test loop, the conditions of a heat pump/cool storage system are being achieved so that rates of formation, water/refrigerant mixing requirements, clathrate phase diagram data, and practical heat pump problems imposed by use of this storage media can be experimentally studied. It is expected that the preliminary favorable economics of this storage system will be modified by realistic requirements for a prototypical system as a result of this program.

Keywords: Clathrates, Materials Characteristics

19. Evaluation of Advanced Thermal Energy Storage Media

	FY 1984	FY 1985
	$ 50,000	$ 250,000

DOE Contact - Imre Gyuk, 202-252-1508
ORNL Contact - J. F. Martin, 615-576-3977

The purpose of this research is to develop dual temperature TES media for heat and cool storage and to evaluate heats of mixing and crystallization in multicomponent solutions. Clathrates suitable for dual temperature storage are being identified through molecular modeling with the use of a computer. In addition, phase behavior of selected singly-complexing and multiply-complexing ammoniated salts in phase regions appropriate to dual temperature storage are being determined.

Keywords: Clathrates, Materials Characteristics

20. Prototype Flywheels

	FY 1984	FY 1985
	$ 20,000	$ 0

DOE Contact - R. Shivers, 202-252-1488
ORNL Contact - J. Martin, 615-576-3977
Garrett, AVCO, G.E., Owens-Corning

Prototype flywheel composites of kevlar, glass and graphite fibers with various matrix materials were fabricated with the purpose of maximizing energy storage density in a flywheel. Both nondestructive ultrasonic testing and radiographic techniques and burst tests were employed to evaluate the flywheels design and the mechanical properties of the materials in a specific flywheel configuration.

Keywords: Composites, Matrix Materials, Fibers, Flywheel

21. Elastomeric Storage

	FY 1984	FY 1985
	$ 10,000	$ 0

DOE Contact - R. Shivers, 202-252-1488
ORNL Contact - J. Martin, 615-576-3977
Eaton

Evaluation of elastomeric materials for energy storage through the fabrication and testing of prototype storage systems. Elastomers included both natural and synthetic rubbers. The emphasis of the testing was in fatigue property measurements.

Keywords: Elastomers, Materials Characterization

22. Superconducting Magnetic Energy Storage

	FY 1984	FY 1985
	$ 250,000	$ 250,000

DOE Contact - R. Shivers, 202-252-1488
LASL, U. of Wisconsin

The overall objective is to develop technology for small-scale (10 kWh) utility system stabilization devices. The major emphases are the development of a low-cost polyester-glass support structure for cryogenic service and the development of a high-purity aluminum stabilizer conductor. The system has been installed at the Tacoma substation of BPA.

Keywords: Superconductors, Glasses, Alloy Development

Energy Conversion and Utilization Technologies Division

The mission of the ECUT Program is to support generic, long-term, high-risk directed basic and applied research and exploratory development of new or improved concepts to produce a technology base which private industry can use in producing products that use energy more efficiently. Materials-related research in the ECUT Program is found in fiscal year 1984 in two projects, the Materials Project and the Tribology Project. The DOE contacts are Jim Eberhardt (202-252-1484; FTS 252-1484) for the Materials Project and Terry Levinson, (202-252-1484; FTS 252-1484) for the Tribology Project. In FY 1984 both projects were managed for ECUT by the Oak Ridge National Laboratory (ORNL). The ORNL technical manager of both projects was Joe Carpenter (615-574-4571; FTS 624-4571). In FY 1985, the Tribology Project will be managed by Argonne National Laboratory (ANL). The ANL technical manager will be Manfred Kaminsky (312-972-4074; FTS 972-4074). The goal of both projects is to develop innovative concepts to a point where they can be taken over for further development by private industry or other government programs.

The materials work in the Materials Project is in the areas of ductile ordered alloys, ceramic-ceramic and ceramic-metal attachments, surface modifications of ceramics, recovery and reuse of plastic scrap, building insulation, ceramic coatings, ceramic composites, and materials structures theory. Materials research in the Tribology Project is in the areas of friction and wear of ceramics, lubricants, and tribological surface modifications and coatings.

23. Ordered Metallic Alloys for High Temperature Applications

	FY 1984	FY 1985
	$ 610,000	$ 850,000

DOE Contact - James Eberhardt, 202-252-1484
ORNL (Contract DE-AC05-84OR21400) Contact - Chain Liu, 615-574-4459
Rensselaer (ORNL Subcontract 19X-22217C) Contact - Norman Stoloff, 518-266-6436
NC State (ORNL Subcontract 19X-43368C) Contact - Carl Koch, 919-737-2377
Lehigh (ORNL Subcontract 19X-43367C) Contact - Russell Chou, 215-861-4235
Vanderbilt (ORNL Subcontract 19X-07821C) Contact - James Wert, 615-322-3583
VPI&SU (ORNL Subcontract 19X-89672C) Contact - Diana Farkas, 703-961-4742
Columbia (ORNL Subcontract 19X-89664C) Contact - John Tien, 212-280-5192
Carnegie-Mellon (ORNL Subcontract 19X-89678V) Contact - Ted Massalski, 412-578-2700

Ductile long-range ordered (LRO) alloys based on the $(Fe,Ni)_3V$ system and ductile intermetallic compounds based on the Ni_3Al system are being developed and assessed as replacements for superalloys in a variety of high temperature applications such as advanced automotive engines, steam turbines and industrial heat exchangers. At ORNL developmental alloys are prepared using classical composition approaches and important properties are measured. Fatigue resistances and crack-growth behavior are studied at RPI; grain boundary diffusion at Lehigh and VPI&SU; and wear resistances at Vanderbilt. At NC State alloys based on mechanical alloying approaches are prepared and investigated. Directionally solidified alloys are prepared and evaluated at Columbia. Theoretical work on better understanding the influence of electronic structure on the ordering temperatures of the LRO alloys being investigated is conducted at Carnegie-Mellon.

Keywords: Alloys, Long-Range Order, Intermetallics

24. Reactive Metallic Brazes for Ceramic-Ceramic and Ceramic-Metal Joints

	FY 1984	FY 1985
	$ 140,000	$ 125,000

DOE Contact - James Eberhardt, 202-252-1484
ORNL (Contract DE-AC05-84OR21400) Contact - Artie Moorhead, 615-574-5153

Reactive metallic brazes are being developed for joining ceramics to ceramics and metals for high-temperature service up to about 900 degrees C. Development brazes are screened by a levitation melting device and a wetting angle (sessile drop) test. Joints are brazed, tested to failure and analyzed.

Keywords: Ceramic, Joining, Brazes

25. Modeling of Solid Ceramic Joints

	FY 1984	FY 1985
	$ 0	$ 150,000

DOE Contact - James Eberhardt, 202-252-1484
The Norton Company (ORNL Subcontract 86X-00208C) Contact - Pierre Charreyron, 617-853-1000, ext. 2667

Generalized finite element models are being developed to predict the stress states existing in and near solid ceramic-ceramic and ceramic-metal joints of simple geometry. Butt-on-butt joints of two members each of rectangular cross sections and each of cylindrical cross sections are being modeled first. The purpose of the effort is to provide guidance as to what materials should and should not be joined in typical geometries for what applications.

Keywords: Ceramics, Metals, Joining, High Temperature Service

26. Electromagnetic Joining of Ceramics

	FY 1984	FY 1985
	$ 72,000	$ 90,000

DOE Contact - James Eberhardt, 202-252-1484
DHR, Incorporated (ORNL Subcontract 86X-47975V) Contact - Richard Silberglitt, 703-556-8660

The objective of this effort is to establish the technical feasibility of using electromagnetic radiation in the radiofrequency (RF) range to effect solid joints between ceramics and ceramics and ceramics and metals. Many ceramics are virtually transparent to electromagnetic radiation in the RF range whereas all metals and other ceramics are not. Therefore, it may be possible to heat a ceramic-ceramic or ceramic-metal interface uniformly without having to use outside-to-inside heating which can tend to crack the ceramics due to nonuniform thermal expansion. In fiscal years 1983 and 1984 preliminary designs of the RF equipment were completed and initial builds were begun.

Keywords: Ceramics, Metals, Joining, High Temperature Service

27. Recovery and Reuse of Plastic Scrap Via Separation and Bonding

	FY 1984	FY 1985
	$ 5,000	$ 35,000

DOE Contact - James Eberhardt, 202-252-1484
Plastics Institute of America (ORNL Subcontract 9100) Contact - Mike Curry, 201-420-5552

The PIA is coordinating and participating in an effort with four universities, a marketing consultant, and several industrial firms to assess the potential of recycling or reusing post-consumer plastic scrap via bonding and/or separation approaches. At the universities binders for clean plastic "fluff" residue from auto shreds and for shredded beverage containers are being developed or acquired, used to produce laboratory test specimens, and the properties of the specimens measured. The use of the auto shred residue as a filler for polymer concretes and techniques for separating it into its constituents are also being investigated. Some binders identified in the laboratory scale tests are being used to produce large specimens from several tons of the residue using large scale equipment supplied by the industrial firms. The large scale tests are funded by the DOE Office of Industrial Programs. A survey to identify potential markets for products made from the recycled plastics is being conducted by the marketing consultant.

Keywords: Plastics, Recycle

28. Recovery and Reuse of Plastic Scrap Via Decomposition

	FY 1984	FY 1985
	$ 0	$ 185,000

DOE Contact - James Eberhardt, 202-252-1484
ORNL (Contract DE-AC05-84OR21400) Contact - Joe Carpenter, 615-574-4571

Work is being conducted in the area of recovery and reuse of plastic scrap by means of techniques in which the scrap plastics are decomposed in some way to such products as uncrosslinked polymers, chemical feedstocks, free monomer, or fuels. Techniques being considered include pyrolysis, hydrolysis, solvolysis, radiolysis and various combinations thereof followed by appropriate separations. An international symposium was held on the subject on August 31 and September 1, 1983 at the Annual Meeting of the American Chemical Society in Washington, D.C. At ORNL, pertinent literature was reviewed to determine the scopes of further work to be done under subcontracts; RFPs for the work were being developed at the end of fiscal year 1984.

Keywords: Plastics, Recycle

29. Economics of Recovery and Reuse of Plastic Scrap

	FY 1984	FY 1985
	$ 45,000	$ 15,000

DOE Contact - James Eberhardt, 202-252-1484
ORNL (Contract DE-AC05-84OR21400) Contact - Randall Curlee, 615-576-4864

These are a series of studies of the economic viability of the recovery and reuse of plastic scrap over the next twenty years. Expected quantities and prices of various types of plastic scrap are predicted, current data on costs of various recycling are collected and assessed, and prices of products made from the recycled plastics are compared to prices for similar products made from virgin materials. Initial results indicated that many plastics recovery and reuse techniques are and will be economically viable. Current studies are concerned with the institutional barriers that may have to be overcome before large scale recovery and reuse of plastic scrap can occur.

Keywords: Plastics, Recycle

30. Aging of Rigid Urethane Foam Insulation

	FY 1984	FY 1985
	$ 0	$ 0

DOE Contact - James Eberhardt, 202-252-1484
Massachusetts Institute of Technology (ORNL Subcontract 9099) Contact-
Leon Glicksman, 617-253-2233

A model to predict the aging of rigid (as opposed to blown-in) urethane foam insulation is being developed. Heat transfer and the diffusion of gases through the insulation are predicted as functions of plastic composition, foam-cell geometry and wall thickness, gas composition, and diffusion barriers. Model predictions are compared against data from accelerated aging tests at elevated temperatures. In mid-FY 1984 this work was transferred to the Office of Building Energy R&D (BERD) for further support.

Keywords: Insulation, Foam, Urethane

31. Materials By Design

	FY 1984	FY 1985
	$ 89,000	$ 600,000

DOE Contact - James Eberhardt, 202-252-1484
ORNL (Contract No. DE-AC05-84OR21400) Contact - Joe Carpenter, 615-574-4571
Signal UOP, Inc. (ORNL Subcontract 86X-00210C) Contact - Alan Wilks, 312-391-3179

The ultimate objective of this effort is to establish the technical feasibility of developing, experimentally verifying, and using mathematical models of certain transition interatomic processes and phenomena in order to have the predictive power to design and optimize practical engineering processes and materials. The materials science phenomena of interest are bonding of solid coatings to solid substrates, grain boundary adhesion, and the structure and properties of amorphous materials; in addition, phenomena in heterogeneous catalysis and tribology are considered. The near term objective is to determine if the current paces of the states of the art in quantum mechanical and semiempirical models, supercomputers, and experimental analytical tools are such that an effort to achieve the ultimate objective is possible, or will be possible, in the next 5 to 10 years. In late FY 1984 an assessment to address that near-term objective was started.

Keywords: Alloys, Metals, Ceramics, Coatings and Films, Joining

32. Cubic Boron Nitride and Diamond-Like Carbon Coatings

	FY 1984	FY 1985
	$ 40,000	$ 0

DOE Contact - Terry Levinson, 202-252-1484
ORNL (Contract W-7405-eng-0026) Contact - Dave Stinton, 615-574-4556

The objective of this work is to explore the feasibility of producing cubic-boron nitride and diamond-like carbon coatings via low cost, plasma-assisted, chemical vapor deposition (CVD) processes. Diamond is the hardest and cubic-BN is the second hardest substance known; practical low-cost coatings of such materials would have myriad applications in cutting and bearing applications.

Keywords: Coatings, Ceramics, Chemical Vapor Deposition, Engines, High Temperature Service, Refractory Liners

33. Magnetron-Sputtered Adherent Amorphous Metal Wear-Resistant Coatings

	FY 1984	FY 1985
	$ 73,000	$ 0

DOE Contact - Terry Levinson, 202-252-1484
Jet Propulsion Laboratory (Interagency Agreement OR-21377) Contact - Satish Khanna, 213-792-4489

The objective of this effort is to determine if it is possible to deposit an adherent wear resistant amorphous metal coating onto a substrate. Amorphous metals are known to have "different" tribological characteristics than their crystalline forms, but, as they can usually only be produced in powder or ribbon form, it is difficult (if not impossible) to produce a very adherent amorphous metal coating since techniques involving heating tend to cause crystallization. In this work glassy (amorphous) coatings are deposited onto glass or metal substrates and their structure, hardness, friction coefficients, and wear rates are determined. Corrosion resistances of the coatings are evaluated in another program sponsored by the Office of Industrial Programs (OIP). In initial work, it was shown that Mo-Ru-B and W-Re-B (good glass formers) amorphous coatings deposited onto 52100 bearing steel had wear rates three order of magnitude lower than the bare steel. Future work will be aimed at producing such coatings without Ru or Re.

Keywords: Amorphous Materials, Coatings and Films, Corrosion, Erosion and Wear, Physical Vapor Deposition

34. <u>Instruments for Harsh Environments</u>	<u>FY 1984</u>	<u>FY 1985</u>
	$ 0	$ 100,000

DOE Contact - James Eberhardt, 202-252-1484
National Bureau of Standards - Gaithersburg (Interagency Agreement OR-21375) Contact - Ken Kreider, 301-921-3281

The objective of this effort is to provide fundamental information needed for the construction and performance of thin-film surface sensors for less intrusive measurements of temperatures of combustion gases. FeCrAlY films are deposited onto iron-based substrates. A thin FeCrAlY oxide layer is thermally grown on the FeCrAlY film. A thermocouple junction (e.g., Pt/Pt-Rh) and electrical leads are sputtered onto the oxide. The oxide serves to electrically insulate the thermocouple from the FeCrAlY and the iron substrate while the FeCrAlY film insures adherence of the thermally grown FeCrAlY oxide to the iron substrate. The experimental work in this effort involves the preparation and testing of the sensors.

Keywords: Coatings and Films, Physical Vapor Deposition, Engines, High Temperature Service

35. <u>Supercritical Fluid Equations of State</u>	<u>FY 1984</u>	<u>FY 1985</u>
	$ 0	$ 0

DOE Contact - James Eberhardt, 202-252-1484
National Bureau of Standards - Boulder (Interagency Agreement OR-21374) Contact - James Ely, 303-320-5467

The objective of this effort is to develop better equations of state for fluid mixtures in the supercritical region. There are potential applications of supercritical fluids technology for separations and extractions in numerous materials processing areas. The work in fiscal year 1984 entails (1) measurements of thermodynamic and transport properties of CO_2, (2) development of a model to predict phase equilibria, and (3) measurements of solubilities of various gases in CO_2, all three phases dealing with the supercritical state.

Keywords: Separations

36. Ordered Metallic Alloys for Lightweight Applications

	FY 1984	FY 1985
	$ 10,000	$ 75,000

DOE Contact - James Eberhardt, 202-252-1484
ORNL (Contract DE-AC05-84OR21400) Contact - Chain Liu, 615-574-4459
Consultant (ORNL Subcontract 11-89661V) Contact - Erland Schulson, 603-646-2888

The objective of this effort is to explore the potential of ordered intermetallic alloys for possible use as lightweight structural materials. Initial efforts are concentrating on magnesium-based alloys; an assessment is being conducted in FY 1984 to determine if ductile intermetallic alloys based on magnesium are possible.

Keywords: Metals, Intermetallics, Lightweight

37. Plasma Sintering of Ceramics

	FY 1984	FY 1985
	$ 10,000	$ 100,000

DOE Contact - James Eberhardt, 202-252-1484
Northwestern (ORNL RFP in process) Contact - D. Lynn Johnson, 312-492-3537

The objective of this effort is to explore and elucidate the mechanisms of sintering of ceramics in a plasma.

Keywords: Ceramics, Sintering, Plasma

38. Coatings for High Temperature Energy Conversion Systems

	FY 1984	FY 1985
	$ 0	$ 0

DOE Contact - James Eberhardt, 202-252-1484
Lawrence Berkeley Laboratory (ORNL Subcontract 41X-70342V) Contact - A. V. Levy, 415-486-5822

The objectives of this effort are to (1) assess the current state of the art of plasma-sprayed and chemically vapor-deposited coatings and (2) to test the friction and wear characteristics and analyze certain thermal barrier and wear resistant coatings being considered for use on the piston rings of the adiabatic diesel engine. Plasma-sprayed coatings include a variety of MCrAl, Y_2O_3-ZrO_2, WC-Co, Cr_3C_2, Al_2O_3-TiO_2, and TiC_2. The CVD coatings include TiB_2 and others. The coatings are tested to determine the friction and wear rates in a Falex 6 washer-or-disk wear tester modified to achieve 1400 degrees F in air. Coatings are analyzed before and after testing to determine compositions, microstructure, surface finish, hardness, and failure mode.

Keywords: Alloys, Ceramics, Coatings and Films, Corrosion and Wear, Physical Vapor Deposition, Chemical Vapor Deposition, Engines

39. Laser Surface Modifications of Ceramics	FY 1984	FY 1985
	$ 0	$ 150,000

DOE Contact - James Eberhardt, 202-252-1484
North Carolina State University (ORNL RFP 5429) Contact - Bob Davis, 919-737-3272

The objective of this effort is to investigate the nature and implications of surface modifications induced by driving or diffusion certain metal ions into ceramic surfaces by irradiation with a pulsed laser. Thin layers of either Cr, Fe or Ni are deposited onto flat surfaces of either - and a-SiC, Si_3N_4, or Al_2O_3 and then irradiated by pulsed lasers. Fracture strength and toughness, friction and wear behavior, fatigue resistance, microstructure and compositional variations are determined and related to the wavelength of the laser radiation, the pulse duration, and the energy density. The major output expected from this work is an initial determination of the effects of such treatment.

Keywords: Ceramics, Coatings and Films, Diffusion, Erosion and Wear, Surface Characterization and Treatment

40. Ion Implantation of Ceramics	FY 1984	FY 1985
	$ 70,000	$ 300,000

DOE Contact - James Eberhardt, 202-252-1484
ORNL (Contract DE-AC05-84OR21400 Contact - Carl McHargue, 615-574-4344
Georgia Institute of Technology (ORNL Subcontract 19B-07802C) Contact- Joseph Cochran, Jr., 404-894-2851

The objective of these efforts is to explore the effects of ion implantation on certain properties of ceramics. Properties measured include strength, hardness, fracture toughness, coefficient of friction, and wear rates. At ORNL work is concentrated in implantation into TiB_2 and at Georgia Tech into Al_2O_3 and ZrO_2. Work on SiC and Si_3N_4 is also planned for the near future.

Keywords: Ceramics, Ion Implantation

41. Materials Approaches to Ice Abatement	FY 1984	FY 1985
	$ 17,000	$ 0

DOE Contact - James Eberhardt, 202-252-1484
Consultant (ORNL Subcontract 11X-89682V) Contact - Lawrence Casper, 612-541-2508

An assessment is being conducted to determine if there may be any viable materials (as opposed to systems) approaches to the abatement of ice adhesion on surfaces such as heat pump condenser coils, roofs, and solar collectors.

Keywords: Surfaces, Ice

42. Lubricant Qualities of the Constituents of Base Stock Oil

	FY 1984	FY 1985
	$ 245,000	$ 400,000

DOE Contact - Terry Levinson, 202-252-1484
National Bureau of Standards - Gaithersburg (Interagency Agreement OR-21350) Contact - Stephen Hsu, 301-921-2113

The overall objective of this effort is to improve the understanding of the influences of lubricant molecular structure on the lubricant qualities. Three commercial base stock (without additives) oils, commonly used in formulating engine oils, are separated into various molecular fractions and each fraction tested for friction and wear in a specially devised four-ball test and oxidation stability in a unique microoxidation test. Chemical species produced during both tests are identified.

Keywords: Metals, Oils, Friction, Wear, Engines

43. Heats of Adhesion of Molecular Constituents of Base Stock Oils

	FY 1984	FY 1985
	$ 0	$ 0

DOE Contact - Terry Levinson, 202-252-1484
Martin Marietta (ORNL Subcontract 86X-47976C) Contact - Keith Bridger, 301-247-0700, ext. 229

The objective of this task is to measure the heats of adhesion of separated fractions of base stock oils on bearing steel. Heats of adhesion are measures of the tenacity with which a substance adheres to and, therefore, can protect a surface. Droplets of base stock oil fractions, supplied by NBS, are deposited onto a well characterized surface of 52100 or M50 bearing steel immersed in water and the angle of wetting of the droplet on the surface is measured. The heat of adhesion of the droplet is calculated through theory from the measured angle of wetting. The goal is to relate the measured heats of adhesion to friction and wear and oxidative stability tests run at NBS.

Keywords: Metals, Lubricants, Films, Wear, Surface Characterization, Engines

44. Friction and Wear of Ceramics at Elevated Temperatures

	FY 1984	FY 1985
	$ 261,000	$ 300,000

DOE Contact - Terry Levinson, 202-252-1484
Advanced Mechanical Technology, Inc. (ORNL Subcontract 86X-17479C) Contact- Forest Carignan, 617-964-2042
ORNL (Contract No. DE-AC05-84OR21400) Contact - Charlie Yust, 615-574-4812

Tribological experiments are run on high technology ceramics of current interest to determine apparent friction coefficients and wear rates and the ceramics are analyzed to elucidate the active wear mechanisms. A 5 X 5 matrix experiment was run in which pins of five types of ceramics were run against disks of themselves and the other four ceramic types. These ceramics studied included a Si_3N_4, a SiC, a toughened Al_2O_3, an untoughened Al_2O_3, and a partially stabilized ZrO_2. Tests were conducted in air and dry nitrogen at room temperature, 400 and 800 degrees F at speeds of 1 foot per second and nominal loads of 40 pounds per square inch (2 lb normal load on 1/4-inch diameter pin). Further work is concentrating on defining the limits of the "no-" or "low-wear" region for these and other ceramics.

Keywords: Ceramics, Friction, Wear

45. Friction and Wear of Ceramics Under Oscillatory Sliding

	FY 1984	FY 1985
	$ 5,000	$ 0

DOE Contact - Terry Levinson, 202-252-1484
Carborundum Company (ORNL RFP 6412-86) Contact - James MacBeth, 716-278-2282

This work entails initial measurements of the friction and wear of ceramics sliding against one another in an oscillatory mode at temperatures between 600 and 1200 degrees C. Ceramics investigated include SiC, PSZ, a Si/SiC composite, a SiC impregnated with a solid lubricant and a sialon.

Keywords: Ceramics, Friction, Wear

46. Observations of "Hot Spots" on Ceramics and Development of Theory

	FY 1984	FY 1985
	$ 40,000	$ 75,000

DOE Contact - Terry Levinson, 202-252-1484
Georgia Institute of Technology (ORNL Subcontract 780219X-15) Contact- Ward Winer, 404-894-3270

The objectives of this effort are (1) to determine if ceramics exhibit "hot spots" during pin-on-disk tests and, if so, (2) to develop a theory for the severe wear of ceramics based on plastic flow or melting of the hot spots. Pins of partially stabilized zirconia or silicon nitride are tested against sapphire (Al_2O_3) disks. The wear of the ends of the pins is observed optically through the transparent disk. The output expected from this work is a better understanding of the mechanisms of wear of ceramics, which understanding should lead to improvements in the wear resistances of ceramics.

Keywords: Ceramics, Erosion and Wear

47. Assessment of X-ray Methods for Investigations of Ceramic Wear Surfaces

	FY 1984	FY 1985
	$ 56,000	$ 81,000

DOE Contact - Terry Levinson, 202-252-1484
Virginia Polytechnic Institute and State University (ORNL Subcontract 19-B07733C) Contact - Charles Houska, 703-961-5652

This is an assessment of the potential of x-ray diffraction and fluorescence techniques for nondestructive investigations of the near-surface region of ceramic wear surfaces. The limitations of standard x-ray diffraction and fluorescence equipment are defined and the possibilities afforded by the Brookhaven Synchrotron Light Source are explored. The ultimate output expected from this work is a program of research to develop and use x-ray techniques for investigating ceramic wear surfaces.

Keywords: Ceramics

48. Solid Lubricants Deposited From the Gas Phase

	FY 1984	FY 1985
	$ 55,000	$ 75,000

DOE Contact - Terry Levinson, 202-252-1484
The Pennsylvania State University (ORNL Subcontract 19X-89616C) Contact- Larry Duda, 814-865-2574

This is an investigation of the feasibility of depositing (from the gas phase) hydrocarbon and solid lubricant films onto metal and ceramic substrates. The objective is to assess the viability of the gas phase deposition approach for lubrication of heat engines and industrial machinery and for metal working. The deposition rates and the compositions and structures of the films are determined as functions of the vapor pressures of the lubricant precursors and oxygen in the gas phase, gas flow rate, and substrate temperature. The films are then tested for friction and wear characteristics. Initial efforts are concerned with the development of a vapor delivery system and deposition of films from mineral oil vapors onto steel substrates held at temperatures below 700 degrees F.

Keywords: Coatings and Films, Chemical Vapor Deposition

49. Tribological Surface Modifications and Coatings

	FY 1984	FY 1985
	$ 300,000	$ 475,000

DOE Contact - Terry Levinson, 202-252-1484
Argonne National Laboratory Contact - Manfred Kaminsky, 312-972-4074
MIT (ANL RFP in process) Contact - Bruce Kramer, 617-253-6049
UCLA (ANL RFP in process) Contact - Ram Bunshah, 213-825-2210
Borg-Warner (ANL RFP in process) Contact - William Sproul, 312-827-3131

This is a newly (FY 1984) initiated effort aimed at advancing the state of the art of tribological surface modifications and coatings. Near-term emphasis in FY 1984 is on coatings for cutting tools. In the longer term, emphasis will be on the development of novel surface modifications and coatings for various tribological applications.

Keywords: Surface Modification, Tribology

Electric Energy Systems Division

The EES program supports R&D to expedite the development of high-risk, long-term payback technologies which have a significant potential for improving the reliability, efficiency, and safety of the nation's electrical energy system. Research is also conducted in technologies for integrating new electrical energy sources (dispersed generation and storage) into the grid.

50. <u>High-Voltage Breakdown Strengths of Insulating Gases and Liquids</u>

	FY 1984	FY 1985
	$ 580,000	$ 520,000

DOE Contact - Russell Eaton, 202-252-4844
ORNL (Contract No. W-7405-eng-0026) Contact - Lucas Christophorou, 615-574-6199

Analyze, from a fundamental physiochemical point of view, the factors influencing the breakdown strengths of gaseous and liquid dielectrics and seek mixtures of gases with superior insulating properties.

Keywords: Insulators (Gaseous), Energy Transmission

51. <u>Aging Process in Solid Dielectrics</u>

	FY 1984	FY 1985
	$ 100,000	$ 150,000

DOE Contact - Russell Eaton, 202-252-4844
Battelle-Columbus Contact - Mike Epstein, 614-424-6424

Developing an understanding of insulating aging characteristics of solid dielectrics used for underground transmission cable systems. Develop and verify short-term cable test procedures which will accurately predict insulation life for its rated service.

Keywords: Insulators, Organic Polymers, Energy Transmission

52. <u>Threshold and Maximum Operating Electric Stresses for Selected High Voltage Insulations</u>

	FY 1984	FY 1985
	$ 150,000	$ 150,000

DOE Contact - Russell Eaton, 202-252-4844
Cable Technology Lab. (Contract No. DE-AC02-80RA50156) Contact - Carlos Katz, 201-846-3220

Determine threshold voltages and maximum operating electric field strengths for selected high voltage insulation systems. Threshold voltages will be used to predict long range performance of cables and other insulation systems.

Keywords: Insulators, Aging, Energy Transmission

53. <u>Multifactor Aging and Evaluation of Polymeric Materials</u>

	FY 1984	FY 1985
	$ 220,000	$ 220,000

DOE Contact - Russell Eaton, 202-252-4844
ORNL (Contract No. W-7506-eng-006) Contact - Steinar Dale, 615-574-4829

Investigate aging of polymeric film materials. The aging will be done under combined mechanical, electrical, and thermal stresses, as well as under single stress application. The materials will be periodically analyzed for characteristic changes.

Keywords: Insulators, Polymeric Films, Multifactor Aging

54. Solid Dielectrics and Interfacial Breakdown

	FY 1984	FY 1985
	$ 100,000	$ 150,000

DOE Contact - Russell Eaton, 202-252-4844
ORNL Contact - Steinar Dale, 6150-574-4829

Investigate electron and ion transports across interfaces between a solid dielectric and metal. Effects of electric fields, impurities, defects, and microstructures at the interfaces will be studied.

Keywords:

55. Investigation of Interfacial Phenomena in Compressed Gases

	FY 1984	FY 1985
	$ 75,000	$ 75,000

DOE Contact - Russell Eaton, 202-252-4844
ORNL Contact - Steinar Dale, 615-574-4829

Investigate the initiation and propagation mechanisms of surface discharges along insulators in compressed gases. Measurements will be made of the secondary yield coefficients from insulator surfaces in the N_2 and SF_6. Models of the discharge propagation will be made.

Keywords: Insulators, Gaseous Dielectrics, Interfacial Phenomena

56. Interfacial Aging Phenomena in Power Cable Insulation Systems

	FY 1984	FY 1985
	$ 0	$ 150,000

DOE Contact - Russell Eaton, 202-252-4844
ORNL Contact - Steinar Dale, 615-574-4829

Investigate aging of semi-conducting/polymer interfaces. Phase II will be initiated using purified materials of semiconducting shields. Union Carbide has agreed to supply the required varieties of materials.

Keywords: Insulators, Extruded Polymeric Materials

57. Study of Dynamic Insulation with Advanced Metal Oxide (ZnO) Materials

	FY 1984	FY 1985
	$ 0	$ 100,000

DOE Contact - Russell Eaton, 202-252-4844
ORNL Contact - Steinar Dale, 615-574-4829

Determine performance of ORNL-developed sol-gel ZnO material in overhead line insulators. The performance will be compared with that of insulators with commercial ZnO material which was studied in FY 84 and FY 85.

Keywords: Insulators, Metal Oxide Materials

58. <u>Development of Amorphous Ferromagnetic Alloy for Motors and Transformers</u>

	FY 1984	FY 1985
	$ 100,000	$ 150,000

DOE Contact - Russell Eaton, 202-252-4844
ORNL Contact - Steinar Dale, 615-574-4829

Investigate micro-alloying of FeO- and Ni-based metallic glasses will continue. A major effort will be to develop understanding of the mechanism by which cerium additions affect the mechanical and magnetic properties. Other elements which can improve the embrittlement problem in metallic glasses will also be investigated.

Keywords: Amorphous Ferromagnetic Alloys

59. <u>AC Superconducting Power Transmission Cable Development</u>

	FY 1984	FY 1985
	$1,600,000	$1,500,000

DOE Contact - Russell Eaton, 202-252-4844
Brookhaven National Laboratory (Contract No. ET-76-C-02-0016) Contact- E. Forsyth, 516-282-4676.

Develop an underground AC superconducting cable system (138 kV, 4000A) based upon a flexible cable employing a Nb_3Sn tape and an insulation system consisting of a synthetic tape impregnated with supercritical helium (refrigerant). Develop optimized polymeric film tapes for superconducting and conventional cable systems.

Keywords: Superconductors, Insulators (Organic Polymers), Energy Transmission

Building Systems Division

60. Unguarded Flat Insulation Nichrome Wire Screen Tester

	FY 1984	FY 1985
	$ 100,000	$ 170,000

DOE Contact - Bill Gerken, 202-252-9191
ORNL Contact - David McElroy, 615-574-5976

Materials under investigation include mineral fiberboard, and powdered insulations. Most existing insulation test equipment has been designed to provide data on steady-state thermodynamic conditions. In actual use, however, insulating materials experience a continually changing thermal environment. The research is designed to (a) validate the device through comparisons with guarded hot plates, and (b) study transient thermodynamic processes in insulation materials. A series of technical presentations and reports, detailing the equipment and the results of a variety of test series, is planned.

Keywords: Building Insulation, Heat Transfer, Nondestructive Evaluation

61. Settled Density Studies of Loose-Fill Insulation

	FY 1984	FY 1985
	$ 25,000	$ 50,000

DOE Contact - Bill Gerken, 202-252-9191
ORNL Contact - David McElroy, 615-574-5976

Loose-fill cellulosic and mineral fiber insulating materials are being subjected to both laboratory and field studies to determine the effects of settling on density and R-value. These materials are typically sold on the basis of the R-value as-installed. R-value is a function of insulation thickness and density, and pronounced settling results in a lower than anticipated insulating capacity for a given quantity of material. Laboratory testing involves vibration of these materials in a simulated wall cavity. The in-situ studies consist of repeated visits to sites in several parts of the country, over as long as two years, to record measurements of insulation depth and density in residential attics. A series of reports and technical presentations will result from this effort.

Keywords: Building Insulation, Settled Density, Nondestructive Evaluation

62. Heat Flow Modeling

	FY 1984	FY 1985
	$ 100,000	$ 100,000

DOE Contact - Bill Gerken, 202-252-9191
ORNL Contact - David McElroy, 615-574-5976

(a) Mathematical modeling of heat transfer along longitudinal and radial coordinates. One dimensional heat flow studies in various materials being undertaken and calculation of errors associated with edge heat loss effects also considered.

(b) Physical description of heat transfers in a material with respect to "apparent" thermal conductivity. Detailed study of factors that contribute to heat transfer phenomena.

Keywords: Building Insulation, Heat Transfer, Mathematical Modeling

63. <u>Improved Standard Reference Materials</u>

	FY 1984	FY 1985
	$ 197,000	$ 100,000

DOE Contact - Bill Gerken, 202-252-9191
National Bureau of Standards Contact - Brian Rennex, 301-921-3195

Candidates for improved standard reference materials are being investigated under this task, using a one meter diameter line-heat-source guarded hot plate. At present, only two materials are available from NBS for calibrating guarded hot plates and heat flow meters. A need exists to supply the measurement community with calibration samples whose apparent thermal conductivity and thermal resistance is both higher and lower than those now available, either using materials that more nearly resemble those that will be measured in current production or using an entirely new calibration material approach. The results of this effort will be, first, an assessment of candidate materials and, later, an improved standard reference material.

Keywords: Building Insulation, Heat Transfer, Nondestructive Evaluation

64. <u>Gas Diffusion and Effective Conductivity of Foam Insulation Versus Age</u>

	FY 1984	FY 1985
	$ 95,000	$ 50,000

DOE Contact - Bill Gerken, 202-252-9191
Massachusetts Institute of Technology Contact - Leon Glicksman, 617-253-2233

Freon-blown rigid urethane foam insulation is being investigated under this task, to quantify the degree to which the effective thermal conductivity of insulation foamed with low thermal conductivity refrigerants changes due to diffusional effects as the insulation ages. A quasi-one dimensional model with upper and lower limits is used to examine heat conduction through the solid and gas in the foam insulation, and to study the effect of cell-wall geometry and cell arrangement on the thermal resistance, as well as the effect of the thermal conductivity of the solid and the amount of solid in the corners of the nodules. The transparency of the cell walls to infrared radiation and the transmission of thin layers of insulation is being measured to evaluate the extinction coefficient versus wavelength. A multi-layer heat transfer model is used together with the measured extinction coefficient to calculate the overall thermal conductivity. The project objective is to develop a combined mass and heat transfer model which will predict that material's overall thermal resistance to aging as well as to develop new concepts which reduce overall conductivity. This work is in follow-up to work begun by the ECUT program.

Keywords: Building Insulation, Heat Transfer, Diffusion

65. Corrosiveness of Thermal Insulating Materials

	FY 1984	FY 1985
	$ 30,000	$ 20,000

DOE Contact - Bill Gerken, 202-252-9191
Stevens Institute of Technology Contact - Rolf Weil, 201-420-5257

The corrosiveness of four materials - cellulose, rock wool, fiberglass, and urea-formaldehyde foam - is being investigated to determine their effects on the metals with which they may come in contact when used as thermal insulation in residential buildings. Metal coupons are exposed to the insulating materials under laboratory and field conditions. A round robin test series involving several laboratories is being conducted using leachants from the insulating materials. Corrosion is evaluated by coupon weight loss and voltammetry. The objective of this study is to develop a uniform method for determining the corrosiveness of these materials.

Keywords: Building Insulation, Corrosion, Leaching

66. Smoldering Combustion Hazards of Thermal Insulation Materials

	FY 1984	FY 1985
	$ 64,000	$ 8,000

DOE Contact - Bill Gerken, 202-252-9191
National Bureau of Standards Contact - Thomas Ohlemiller, 301-921-3771

Cellulosic insulation is being studied under this task to (a) examine the conditions and mechanism for transition from smoldering to flaming combustion, with special emphasis on the effect of forced air flow past or through the smoldering insulation, (b) determine how much various combustion retardants in the insulation influence the transition process, and (c) assess whether a test method for smoldering-to-flaming tendency is needed and is feasible. Cellulosic insulation is particularly prone to smoldering combustion. Once initiated, smoldering is self-sustaining and provides a relatively easy pathway to flaming combustion that is not precluded by the presence of flame retardants. In a test apparatus, air is forced across or through a layer of insulation, and smoldering is initiated by an igniter. Behavior of the smolder zone is followed by thermocouples embedded in the insulation, by monitoring the major exhaust gases, and by a near infrared TV camera. The expected output of this activity will be a technical report covering the research and a suggested standard test for the tendency to transition.

Keywords: Building Insulation, Combustion Ignition, Transition and Propagation, Fire Safety

67. Reflective Foil Thermal Performance Modeling

	FY 1984	FY 1985
	$ 39,000	$ 40,000

DOE Contact - Bill Gerken, 202-252-9191
Tennessee Technological University Contact - David Yarbrough, 615-528-3494

Modeling of reflective foil radiation barrier systems is being conducted as part of an effort to develop an acceptable method for testing the R-value of such systems. No such test now exists, making it difficult to make valid comparisons between foil and other insulating materials. A technical report will be prepared at the conclusion of this effort.

Keywords: Building Insulation, Heat Transfer, Mathematical Modeling, Reflective Foils, Metals

68. Assessment of Urea-Formaldehyde Foam Insulation

	FY 1984	FY 1985
	$ 50,000	$ 0

DOE Contact - Bill Gerken, 202-252-9191
National Bureau of Standards Contact - Walter Rossiter, 301-921-3109

An assessment of current knowledge concerning urea-formaldehyde foam insulation (UFFI) is being conducted to update the information base on the properties and use of this material, excluding those which relate specifically to health-related aspects. Literature search, correspondence with researchers and building officials, both within and outside the U.S., and visits to selected laboratories and UFFI removal sites are being employed to develop the data base. A technical report is being prepared.

Keywords: Building Insulation, Urea-Formaldehyde Foam, Organics

69. High Temperature Insulation Standard Reference Materials

	FY 1984	FY 1985
	$ 50,000	$ 50,000

DOE Contact - Bill Gerken, 202-252-9191
National Bureau of Standards Contact - Jerome Hust, 303-497-3733

Cerroboard and a high temperature loose-fill insulation are candidates to be investigated for use as new Standard Reference Materials (SRM), using a new 800 degree K guarded hot plate being completed as part of this effort. High temperature SRMs are needed in the industrial insulation field, and it is expected that this effort will complete certification testing of one such material during FY 1986.

Keywords: Industrial Insulation, Heat Transfer, Nondestructive Evaluation

70. Radiation Transmission Properties of Thermal Insulation

	FY 1984	FY 1985
	$ 41,000	$ 40,000

DOE Contact - Bill Gerken, 202-252-9191
University of Kentucky Contact - Timothy Tong, 606-257-3236

This project is developing a data-reduction method for determining the thermal conductivity of thermal insulation from transient heat transfer data and is measuring radiation transmission properties. The energy transport equation being used includes conduction and radiation heat transfer terms, and is an extension of Fourier's law for conductive heat flow. The output will be a data reduction method for dynamic test results.

Keywords: Building Insulation, Radiative Heat Transfer, Computer Modeling

71. Theory of Radiative Heat Transport in Low-Density Insulations

	FY 1984	FY 1985
	$ 13,000	$ 30,000

DOE Contact - Bill Gerken, 202-252-9191
University of Connecticut Contact - Paul Klemens, 203-486-3134

Radiative heat flow under transient conditions is divided into an instantaneous component that is transmitted without interacting with the insulation, and an absorbed and re-emitted component that contributes to diffusive heat transfer. This theoretical mathematical and physics-based analysis employs a realistic model that accounts for this division. A new heat transfer equation will be derived and applied to steady-state and transient test cases. The analysis will also lead to computer simulations of heat transfer for diurnal cycle effects and for measurement techniques such as laser diffusivity and the flat screen tester. This project is complementary to the radiation transmission properties study listed above, and will result in technical reports and papers describing the work.

Keywords: Building Insulation, Radiative Heat Transfer, Mathematical Analysis

Building Equipment Division

The mission of the Building Equipment Division is to provide the long range technical support needed to supply the private sector with the technological basis for developing and testing high efficiency equipment utilized in the operation of residential and commercial buildings. This equipment supplies the heating, cooling, lighting, hot water, and other services required to operate a building efficiently and offer its occupants a comfortable environment. The division supports applied research in the engineering phenomena surrounding the conversion of raw energy in the form of oil, gas, and electricity into the useful energy forms of heat, refrigeration, and light. The division supports the development and revision of the DOE test procedures for consumer products. As part of the applied research program, the division conducts research on materials problems that are key to advanced technology equipment.

72. Materials for Condensing Heat Exchangers

	FY 1984	FY 1985
	$ 485,000	$ 125,000

DOE Contact - Danny C. Lim, 202-252-9130
Battelle Contact - Richard Razgaitis, 614-424-4212
Brookhaven Contact - Roger J. McDonald, 515-282-4197

This project investigates materials feasible for use in heat exchangers for condensing oil- and gas-fired heating systems. Properties of metallic and non-metallic materials are being experimentally evaluated for corrosion rates, stress resistance, and fabrication techniqhes under corrosive condensate environments. Low cost materials capable of 30 year service life are being sought.

Keywords: Corrosion, Materials, Characterization, Ceramics, Polymers, Coatings, Metals Fabrication Techniques

73. Advanced Insulation for Appliances

	FY 1984	FY 1985
	$ 162,000	$ 250,000

DOE Contact - Ronald Fiskum, 202-252-9130
ORNL Contact - Fred Creswick, 615-574-2009

The objective of this project is to develop the technology for advanced insulation for refrigeration systems and appliances having an R-value of 20 hr. Ft^2Btu in @ 200 degrees F. To evaluate the thermal conductivity of materials or combinations of materials that are potentially suitable for advanced insulation, and to develop the best transfer theory governing novel insulation concepts.

Keywords: Conductivity, Material Characterization

74. Non-Azeotropic Refrigerant Mixtures

	FY 1984	FY 1985
	$ 189,000	$ 400,000

DOE Contact - Ronald Fiskum, 202-252-9130
ORNL Contact - Phil Fairchild, 615-574-2020

The objective of this project is to investigate and expand the knowledge base of non-azeotropic refrigerants for use in refrigeration systems in an effort to improve the energy efficiency. To develop computer codes for design and investigative purposes to enhance the understanding of the operational characteristics of non-azeotropic refrigerant mixtures. To identify necessary modifications to the system for enhanced compatability with various mixtures. To test and evaluate novel systems and components. To produce mixture properties data.

Keywords: Refrigerants, Refrigeration Systems

75. Mercury Isotope Separation Process

	FY 1984	FY 1985
	$ 50,000	$ 0

DOE Contact - Robert Boettner, 202-252-9136
GTE Sylvania Contact - Bill Staubitz, 617-777-1900

The material under investigation is Mercury (Hg) with its various isotopes that are used as a fill gas in discharge lamps to maintain the discharge. The applied research effort is aimed at determining the efficiency improvement of fluorescent lamps that have altered isotope compositions and developing an efficient and high throughput isotope separation process that would enable the retrieval of selected isotopes from a natural composition of mercury. The problems under investigation are identification of efficiency improvements, identification of an efficient separation process, construction and operation of a laboratory scale reactor, and improvement of separation process efficiency. The process used for the isotope separation is a photochemical technique that selectively combines the desired isotope through the use of a highly selective optical filter with an appropriate reactant. The expected output of this project is the identification of efficiency improvements in altered composition fluorescent lamps and the development of an effective separation process.

Keywords: Metals, Isotope Separation

76. Mercury Isotope Enrichment	FY 1984	FY 1985
	$ 120,000	$ 80,000

DOE Contact - Robert Boettner, 202-252-9136
Lawrence Berkeley Laboratory Contact - Sam Berman, 415-486-5682

The material under investigation is the element mercury (Hg) and its various isotopes that are used as a fill gas (in vapor form) in discharge lamps to maintain the discharge. The research is both basic and applied and was undertaken for the purpose of improving the efficiency of the conversion of electricity to visible spectrum radiation. Based on a theory developed by Dr. Berman, improved efficiency can be achieved by increasing the concentration of certain Hg isotopes that are found naturally and normally used in lamp fills. The problems under investigation are determining the optimum isotope mix, both technically and economically. The investigation involves precipitating desired Hg isotopes from HgO feedstock, introducing the isotopes into the test lamps in the desirable concentrations and testing the radiation characteristics for improved ultraviolet radiation. The expected results include the determination of an optimum isotope mix for an efficiency improvement of 10-15%.

Keywords: Metals, Precipitation, Radiation

77. Zeeman Effect on Lamp Gas Plasma	FY 1984	FY 1985
	$ 60,000	$ 40,000

DOE Contact - Robert Boettner, 202-252-9136
Lawrence Berkeley Laboratory Contact - Sam Berman, 415-486-5682

The specific material under investigation is Mercury (Hg) and its isotopes that are used in gas discharge lamps. This basic research effort aims to determine the improvement of efficiency of radiation of ultraviolet spectra through the application of a magnetic field to the lamp discharge. The problems under investigation are the quantity and characteristics of the phenomena and its potential for lamp efficiency improvements. The techniques used to study this phenomena are the testing lamps containing various Hg isotope mixes enclosed by a Helmholtz coil that generates the magnetic field. The project is expected to identify the increase in ultraviolet radiation (253.7nm) as a function of magnetic field strength for each type of lamp. These test results will then be compared to theoretical predictions developed earlier by Dr. Sam Berman.

Keywords: Metals, Radiation

78. Absorption Fluid Pairs Research	FY 1984	FY 1985
	$ 500,000	$ 100,000

DOE Contact - Ronald Fiskum, 202-252-9130
ORNL Contact - George Privon, 615-574-1013

The objective of this project is to develop a complete data base on existing known fluid pairs over the temperature and pressure ranges experienced by heat pumps. To develop a methodology for screening characterizing and selecting novel fluid pairs and ternary mixtures for advanced absorption cycles. To explore selected materials for corrosion effects and compatibility with existing and novel fluid pairs.

Keywords: Absorption, Fluid Pairs, Corrosion, Heat Pump

This office supports cost-shared research and development for industrial energy conservation technologies that offer large potential for saving scarce fuels and to encourage the private sector to implement and deploy such technologies as they are developed. Materials research is done in support of the technologies under development or to develop materials with lower embodied energy.

Improved Energy Productivity Division

This division conducts research and creates new energy conserving processes for ore reduction, base metals, and basic shape processing; sensing and control instrumentation; concentration, evaporation, separation, and reaction processes and food production and processing.

79. Corrosion Resistant Amorphous Metallic Films

	FY 1984	FY 1985
	$ 225,000	$ 226,000

DOE Contact - Robert Massey, 202-252-2079
JPL Contact - Dennis Fitzgerald, 818-577-9079

A technology is being developed for depositing amorphous metallic films having high corrosion resistance on carbon steel shapes of industrial interest. Magnetron sputtering is being used to deposit mixtures of MoRuB and FeCrPC. The objective is to provide a material of construction that will reduce the impact of corrosion on heat transfer, equipment maintenance and capital cost.

Keywords: Coatings and Films, Sputtering, Corrosion

80. Investigation of Material for Inert Electrodes in Aluminum Electrodeposition Cells

	FY 1984	FY 1985
	$ 169,000	$ 267,000

DOE Contact - M.J. McMonigle, 202-252-2087
MIT Contact - J.S. Haggarty,

Materials being tested are ceramics (TiB_2, LaB_6, $NiO-NiFe_2O_4$). Laser units are being used to generate ultra pure powders and single crystals of candidates. Electrical conductivity and rate of solution tests in cryolite melts will be run. Data will characterize these materials and lead to better candidate materials for inert anodes and stable cathodes.

Keywords: Ceramics, Material Science, Aluminum, Cryolite

81. Diagnosis Sources of Current Inefficiency in Industrial Molten Salt Electrolytic Cells by Raman Spectroscopy

	FY 1984	FY 1985
	$ 65,000	$ 84,000

DOE Contact - M.J. McMonigle, 202-252-2087
MIT Contact - D.R. Sadoway, 617-253-3300

Cryolite, aluminum chloride, and magnesium chloride melts will be analyzed with Raman spectroscopy to determine bath chemistry during electrolysis. Identification of molten species will lead to identification of process chemical steps and possible sources of current efficiency losses.

Keywords: Molten Salts, Cryolite, Aluminum Chloride, Magnesium Chloride

82. Non-destructive Evaluation of Weldments

	FY 1984	FY 1985
	$ 165,000	$ 0

DOE Contact - Robert Massey, 202-252-2079
EG&G Idaho Contact - Basil Barna, 202-252-2079

This project combines an ultrasonic non-destructive evaluation technique with a continuous welding head to detect weld flaws as they occur. A computer algorithm has been devised to evaluate signals generated in the weld. Flaw detection is about at the 85% confidence level currently. The objective is to reduce the energy and materials usage and the time required to produce acceptable welds.

Keywords: Metals, Nondestructive Evaluation

83. Automatic Inspection of Hot Steel Slabs

	FY 1984	FY 1985
	$ 63,000	$ 0

DOE Contact - J.C. Fulton, 202-252-8668
Honeywell, Inc. Contact - D. Waters, 612-638-5944

Steel slabs are the material being tested. It is a proof-of-concept of automated imagery of surface cracks in hot steel slabs. The steel industry needs the capability of hot inspection to encourage hot charging or direct processing of slabs with little or no slab reheat energy. Currently a host site is needed to cost share in continuation of the program. An automatic system to identify and locate cracks in slab surface is expected.

Keywords: Automation, Hot Charging, Steel Slabs, High Temperature

84. Rapid In-Situ Analysis of Molten Metal

	FY 1984	FY 1985
	$ 150,000	$ 51,400

DOE Contact - J.C. Fulton, 202-252-8668
LANL Contact - L. Blair, 505-667-6250

Material of tests is liquid steel. A laser-based system for spectrographic analysis of samples is being developed. The steel industry needs a faster analytical method to increase productivity. Problems relate to the type of laser and the thermal diffusion in the liquid. A system for use in steel refining is expected.

Keywords: Chemical Analysis, Liquid Steel, Laser, Spectrographic Analysis

85. Direct Measurement of Thermal State of Solids

	FY 1984	FY 1985
	$ 146,000	$ 169,000

DOE Contact - J.C. Fulton, 202-252-8668
PNL Contact - Douglas Lemon, 509-375-2306

Materials tested are steels. An ultra-sonic device is being used to determine the temperature distribution in a piece of steel slab or in a recently poured ingot. The steel industry needs the instrument for measurement of heat content of hot slabs or ingots before entering reheating furnaces. It will control the reheating schedule according to heat content. Problems include calibration of various steel alloys for response to ultra-sonic signal. Development of an instrument is expected.

Keywords: Temperature Distribution, Ultra-sonics, Physics, Heat Transfer, Metallurgy, Steel

OFFICE OF VEHICLE AND ENGINE R&D

The Office of Vehicle and Engine R&D (OVERD) has established a number of programs to conserve energy used for transportation and to shift transportation energy demand to nonpetroleum fuels.

The Vehicle Propulsion Technology Development program is underway to provide industry with proof-of-concepts for advanced gas turbine and Stirling engine technologies that demonstrate improvements in fuel efficiency and to develop technology for heavy-duty diesel operation under uncooled minimum friction conditions, including waste heat utilization.

The Advanced Materials Development program is to establish an industrial technology base capable of providing reliable and cost-effective structural ceramics for application to advanced heat engines. Project management responsibility for the Heat Engine Highway Vehicle Systems project (gas turbine and Stirling engines) and the Heavy Duty Transport Technology project (diesel engine) has been delegated to the NASA Lewis Research Center. Project management of the Ceramic Technology for Advanced Heat Engines project (Advanced Materials Development program) has been assigned to the Oak Ridge National Laboratory (ORNL). The Army Materials and Mechanics Research Center (AMMRC) support is part of the Ceramic Technology project under ORNL technical management.

The success of these advanced heat engine systems depends strongly on the development of new or improved materials. Ceramic materials are needed for the hot-flow-path components of the advanced gas turbine and the minimum friction adiabatic (uncooled) diesel engines, to meet operating temperature and manufacturing cost requirements. The Stirling engine requires low-cost iron-based alloys capable of operating at high temperatures while exposed to high-pressure hydrogen. Material technology development programs are underway for each of these heat engine systems. The generic ceramic technology program consists of three general topics: materials and processing; data base and life prediction; and design methodology. To support the advanced material work conducted under this and other research programs, a High Temperature Materials Laboratory (HTML) is being constructed at ORNL.

Key elements of each program are organized and described briefly in the following. Robert B. Schulz is the DOE contact, (202) 252-8055, for overall coordination of the following OVERD material projects.

	FY 1984	FY 1985
86. Powder Characterization	$ 34,000	$ 31,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
MIT Contact - H.K. Bowen, 617-253-6892

The four areas to be investigated include solution chemistry, laser vapor chemistry, and organometallic chemistry, and other novel techniques.

Specific goals and plans for this work are reviewed by an MIT-developed industrial consortium at regular meetings at MIT.
Keywords: Structural Ceramics, Powder Synthesis, Powder Processing

87. <u>Powder Synthesis and Characterization</u>

	FY 1984	FY 1985
	$ 130,000	$ 0

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123

Silicon carbide synthesis focuses on carbothermic reduction of sol-gel precursors, including rotary furnace reactions. Silicon carbide powders have been synthesized using fumed silica and carbon precursors: pitch, sucrose, and phenolic resin at temperatures between 1500 and 1650 degrees C.

Keywords: Monolithics, Silicon Carbide, Sintering

88. <u>Silicon Carbide Powder Synthesis</u>

	FY 1984	FY 1985
	$ 112,000	$ 110,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - E.L. Long, Jr., 615-574-5172
SOHIO/Carborundum Contact - John Halstead, 716-278-2330

Gas phased reactions in a plasma reactor has been selected after a review of the powder synthesis flow sheets described in the competitive proposals.

Keywords: Silicon Carbide, Sintering, Structural Ceramics

89. <u>High Pressure Sintering Furnace</u>

	FY 1984	FY 1985
	$ 79,000	$ 80,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
AMMRC/GEO Contact - George E. Gazza, 617-923-5408

This project provides technical support for the project entitled "Sintering of Si_3N_4" (AMMRC).

Keywords: Sintering, Silicon Nitride, High Pressure

90. <u>Si_3N_4 Powder Synthesis</u>

	FY 1984	FY 1985
	$ 112,000	$ 110,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - E.L. Long, Jr., 615-574-5172
Ford Motor Co. Contact - Gary M. Crosbie, 313-574-1208

Emphasis will be placed on control of particle nucleations and choice of seed materials.

Keywords: Silicon Nitride, Powder Synthesis, Engines

91. Sintering of Si_3N_4

	FY 1984	FY 1985
	$ 71,000	$ 70,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
AMMRC Contact - R.N. Katz, 617-923-5415

Use post-heat Si_3N_4 treatments to increase the viscosity of phases produced by sintering Si_3N_4 with Y_2O_3/Al_2O_3 additions. Use high N_2 overpressure either directly or by use of a two-step technique.

Keywords: Silicon Nitride, Sintering, High Temperature Service

92. Ceramics for Stirling Engine Applications

	FY 1984	FY 1985
	$ 170,000	$ 26,000

DOE Contact - Patrick L. Sutton, 202-252-8012
NASA LeRC Contact - Tom Herbell, 216-433-4000, ext. 6905

Assess the potential of several candidate ceramics for application to Stirling engines. Concentrate on investigation of mullite whose properties appear to be ideally suited to Stirling engine applications, especially in high strength applications.

Keywords: Ceramics, Mullite, Stirling Engine, Silicon Carbide, Silicon Nitride

93. Silicon Carbide Whiskers

	FY 1984	FY 1985
	$ 35,000	$ 0

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
Los Alamos National Laboratory Contact - George Hurley, 505-667-9498

A Vapor Liquid Solid (VLS) process furnace is being constructed, and 100g of beat-SiC whiskers produced for evaluation by ORNL.

Keywords: Silicon Carbide, Whiskers, Toughness

94. Dispersion Toughened Silicon Carbide

	FY 1984	FY 1985
	$ 100,000	$ 77,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123

Initially conventional uniaxial hot pressing and hot isostatic pressing are utilized for fabrication of dispersion toughened SiC. Doping of dispersoids will involve solid state mixing. Microstructures and mechanical properties are determined.

Keywords: Dispersoids, Toughness, Silicon Carbide, Sintering, Hot Pressing, Hot Isostatic Pressing

95. Si_3N_4 - Metal Carbide Composite

	FY 1984	FY 1985
	$ 300,000	$ 38,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - Mark Janney, 615-574-4281
GTE Laboratory Contact - S.T. Bulzan, 617-890-8460

Develop silicon nitride matrix composite based on a commercial GTE material with SiC and other particles or whiskers dispersed in the matrix. Characterize the material. Develop a low-cost, near-net-shape process (injection molding) for fabricating CATE turbine blades.

Keywords: Toughness, Near-net-shape Processing, Whiskers, Particulates, Si_3N_4 Matrix

96. Si_3N_4-SiC Whisker Composite

	FY 1984	FY 1985
	$ 120,000	$ 35,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - T.N. Tiegs, 615-574-5173
AiResearch Casting Co. Contact - Hun Yen, 213-618-7449

Standard powder processing specifications will be used. Hot pressing, sintering, and/or HIPing will be used for final consolidation. Material will be characterized. A low cost slip casting process will be developed.

Keywords: Structural Ceramics, SiC Whiskers, Hot Pressing, Hot Isostatic Pressing, Near-net-shape Processing

97. Si_3N_4 Matrix Transformation Toughened Si_3N_4

	FY 1984	FY 1985
	$ 140,000	$ 35,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - T.N. Tiegs, 615-574-5173
Rocketdyne Contact - Harry Carpenter, 818-710-3828

Develop a transformation-toughened silicon nitride composite based on commercially available silicon nitride powder and a hafnia-rich mixed oxide for retention of strength and toughness at high temperature.

Keywords: Silicon Nitride Matrix, Composite, Near-net-shape Processing, High Temperature

98. Advanced Transformation Toughened Oxides

	FY 1984	FY 1985
	$ 90,000	$ 160,000

DOE Contact - Robert B. Schulz, 202-252-8055
AMMRC Contact - R.N. Katz, 617-923-5415
University of Michigan Contact - T.Y. Tien, 813-764-9449

Research includes alloying of alumina-based ceramics with chromia to lower thermal conductivity of the ceramic material. Investigate sintering conditions, thermal conductivity, hardness, and fracture toughness.

Keywords: Transformation-Toughened, Sintering, Engines, Oxides, Thermal Conductivity

99. Improved Transformation-Toughened Ceramics

	FY 1984	FY 1985
	$ 83,000	$ 100,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - P.F. Becher, 615-574-5157
Norton Co. Contact - C.A. Ebel, 617-853-1000, ext. 2351

The mechanical property goals are:

	Temperature, Degrees C			
	22	500	750	1000
• Fracture Strength, MPa	600	500	500	500
• Fracture Toughness, MPa $m^{1/2}$	8			6

- Room temperature strength and toughness retained after aging at 1000 degrees C.
- Thermal conductivity greater than 0.1 W/cm at T greater than 400 degrees C.

Keywords: Transformation-Toughened, Sintering, Diesel Engines, Powder Synthesis

100. Injection Molded Composites

	FY 1984	FY 1985
	$ 0	$ 200,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123

First approach -- Demonstrate a complex shape forming capability for Al_2O_3-SiC whisker composites, utilizing wax- or polymer-based binder to injection mold test bars. Second approach -- Develop complex shape forming techniques which improve on wax- or polymer-based molding techniques currently in use.

Keywords: Injection Molding, Composites, Binders, SiC Whiskers

101. SiC Whisker Reinforced Ceramics

	FY 1984	FY 1985
	$ 200,000	$ 345,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - P.F. Becher, 615-574-5157

Development of whisker reinforced composites emphasizes four areas: (1) characterization of whiskers with respect to whisker-matrix interface properties; (2) characterization of mechanical properties as a function of composition and temperature; (3) pressureless sintering of the composites; and (4) development of whisker-reinforced matrices having low thermal conductivity.

Keywords: Oxide Matrix, Alumina, Mullite, SiC Whiskers, Sintering, Structural Ceramics

102. Sol Gel Oxide Powder

	FY 1984	FY 1985
	$ 105,000	$ 100,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123

Prepare nitric acid dispersal sols. Adjust pH to govern agglomerations of crystallites and control surface area and sinterability of dried gel particles. Determine most promising phase-stabilized alloys of ZrO_2 for use in dispersed phase toughening of alumina. Develop rapid solidification methods.

Keywords: Transformation-Toughened, Oxide, Sintering, Whiskers, Powder Synthesis

103. Mullite-SiC Whisker Composites	FY 1984	FY 1985
	$ 0	$ 130,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - T.N. Tiegs, 615-574-5173
General Electric Contact - S. Musikant, 215-354-3020

Liquid phase sintering will be evaluated for final consideration. Elastic modules, four-point bend strength, density, thermal expansion, thermal conductivity, and fracture toughness will be determined. A low cost, near-net-shape process will be developed. Research will lead to the development of a mullite matrix composite with SiC whiskers dispersed in the matrix.

Keywords: Composites, SiC Whiskers, Sintering, Near-Net-Shape, Engines, Mullite

104. Transformation-Toughened Ceramics	FY 1984	FY 1985
	$ 178,000	$ 200,000

DOE Contact - Stephen J. Goguen, 202-252-8055
NASA LeRC Contact - George M. Prok, 216-433-4000, ext. 981
General Electric Contact - Solomon Musikant, 215-354-3020

Three ceramic systems will be investigated: mullite, aluminum, and SIALON. Alloys of HfO_2-ZrO_2 will be used as toughening agents. Processing parameters will be optimized, specimens will be fabricated, and materials will be characterized.

Keywords: Ceramics, Transformation-Toughening, Advanced Heat Engines

105. Advanced Coating Technology AGT	FY 1984	FY 1985
	$ 0	$ 100,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

Procurement plan for FY 1985.

Keywords: Coatings, Films

106. CVD and Sol Gel ZrO_2	FY 1984	FY 1985
	$ 200,000	$ 0

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

Assess the coating needs for advanced heat engine technology. Further develop ZrO_2 base coatings. Develop partially stabilized ZrO_2 (PSZ) coatings prepared by CVD. Document results for low temperature CVD ZrO_2 coating deposition.

Keywords: Chemical Vapor Deposition, Coatings, Zirconia, Thermal Insulation, Toughness

	FY 1984	FY 1985
107. Development of Thermal Barrier Coatings	$ 87,000	$ 255,000

DOE Contact - Stephen J. Goguen, 202-252-8055
NASA LeRC Contact - M. Murray Bailey, 216-433-4000, ext. 5181
Allison Gas Turbine Co. Contact - David L. Clingman, 317-242-4535

Test specimens of at least three Yttria-stabilized zirconia thermal barrier coatings (TBC) systems have been prepared using automated plasma spray equipment. Specimens have been screened for thermal shock fatigue resistance, ranked according to erosion resistance, and evaluated for corrosion oxidation resistance. Most promising specimens will be applied to valves, fire deck, and piston dome of a single cylinder diesel engine for evaluation.

Keywords: Thermal Coating, ZrO_2, Fatigue, Corrosion, Advanced Diesel Engine

	FY 1984	FY 1985
108. ZrO_2-CrO_3 Coating Evaluation	$ 113,000	$ 0

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - E.L. Long, Jr., 615-574-5172
Cummins Engine Co. Contact - Thomas W. Yonushonis, 812-377-7078

Evaluations to be completed include: microstructure and chemical analysis, including scanning electron microscopy, x-ray diffraction, x-ray fluorescence and/or emission spectroscopy, thermal stability, thermal fatigue. Friction and wear behavior of ceramic coatings in sliding contact will be characterized. Components and coatings will be tested in Cummins test engines.

Keywords: Coatings and Films, Adiabatic Diesel Engines, Zirconia, Chromia

	FY 1984	FY 1985
109. Advanced Coating Technology Diesel	$ 0	$ 200,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

Industry Procurement FY 1985.

Keywords: Chemical Vapor Deposition, Adiabatic Diesel Engine, Coatings

	FY 1984	FY 1985
110. Active Metal Brazing PSZ-Iron	$ 180,000	$ 250,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123

In FY 84, processes were developed and demonstrated for brazing PSZ to nodular cast iron (NCI) at temperatures below 735 degrees C. In FY 85, brazing cycles at 723 and 735 degrees C with 10 minute holds will be qualified for fabricating PSZ/NCI joints in piston quality grade 5506 cast iron; shear strength of braze interfaces will be characterized. In FY 86-87, avenues for improving mechanical properties and lowering the costs of fabricated PSZ/NCI joints will be pursued.

Keywords: Joining Dissimilar Materials, PSZ, Iron Base Alloys, Adiabatic Diesel

	FY 1984	FY 1985
111. Ceramic-Metal Joints AGT	$ 0	$ 105,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

Industry Procurement FY 1985.

Keywords: Joining, Structural Ceramics, Gas Turbine Engine

	FY 1984	FY 1985
112. Diesel Ceramic-Metal Joint Scale-up	$ 0	$ 100,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

Industry Procurement FY 1985.

Keywords: Joining, Ceramic-to-Metal, PSZ, Iron Base Alloys, Adiabatic Diesel Engines

	FY 1984	FY 1985
113. Ceramic-Ceramic Joints AGT	$ 0	$ 100,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

Industry Procurement FY 1985.

Keywords: Joining, Ceramic-to-Ceramic, Similar Materials, Silicon Carbide, Silicon Nitride

	FY 1984	FY 1985
114. Materials Development - Intermetallic Evaluation	$ 200,000	$ 48,000

DOE Contact - Patrick L. Sutton, 202-252-8012
NASA LeRC Contact - Joseph R. Stephens, 216-433-4000, ext. 6676
Case Western University - Krishna Vedula, 216-368-4211

The advantage of intermetallic compounds is their lightweight, good oxidation resistance and resistance to hydrogen permeation, and potential strength at required temperatures. Research is being performed on developing process methods, alloying techniques, and other possible matrix modifications of equatomic aluminides of iron and nickel which will improve low temperature ductility. Part of the effort will include a grant-funded fundamental study at Case Western University on two temperature deformation mechanisms of Fe-50 atomic Al and Ni-50 atomic Al.

Keywords: Intermetallics, Iron Aluminide, Nickel Aluminide, Material Properties

115. Cast Iron Alloy Containing Nonstrategic Elements

	FY 1984	FY 1985
	$ 185,000	$ 150,000

DOE Contact - Patrick L. Sutton, 202-252-8012
NASA LeRC Contact - C.M. Scheurman, 216-433-4000, ext. 5213
United Technologies Research Center Contact - A. Giamei, 203-727-7172

Identify alloy based on Fe-Cr-Mn(Mo)-Al-C(N) system containing asymmetric iron solid solution matrices reinforced by finely dispersed carbide (carbonitride) phases. Apply alloys to fabrication of Stirling engine cylinder and regenerator housings.

Keywords: Alloy Development and Alternative Materials, Iron-Based Alloys, Material Properties

116. High Temperature Coating to Reduce Contact Stress

	FY 1984	FY 1985
	$ 123,000	$ 150,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
Garrett Turbine Engine Co. Contact - Y. Schienle, 602-231-4666

After receiving ZrO_2-20% Y_2O_3, electron beam physical vapor deposition coatings and exposure to static oxidation (1200-1400 degrees C), RBSN, SSN, SSC specimens were subjected to four-point flexure tests and coating evaluation. In FY 1985, task two was revised to "Advanced pre-treatment and coating study" with seven subtasks including oxidation, oxygen diffusion barrier, high purity interlayer, diffusion/graduation zone, coating variation, surface preparation, and mullite coating.

Keywords: Coating, High Temperature ZrO_2, Physical Vapor Deposition, Silicon Carbide, Silicon Nitride

117. Dynamic Interfaces

	FY 1984	FY 1985
	$ 139,000	$ 110,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - E.L. Long, Jr., 615-574-5172
Battelle Columbus Labs Contact - Keith Dufrane, 614-424-4618

Specimens of a monolithic ceramic, ceramic coatings and chrome plated coatings will be obtained from commercial vendors for testing in a diesel engine environment. Specimens will be tested with a wear testing machine that simulates the sliding action and environment of an adiabatic engine. A wear model will be developed.

Keywords: Tribology, Coatings, Adiabatic Diesel Engine Wear

118. Friction and Wear Characteristics of Load Bearing Materials

	FY 1984	FY 1985
	$ 159,000	$ 0

DOE Contact - Stephen J. Goguen, 202-252-8055
NASA LeRC Contact - Howard G. Yacobucci, 216-433-4000, ext. 5331
Westinghouse R&D Center Contact - David J. Boes, 412-256-9387

Evaluate specific carbide, nitride, and oxide materials under loads and temperatures anticipated for an uncooled diesel engine. Candidate materials are silicon nitride, silicon carbide, boron carbide, lithium aluminum silicate, zirconia, Refel, Rene 41, Clevite 300. Compare similar and dissimilar combinations of materials. Evaluate friction and wear characteristics of low friction coatings and solid lubricant infiltrated metallic bodies.

Keywords: Ceramics, Friction and Wear, Coatings and Films

119. Advanced Statistical Calculations

	FY 1984	FY 1985
	$ 25,000	$ 40,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - W.P. Eatherly, 615-574-5220

Determine whether Weibull statistics should be used to represent data. Establish non-failure tolerance limites for the ceramic material.

Keywords: New Concepts, Fracture, Advanced Statistics, Brittle Material

120. Advanced Statistics Calculations

	FY 1984	FY 1985
	$ 222,000	$ 100,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - W.P. Eatherly, 615-574-5220
General Electric Research Lab Contact - C.E. Johnson, 518-385-8649

Perform a literature review to assess current state-of-the-art statistics techniques. Develop analytic methods and algorithms before initiating Monte Carlo calculations. Concurrently, perform studies on fracture position and time-dependent materials.

Keywords: New Concepts, Advanced Statistics, Fracture, Brittle Material

121. Design Allowables Code

	FY 1984	FY 1985
	$ 130,000	$ 130,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
AMMRC Contact - E.M. Lenoe, 617-923-5427

Building of the AMMRC computer code for characteristic experimental strength data, determining design allowables, and interfacing with a finite element analysis code, the code will be developed and improved to accommodate the required advanced statistical concepts.

Keywords: New Concepts, Advanced Statistics, Brittle Material

122. Failure Analysis

	FY 1984	FY 1985
	$ 65,000	$ 0

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
National Bureau of Standards Contact - Nancy J. Tighe, 301-921-2901

An interagency agreement will be placed with the National Bureau of Standards for this analysis. Analysis shall include electron microscopy and small angle neutron diffraction scattering.

Keywords: Environmental Effects, Microstructure, Components, Structural Ceramics

123. Ceramic Durability Evaluation

	FY 1984	FY 1985
	$ 190,000	$ 100,000

DOE Contact - Saunders B. Kramer, 202-252-8012
NASA Contact - Sunil Dutta, 216-433-4000, ext. 611
Garrett Turbine Engine Co. Contact - K.W. Benn, 602-231-4373

Evaluate commercially available silicon carbides and silicon nitrides under extended thermal exposures of up to 2500 degrees F for 3500 hours.

Keywords: Time-Dependent Behavior, Silicon Carbide, Silicon Nitride, Gas Turbine Engine, High Temperature

124. Characterization of Transformation-Toughened Ceramics

	FY 1984	FY 1985
	$ 70,000	$ 80,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
AMMRC Contact - R.N. Katz, 617-923-5415

FY 1985 -- Examine Japanese produced Y203-TZP materials for resistance to over-aging at engine temperatures. FY 1986 -- Complete heat treatment of Japanese materials. AMMRC perform stepped-temperature-stress-rupture and stress-rupture tests. Characterize the Japanese materials.

Keywords: Fracture Toughness, Time-Dependent Behavior, Transformation-Toughened

125. Cyclic Fatigue of Toughened Ceramics

	FY 1984	FY 1985
	$ 0	$ 90,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123

FY 1985 -- Design and fabricate a prototype grip system with self centered features. Complete evaluation of grips and load train at room temperatures. Develop elevated-temperature testing capabilities. Conduct tension-tension fatigue tests on advanced ceramic materials.

Keywords: Tensile Strength, Time-Dependent Behavior, Structural Ceramics, Fatigue

126. Fracture Behavior of Toughened Ceramics	FY 1984	FY 1985
	$ 0	$ 190,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123

Determine key mechanical properties such as fracture strength, fracture toughness, and subcritical crack growth as functions of time and environmental exposure. Conduct detailed microscopic analysis of exposed ceramics to determine phase and composition changes. Formulate physical models of the observed toughening behavior of the ceramics.

Keywords: Fracture Toughness, High Temperature, Crack Growth, Structural Ceramics, Microstructure

127. High Temperature Creep Evaluation	FY 1984	FY 1985
	$ 65,000	$ 44,000

DOE Contact - Patrick L. Sutton, 202-252-8012
NASA LeRC Contact - R.H. Titran, 216-433-4000, ext. 398

Creep properties of both commercial alloys and new experimental alloys will be characterized over a temperature range spanning the proposed operating temperature of the Stirling engine. The effects of brazing cycle and alloy composition on creep-ruptured properties will be evaluated.

Keywords: Alloy Development, Creep Rupture, High Temperature, Stirling Engine

128. Time-Temp Properties of Advanced Ceramics	FY 1984	FY 1985
	$ 100,000	$ 85,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
AMMRC Contact - N. Katz, 617-923-5415

Perform stepped temperature stress rupture (4 point bending) tests on specimens (SiC and Si_3N_4). Initiate tensile testing.

Keywords: Flexural Strength, Time-Dependent Behavior, High Temperature

129. Experimental Life Testing	FY 1984	FY 1985
	$ 230,000	$ 0

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
Ford Motor Co. Contact - A.F. Mclean, 313-322-3855
AMMRC Contact - R.N. Katz, 617-923-5415

Predict time-to-failure from conventional high temperature data bases: MOR, stress rupture, high temperature. Measure time-to-failure in biaxial stress at high temperatures by spin-testing. Compare experimental and calculated reliabilities.

Keywords: Ceramics, Strength, Stress, Engines, High Temperature

130. Alloy Properties in High Pressure Hydrogen

	FY 1984	FY 1985
	$ 110,000	$ 0

DOE Contact - Patrick L. Sutton, 202-252-8012
NASA LeRC Contact - R.H. Titran, 216-433-4000, ext. 398
IIT Research Institute Contact - S. Bhattacharyya, 312-567-4192

Creep properties of candidate Stirling engine alloys will be measured in high pressure hydrogen at engine operating temperatures using a specially designed creep test apparatus. Creep properties measured in Stirling engine alloys at high pressure in hydrogen are compared to tests in air.

Keywords: Creep Rupture, Alloy Development, Hydrogen Embrittlement

131. Structural Ceramics Corrosion/Erosion Studies

	FY 1984	FY 1985
	$ 0	$ 120,000

DOE Contact - Robert B. Schulz, 202-252-8055
NASA LeRC Contact - Carl S. Stearns, 216-433-4000, ext. 6826

Determine the effect of fuel ingested impurities on structural ceramic materials under simulated gas turbine engine conditions.

Keywords: Corrosion, Microstructure, Gas Turbine Engines

132. Corrosion/Erosion Effects

	FY 1984	FY 1985
	$ 0	$ 240,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

Plan a joint effort with NASA in which AGT ceramic material specimens tested in combustion rigs at NASA Lewis Research Center will be made available to this project for detailed analysis and characterization.

Keywords: Corrosion, Erosion, Microstructures, Gas Turbine Engines

133. Environmental Effects in Toughened Ceramics

	FY 1984	FY 1985
	$ 139,000	$ 125,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123
University of Dayton Contact - N. Hecht, 513-229-4341

Determine the water vapor and other environmental degradation processes operative in PSZ and DTA toughened ceramics using the dynamic fatigue measurement technique. Measure flexure strength over a wide range of stressing rates, temperature and atmospheric conditions to quantitatively determine relevant fatigue parameters.

Keywords: Fatigue, Transformation-Toughened Ceramics, Flexure Strength, Microstructure, Environmental Effects

134\. <u>Static Behavior of Toughened Ceramics</u>

	FY 1984	FY 1985
	$ 112,000	$ 120,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
University of Illinois Contact - M.K. Ferber, 217-333-1770

Employ the interrupted static fatigue (ISF) method for determining retained fracture strength of ceramic specimens as a function of stress, time, and temperature. Analyze the results of these tests and calculate fatigue life. Perform microstructural analyses of specimens previously fatigued and fractured.

Keywords: Fatigue, Fracture Strength, Toughened Ceramics, Microstructure

135\. <u>Static Fatigue of Toughened Ceramics</u>

	FY 1984	FY 1985
	$ 175,000	$ 0

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123

Construct and make operational equipment necessary for property measurements. Take v-K measurements at 22 degrees C in H_2O and air. Conduct strength tests (fast fracture) up to 1000 degrees C.

Keywords: Toughened Ceramics, Fatigue, Slow Crack Growth, High Temperature

136\. <u>High Temperature Fracture Toughness Measurement</u>

	FY 1984	FY 1985
	$ 66,000	$ 150,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123
University of Washington Contact - R.C. Bradt, 206-543-2613

Perform critical analysis of known measurement techniques for determining fracture resistance. Identify new approaches. Using selected ceramic material specimens (including beta-SiC, sintered alfa-SiC, sintered Si_3N_4) and two ceramic matrix composites in which the matrix is SiC, Si_3N_4, Al_2O_3, ZrO_2, or MAS, verify the measurement techniques.

Keywords: Fracture Toughness, Structural Ceramics, Monolithic Composites, Microstructure

137\. <u>High Temperature Tensile Testing</u>

	FY 1984	FY 1985
	$ 338,000	$ 100,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
N.C. A&T University Contact - J. Sankar, 919-379-7620

Design and fabricate the ceramic specimens, grips, and extensometer. Use conventional mechanical testing machines for uniaxial tensile testing which include fast fracture, and static and/or dynamic fatigue. Conduct high temperature uniaxial tensile testing of SiC and Si_3N_4.

Keywords: High Temperature, Fracture Mechanics, Fatigue, Silicon Nitride, Silicon Carbide

138. Standard Tensile Test Development	FY 1984	FY 1985
	$ 0	$ 90,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
National Bureau of Standards Contact - Sheldon M. Wiederhorn, 301-921-2901

Construct test fixtures for high temperature tensile testing of sintered SiC to withstand high temperature creep. Collect experimental creep data on model materials using tensile, compressive, and bending test techniques. Provide test fixtures and test specimens, or their design to collate from laboratories to obtain the degree of interlaboratory scatter expected from creep studies.

Keywords: Tensile Strength, Creep, High Temperature, Structural Ceramics

139. Ceramic Component Technology	FY 1984	FY 1985
	$ 90,000	$ 95,000

DOE Contact - Saunders B. Kramer, 202-252-8012
NASA LeRC Contact - Alex Vary, 216-433-4000, ext. 357

NDE methods under study are x-ray, radiography, ultrasonics, scanning laser acoustic microscopy, thermo-acoustic microscopy.

Keywords: Ceramics, NDE

140. Characterization Needs Assessment	FY 1984	FY 1985
	$ 0	$ 80,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - Robert McClung, 615-574-5123

Complete a draft assessment in FY 1985, based on literature search and internal DOE/ORNL working group meetings. Submit draft to selected outside reviewers for additional comments.

Keywords: Characterization, Component Qualifications, Nondestructive Evaluation

141. Non Destructive Characterization	FY 1984	FY 1985
	$ 0	$ 70,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123

As selected NDE techniques are developed and applied to ceramic specimens (first to monolithic ceramic mechanical test specimens and then ceramic composites) from ORNL and contractor research, comparison of mechanical properties will be made for the purpose of correlation.

Keywords: Non Destructive Evaluation, Property Correlations, Structural Ceramics, Composites

142. International Exchange Agreements

	FY 1984	FY 1985
	$ 90,000	$ 100,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

The major goal is to foster the development of voluntary consensus standards for ceramic materials for advanced engines and other conservation applications through international cooperation and calibration with appropriate professional societies, under the sponsorship of the International Energy Agency (IEA).

Keywords: Technology Transfer, International, Structural Ceramics, Advanced Heat Engines

143. NBS Standard Reference Material

	FY 1984	FY 1985
	$ 0	$ 50,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
National Bureau of Standards Contact - Allen Dragoo, 301-921-2901

The domestic powder chosen for characterization as a part of the IEA agreement, Annex II, will be extensively characterized by the National Bureau of Standards and a standard reference powder developed.

Keywords: Technology Transfer, Characterization, Powder, Structural Ceramics

144. Specimens and Hardware for IEA

	FY 1984	FY 1985
	$ 0	$ 50,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

Specimens and hardware for Annex II of the IEA assessment will be procured.

Keywords: Technology Transfer, International, Structural Ceramics

145. Technical Support and Monitoring Contracts

	FY 1984	FY 1985
	$ 0	$ 250,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

This task provides expert technical support and technical program monitoring by cognizant researchers who support industrial and university subcontracts.

Keywords: Technology Transfer, Subcontracts, Industry, Universities

146. Technology Assessment and Planning

	FY 1984	FY 1985
	$ 30,000	$ 30,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

This task involves extensive interaction.

Keywords: Technology Assessment

147. Technology Transfer

	FY 1984	FY 1985
	$ 60,000	$ 120,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - D. Ray Johnson, 615-576-6832

The approach to technology transfer is the involvement of private industry in planning and implementation of the program by means of assessment and coordination activities and by having most of the work done in private industry by means of subcontracts.

Keywords: Technology Transfer, Private Industry, Subcontracts

148. Advanced Gas Turbine Engine Technology (AGT-100)

	FY 1984	FY 1985
	$5,879,000	$4,860,000

DOE Contact - Saunders B. Kramer, 202-252-8012
NASA LeRC Contact - P. Kerwin, 216-433-4000, ext. 770
GM/ALLISON/PONTIAC Contact - H.E. Helms, 317-242-5335

Demonstrate improved fuel economy, reduced emissions, and alternate fuel capability. Develop ceramic materials for most or all of the hot section components. Efforts include material characterizations, process development, and component design and test.

Keywords: Structural Ceramics, Component Design, Monolithic Fabrication, Component Test, Gas Turbine, Rotor, Stator, Combustion

149. Advanced Gas Turbine Engine Technology (AGT-101)

	FY 1984	FY 1985
	$6,070,000	$4,900,000

DOE Contact - Saunders B. Kramer, 202-252-8012
NASA LeRC Contact - Robert C. Evans, 216-433-4000, ext. 770
Garrett/Ford Contact - E.E. Strain, 602-231-2797

Demonstrate improved fuel economy, reduced emissions, and alternate fuel capability. Develop ceramic materials for most or all of the hot section components. Efforts include material characterizations, process development, and component design and test.

Keywords: Structural Ceramics, Component Design, Gas Turbine, Rotor, Stator, Combustor

150. <u>HTML Pre-Operational Support</u>

	FY 1984	FY 1985
	$ 0	$ 160,000

DOE Contact - Anne Marie Zerega, 202-252-8053
ORNL Contact - V.J. Tennery, 615-574-5123

Pre-operational support includes the planning and management activities associated with the construction phase of HTML.

Keywords: High Temperature, User/Facility Research Laboratory Construction

151. <u>Capital Equipment for Advanced Materials Development Program</u>

	FY 1984	FY 1985
	$ 0	$1,900,000

DOE Contact - Robert B. Schulz, 202-252-8055
ORNL Contact - V.J. Tennery, 615-574-5123

Purchase the following equipment: NDE System, Electron Microscope, Powder Characterization Equipment and Instrumentation, Laser Raman Microscope, Ceramic test specimen machining and preparation equipment, ceramic injection molding unit, Ceramic Hot Isostatic Processing (HIP) Unit.

Keywords: NDE, Instrumentation or Technique Development

Active Heating and Cooling Division

This program funds R&D projects with industry and academic institutions directed towards the development of cost-effective, reliable and publicly acceptable active solar heating and cooling systems. A major emphasis of the program is to ensure that the information derived from these projects is made available to all of the members of the solar research, manufacturing and construction communities who will benefit from it.

152. Influence of Combined Stresses on Degradation of Polymeric Coverplate Materials	FY 1984	FY 1985
	$ 320,000	$ 300,000

DOE Contact - John Goldsmith, 202-252-8171
NBS Contact - David Waksman, 301-921-3114

The objectives are to (1) characterize the moisture degradation mechanisms occuring in polymeric cover materials and develop evaluation procedures for such materials when used in humid environments, (2) determine the relationships between microstructural and engineering properties of cover materials and investigate the use of micro-level changes as a tool for the early detection of materials degradation, and (3) develop mathematical models which can be used in conjunction with short-term accelerated aging test data to predict the service life of polymeric materials. This information is used to assess the suitability of polymeric materials for use in low cost, higher performance solar collectors.

Keywords: Polymers, Material Degradation, Solar Collectors

153. Thin Film Materials Research	FY 1984	FY 1985
	$ 300,000	$ 625,000

DOE Contact - John Goldsmith, 202-252-8171
SAN Operations Office Contact - Robert LeChevalier, 415-273-6362

The objective is to identify appropriate materials for glazing, laminates for absorbers, adhesives and fabrication techniques to make a practical, durable and low-cost thin film collector.

Keywords: Organics, Composites, Adhesives and Bonding Agents, Solar Collectors

154. Sorption Studies of Desiccant Materials	FY 1984	FY 1985
	$ 123,000	$ 120,000

DOE Contact - John Goldsmith, 202-252-8171
SERI Contact - Frederica Zangrando, 303-231-1761

The objective is to measure adsorption/desorption characteristics of promising desiccant materials as a function of physical properties, geometry, and operating environment. A gas chromatograph is used to determine these properties for gramma-manganese dioxide and silica gel under isothermal and adiabatic conditions. The data from this project will be used to validate performance models and to identify the suitability of various materials for use in advanced solar desiccant dehumidifiers.

Keywords: Surface, Instrumentation or Technique Development

155. Heat and Mass Transfer Analysis of Advanced Dehumidifiers

	FY 1984	FY 1985
	$ 173,000	$ 300,000

DOE Contact - John Goldsmith, 202-252-8171
SERI Contact - Ahmad Pesaran, 303-231-7636

The objective is to extend, improve, and validate the solid-side resistance model of packed dehumidifier to more advanced, cost-effective dehumidifier geometries for incorporation in performance prediction and design tools. Detailed information on mass transfer as a function of particle size and shape, water loading, particle diffusion coefficient, and geometry will be developed. The initial focus will be on silica gel desiccants.

Keywords: Surface, Predictive Behavioral Modeling

156. Desiccant Materials Contamination Research

	FY 1984	FY 1985
	$ 78,000	$ 0

DOE Contact - John Goldsmith, 202-252-8171
SERI Contact - Terry Penney, 303-231-1751

The objective is to experimentally determine the influence of airborne contaminants on solid desiccant performance/degradation. A comparison of field samples including new and used desiccant specimens will be undertaken. In addition, a literature search on desiccant contamination will be performed.

Keywords: Surface, Instrumentation or Technique Development

157. Research on Liquid Desiccant Materials

	FY 1984	FY 1985
	$ 144,000	$ 100,000

DOE Contact - John Goldsmith, 202-252-8171
ANL Contact - Jack Parks, 312-972-4334

The objective is to identify and evaluate candidate organic liquids on multi-component liquid mixtures for use in the Liquid Desiccants that can be regenerated by Liquid-Liquid Phase Separation (LIQDES-RELLPS) concept. Specific materials to be investigated must have low critical solution temperatures. Candidate materials include amines, amides, and amide polymers, and in particular N-cyclohexyl-2-pyrrolidone (CHP)-water mixture.

Keywords: Organics, Predictive Behavioral Modeling

158. Open Cycle Absorption Chiller Research

	FY 1984	FY 1985
	$ 225,000	$ 0

DOE Contact - John Goldsmith, 202-252-8171
San Operations Office Contact - Robert LeChevalier, 415-273-6362

The objective of the material research aspect of this project is to identify a suitable mixture of absorbent-refrigerant pairs for use in a high performance open cycle absorption system. The combination of an open flow collector/regenerator and low cost/high performance mixture will be explored. Candidate materials include lithium bromide, lithium chloride, and calcium chloride solutions. Experiments to determine crystallization concentrations as a function of temperature will be performed. Equations for calculating the various solutions thermophysical properties will be developed.

Keywords: Predictive Behavioral Modeling

159. Solar Collector Materials Exposure Testing

	FY 1984	FY 1985
	$ 100,000	$ 70,000

DOE Contact - John Goldsmith, 202-252-8171
LANL Contact - Robert Jones, 505-667-6441

The objective is to develop a database of information on the response of various solar collector materials to long-term exposure to solar radiation, elevated temperatures, and moisture. In particular, glazings and absorber materials will be tested at the high altitude exposure test facility. Information on insolation, temperature, humidity, and ultraviolet radiation will be collected and analyzed. The results will be used to aid in correlating short-term and accelerated tests and in developing degradation prediction models.

Keywords: Polymers, Organics, Metals: Non-Ferrous and Ferrous, Coatings and Films

160. Low Cost Process for the One Step Synthesis of U.V. Inhibitor

	FY 1984	FY 1985
	$ 50,000	$ 395,000

DOE Contact - John Goldsmith, 202-252-8171
Helix Associates Contact - Walter Heldt, 302-738-6581

Transparent films require the use of additives to inhibit their degradation as a result of exposure to sunlight (the U.V. component). One of the best known long life additions is tetrahydroxybenzophenone. Extremely high cost has limited the application of this material. This research seeks to develop a low cost one step synthesis of this compound. (This is a Small Business Innovation Program project which is managed by this office.)

Keywords: UV Inhibitors, Manufacture, Materials Degradation, Solar Collectors

161. <u>Development of Improved Desiccant Materials</u>

	FY 1984	FY 1985
	$ 170,000	$ 225,000

DOE Contact - John Goldsmith, 202-252-8171
ANL Contact - Anthony Fraioli, 303-972-7550

The objective is to determine whether lower absorption energetics due to MnO_2 would adversely affect the rates of water take-up. Analysis of powder samples for surface area measurements by gas absorption techniques, water vapor adsorption by gravimetric techniques, x-ray diffraction and scanning electron microscopy are required. Methods to measure and compare adsorption equilibrium rate data for the adsorption of water on MnO_2 and silica gel are developed.

Keywords: Crystalline Material, Surface Effect, Solar Cooling

162. <u>Research and Development on Stainless Steel Thin Material Collectors</u>

	FY 1984	FY 1985
	$ 350,000	$ 320,000

DOE Contact - John Goldsmith, 202-252-8171
BNL Contact - William Wilhelm, 516-282-4708

Development of a thin foil stainless steel/copper foil absorber-heat exchanger solar collector which is ultrasonically welded and capable of withstanding temperatures > 150 degrees C. Foil thickness is the range of 3 mails. Application is for a non-pressurized collector.

Keywords: Metals, Composites, Non-Destructive Evaluation, Material Degradation, Solar Collectors

<u>Passive and Hybrid Solar Energy Division</u>

The objective of the Passive and Hybrid Solar Energy Program is to expand the generic technology base of solar thermal energy, which will allow the private sector to develop passive and hybrid solar systems capable of meeting the range of space conditioning and lighting energy demand typical of American residential and non-residential structures.

The initial thrust of materials R&D projects was to develop toward commercialization passive solar materials and components that incorporate present technology to meet individual specific building related problems.

In the recent phase of passive materials R&D projects were undertaken to systematically explore advanced materials and components as well as thermal processes that have the potential to greatly enhance the thermal performance of passive buildings.

System studies employing realistic estimates for the properties of new candidate materials show that: (1) the efficiency of passive heating systems can be raised to the point where any exterior surface of a building (not just its south wall) can be designed which provide double the efficiency of current designs; and (2) the passive aperture, transport and storage components can be controlled so as to reject thermal energy in the summer.

163. Optical Switching Apertures

	FY 1984	FY 1985
	$ 225,000	$ 100,000

DOE Contact - Dave Pellish, 202-252-8110
SERI Contact - Dave Bensen, 303-231-1162

The objective of this project is to evaluate the feasibility of using solid state electrochromic coatings to control transmittance through apertures in passive solar heated buildings. The emphasis is to develop process and film parameters that are adaptable to large scale architectural window processing. Durability and optical properties of multilayer, absorbtive coatings will be evaluated and optimized.

Keywords: Coatings

164. Optical Switching Materials

	FY 1984	FY 1985
	$ 185,000	$ 100,000

DOE Contact - Dave Pellish, 202-252-8110
LBL Contact - Carl M. Lampert, 415-486-6093

This program provides scientific coordination, materials analysis, and guidance for all DOE contractors in the area of solar optical switching devices. This program is also aimed at research and synthesis of new electrochromic materials with broad band and response characteristics not seen in existing materials (WO_3, IrO_2, MoO_3, etc.). Studies have focused on electrochromic NiO_x. Another part of this program is to identify and synthesize potential compounds that exhibit photochromic or thermochromic properties useful for passive solar apertures. This research does not deal with critical, strategic, or essential materials.

Keywords: Coatings and Films, Microstructure, Sputtering, Switchable Glazings, Surface Characterization and Treatment, Energy Transmission

165. Transparent Insulating Materials

	FY 1984	FY 1985
	$ 150,000	$ 100,000

DOE Contact - Dave Pellish, 202-252-8110
LBL Contact - Arlon Hunt, 415-486-5370

This program investigates the optical, thermal, and structural properties of silica aerogel, a microporous material that has potential for use as an insulating material in glazing systems. Research is being performed on the formation, growth, and drying of the material; on methods for protecting the material from environmental stresses; and on methods for simplifying the synthesis process which is now based on supercritical drying. Results of this research will be clarification of the relationship between optical and thermal properties of the aerogel and its chemistry and structure. The intent is to optimize thermal and optical properties so that the material can be used as a component in a highly insulating window system. This research does not deal with critical, strategic, or essential materials.

Keywords: Insulating Materials, Microstructure, Glazing Thermal Performance

166. Phase Change Thermal Storage Materials

	FY 1984	FY 1985
	$ 265,000	$ 100,000

DOE Contact - Dave Pellish, 202-252-8110
SERI Contact - Dave Bensen, 303-231-1162

Solid state phase change materials (SS PCM's) are being studied for use in thermal energy storage components of passive solar heated buildings. The polyalcohols pentaerythritol ($C_5H_{12}O_4$), trimethylol ethane ($C_5H_{12}O_3$), neopentyl glycol ($C_5H_{12}O_2$) and closely related compounds are the focus of the on-going research. The project objectives are to improve upon the understanding of the solid state phase transformations in these materials and to develop improved SS PCM's based upon this understanding. Possible improvements include enhanced properties, optimized transformation temperatures or more convenient forms (such as composites) for use in buildings.

Keywords: Composites, Phase Change Materials

167. Selective Opaque Coatings

	FY 1984	FY 1985
	$ 80,000	$ 0

DOE Contact - David Pellish, 202-252-8110
Los Alamos Contact - Stan Moore, 505-667-2228

A surface with a selective opaque coating has a high solar absorptance but a low emittance in the far infrared. Selective surfaces are already in wide use for passive collectors, especially in unvented Trombe walls. The performance of the selective surface in this application is well established: a selective surface in conjunction with a single glazing has a performance that is comparable to a normal surface and double glazing. The breakthrough that is required to make this option a significant advantage is the development of coating materials that are much cheaper than those currently available. Progress is being made at Los Alamos and elsewhere on the development of selective paints, the concept involving the mixture of selective metallic flakes with a binder to produce a paint. The paint is applied in a conventional fashion without regard to the thickness of the coating. Accordingly, such paints are called thickness-insensitive selective paints; they are potentially much cheaper than existing selective surfaces.

Keywords: Coatings and Films

168. Daylight Enhancement

	FY 1984	FY 1985
	$ 140,000	$ 100,000

DOE Contact - Dave Pellish, 202-252-8110
LBL Contact - M. Rubin, 415-486-7124

The objective of this program is to identify, develop, and characterize light guide materials and systems to collect and transmit sunlight and daylight within buildings to reduce electric lighting requirements. Studies have concentrated on several types of solid and hollow light guides for various collector optics configurations. Estimations of net usable light flux for several building types is being studied. This research does not deal with critical, strategic or essential material.

Keywords: Polymers, Glasses, Fibers, Bulk Characterization, Energy Transmission

169. Low-Emittance, High-Transmittance Materials

	FY 1984	FY 1985
	$ 130,000	$ 100,000

DOE Contact - Dave Pellish, 202-252-8110
LBL Contact - Mike Rubin, 415-486-7124

The objective of this program is to conduct research to develop the next generation of low-emittance, high-transmittance coatings for the control of radiant heat transfer in buildings. Low-emittance coatings should combine the best optical performance of multilayer interference films and the durability of nitride and oxide semiconductors.

Studies are aimed at the development of refractory optical materials (TiN and TiN_xO_y). These materials are synthesized by reactive sputtering and PCVD and analyzed for their optical and chemical properties. This research does not deal with critical, strategic, or essential materials.

Keywords: Coatings and Films, Microstructures, Sputtering, Surface Characterization and Treatment, Energy Transmission, Polycrystalline Materials

170. Selective Transmittance Materials

	FY 1984	FY 1985
	$ 45,000	$ 0

DOE Contact - Dave Pellish, 202-252-8110
LBL Contact - Carl M. Lampert, 415-486-6093

The objective of this project is to determine desirable angle selective properties and to investigate methods to produce angle selective growth structures. Initially, this study involves research into different methods of producing preferentially oriented structures in a coating or in the substrate and the correlation of growth structures to optical properties required by passive solar design. Specific attention is paid to modification of structures in terms of orientation angle, aspect ratio, dendrite or column spacing. This research does not deal with critical, strategic, or essential materials.

Keywords: Coatings and Films, Microstructures, Surface Characterization and Treatment, Surface Effects, Energy Transmission

Solar Thermal Technology Division

Solar Thermal Technology is developing central receivers, parabolic dishes, and parabolic troughs to concentrate the sun's energy to produce electricity or industrial process heat. The combination of concentrated direct solar flux (to 2,000 suns) and high temperatures (to 2000 degrees F) cause solar unique materials problems that are now being characterized in areas of heat transfer fluids, ceramics and windows. In addition, the solar-caused degradation of silvered polymers is also being studied with the objective being a highly reflective, environmentally stable, low cost reflector.

171. Silver/Polymer Reflector Research

	FY 1984	FY 1985
	$ 402,000	$ 275,000

DOE Contact - Frank Wilkins, 202-252-1684
SERI Contact - Gordon Gross, 303-231-1222

Applied research is being conducted on silver/polymer materials that are resistant to ultraviolet and pollutant degradation, cleanable, mar resistant, have reflectances of 90% or more and useful lives of 5-10 years.

The rationale for the research is that solar concentrators account for about 50% of the installed cost of a solar thermal system. Polymers are a high priority research activity because they offer the potential for substantially reducing the life cycle costs of concentrators and, hence, for solar thermal systems. Silver/polymer reflectors offer the advantages of lighter weight, reduced cost, and design flexibility compared with silvered glass. Also, they provide greater reflectance than the rather durable aluminized polymers currently in use.

This research focuses on studying, testing, characterization and evaluating polymer-coated silver mirrors. Silver is being deposited onto candidate commercially available polymers or polymers modified by laboratory procedures to meet performance requirements. Research is also being conducted to develop an understanding of degradation mechanisms in candidate polymer/silver combinations in simulated solar environments.

The expected result is the identification of at least one silvered polymer that meets the solar thermal requirements - useful life of 5-10 years, reflectance of at least 90% specularity equal to that for silvered glass and resistant to UV and pollutant degradation.

Keywords: Polymers, Sputtering, Surface Characterization and Treatment, Radiation Effects

172. Polymer Synthesis and Characterization

	FY 1984	FY 1985
	$ 348,000	$ 605,000

DOE Contact - Frank Wilkins, 202-252-1684
SERI Contact - Gordon Gross, 303-231-1222

Applied research is being conducted on polymer materials for solar thermal technology applications. The problems being investigated are: identification, testing and evaluation of chemically bound stabilizers/antioxidants to improve the durability of polymers in solar thermal applications; and identification, testing and evaluation of additives for polymers that act as ultraviolet (UV) absorbers and quenchers of excitation energy.

The many attractive features of polymers (e.g., lightweight and low-cost) can be exploited for solar thermal applications only if polymers are able to withstand the stresses of environmental and solar exposure. To date, no effective chemically bound antioxidant exists.

The research focuses on the testing, characterization and evaluation of low-cost candidate polymer materials. Concurrently, research is being conducted to identify or develop and then evaluate chemically bound stabilizers (UV-absorbers, antioxidants, quenchers, etc.) to improve the durability of polymers in solar thermal applications. Modifications of polymers is proceeding along two main approaches - bulk stabilization and surface modification. Candidate polymer/coating or laminate combinations with stabilizer additives are being identified and evaluated regarding their performances.

The expected result of this task is the development of durable, low-cost, lightweight polymer materials for solar thermal applications - materials with a useful life of 5-10 years.

Keywords: Polymers, Coatings and Films, Surface Characterization and Treatment, Corrosion, Radiation Effects

	FY 1984	FY 1985
173. Ceramic Materials Research	$ 362,000	$ 375,000

DOE Contact - Frank Wilkins, 202-252-1684
SERI Contact - Gordon Gross, 303-231-1222

Applied research is being conducted on ceramic materials for high temperature solar thermal technology applications. The problems being investigated are: identification, characterization and testing of ceramic structural materials in contact with molten carbonate salts at high temperatures. Activities include the measurement of mechanical and optical properties of ceramics at temperatures above 800 degrees C. In addition, the chemical stability of ceramics in contact with molten salts will be determined. Twenty candidate ceramic materials, including refractories, fused cast materials and high density alumina have been selected for investigation.

The need for higher operating temperatures in solar thermal technologies in order to broaden their number of applications and perhaps increase their efficiency encourages the search for high temperature materials. Numerous metal alloys can be used up to 850 degrees C, but beyond that point only special refractory alloys can be used.

The long-term objective of this task is to determine the feasibility of using existing high temperature materials for improving the operating range of central receivers and parabolic dishes to above 800 degrees C.

Keywords: Ceramics, Sintering, Surface Characterization and Treatment, Corrosion, Radiation Effects, High Temperature Service

	FY 1984	FY 1985
174. High Temperature Thermal Fluids/Containment	$ 192,000	$ 245,000

DOE Contact - Frank Wilkins, 202-252-1684
SERI Contact - Gordon Gross, 303-231-1222

Applied research is being conducted on heat transfer fluids and storage system materials for high temperatures (i.e., greater than 600 degrees C) solar thermal technology applications. Specific problems being investigated are: identification, characterization and evaluation of heat transfer fluids for use in solar thermal receivers and heat exchangers that operate at temperatures in the range of 600 - 1100 degrees C - materials that are low-cost, chemically inert, resistant to corrosion and able to withstand thermal cycling, non-uniform heating and transient solar input; identification, characterization and evaluation of containment materials for high temperature thermal fluids. The rationale for the project is that systems that operate at temperatures in the range of 600 - 1100 degrees C will require advanced fluids and compatible containment materials to extract efficiently the high temperature heat. Efficient and reliable high temperature receivers depend on the suitable performance of containment materials/fluid pairs. Data obtained from research experiments will form the basis for determining the feasibility of efficient high temperature receivers.

The objectives of the work in 1984 will be to experimentally verify the utility of at least one stable thermal fluid/containment system at 900 degrees C. Research will focus on obtaining a carbonate salt that can serve in the above temperature range with a long lifetime. In addition, the possibility of using direct absorption receiver technology necessitates learning how to darken salts to control their absorptance and to maintain stable conditions when a darkener has been added to the salt.

Keywords: Alloys, Nondestructive Evaluation, Corrosion, High Temperature Service

175. <u>High Temperature Windows</u>	<u>FY 1984</u>	<u>FY 1985</u>
	$ 150,000	$ 75,000

DOE Contact - Frank Wilkins, 202-252-1684
Georgia Institute of Technology Contact - Robert A. Cassanova, 404-894-3589

Applied research is being conducted on materials that can be used to fabricate transparent windows for use in high temperature (i.e., above 600 degrees C) central and distributed solar thermal systems. The problems being investigated are: development and selection of transparent refractory windows capable of withstanding the solar, mechanical and chemical environment of the receiver while transmitting a maximum amount of thermal energy into the reactor; development of methods for inhibiting the devitrification of fused quartz and high-silica window materials when they are employed in solar thermal receivers and chemical reactors.

The rationale for the project is that many high temperature applications require transparent windows over the receiver aperture to contain reactants or other absorbing media and to reduce reradiation and convection losses. The use of a windowed receiver/reactor offers the possibilities for conducting chemical reactions in a unique environment, allowing the direct interaction between the reacting chemical species, or absorbing media, and a high intensity field of radiant thermal energy. The development and selection of such window materials would allow the fabrication of reactors which exploit the unique nature of solar chemical reactors, using concentrated, direct radiant energy.

Coatings are being developed for inhibiting the devitrification of silica-based windows. Emphasis is on boron-silica oxide polymer coatings which have produced encouraging results from preliminary tests.

The expected results of this project are: identification of at least one coating material for inhibiting the devitrification of silica-based windows for solar thermal receivers; and identification of at least one material for fabricating windows for solar thermal system receivers designed to operate at temperatures above 600 degrees C.

Keywords: Silica, Surface Characterization and Treatment, Corrosion, Radiation Effects, High Temperature Service

176. <u>High Temperature Materials - Solar-Caused Degradation</u>

	FY 1984	FY 1985
	$ 85,000	$ 120,000

DOE Contact - Frank Wilkins, 202-252-1684
University of Houston Contact - Lorin Van Hull, 713-749-1154

Applied research is being conducted on absorptive coatings for materials to be used in high temperature solar thermal systems. The problem is to define, characterize and acquire a basic understanding of photo-induced optical and compositional degradation of absorber coatings and other materials exposed to high temperature/high flux solar radiation and utilize that knowledge to modify materials or to develop surface treatments to improve performances and durability. High temperature/high flux solar thermal systems require materials with specialized optical properties (i.e., high solar absorption, low infrared emissivity, solar reflectivity, and long life at high temperatures). For materials with specialized optical (and therefore surface) properties, deterioriation of the surface is often found to depend not only on temperature but also on the solar flux. Determination of the mechanism of the degradation process provides the possibility of preventing the degradation or of developing a new material where the degradation mechanism has been retarded or stopped.

The approach in this project is to: conduct photocorrosion studies of Fe, Al and Cu (important solar thermal materials); conduct photocorrosion studies of commercial solar absorber coatings; produce high temperature/high flux absorber coatings by ion bombardment of ZrN, ArO_2 and VN; and acquire an understanding of photo-induced degradation in ceramics. The expected results of this research are development of an understanding of photo-induced optical degradation and the development of at least one coating material to improve the optical performance of solar thermal receivers operating at high temperatures and fluxes.

Keywords: Coatings and Films, Surface Characterization and Treatment, Radiation Effects, High Temperature Service

Photovoltaic Energy Technology Division

The primary goal of the national photovoltaic program is to reduce the uncertainties surrounding photovoltaic technology, so that the private sector may make informed investment decisions in this area. Successful uncertainty reduction will require advances in several areas of materials technology.

177. Amorphous Silicon for Solar Cells

	FY 1984	FY 1985
	$7,500,000	$8,000,000

DOE Contact - Anthony Scolaro, FTS 252-5548
SERI Contact - Ed Sabisky, FTS 327-1483

This project performs applied research upon the deposition of amorphous silicon alloys to improve solar cell properties. Efficient solar energy conversion is hindered by improper impurities or undesired structure in the deposited films and the uniformity of the films over large (1000 cm^2) areas. The films are deposited by plasma enhanced chemical vapor deposition (glow discharge), thermal chemical vapor deposition and sputtering. The long term goal of this effort is to develop the technology for 12% efficient solar cells with an area of about 1000 cm^2. Achieving that goal should enable amorphous silicon to be a cost-effective electrical generator.

Keywords: Amorphous Materials, Coatings and Films, Semiconductors, Chemical Vapor Deposition, Sputtering and Solar Cells

178. Polycrystalline Thin Film Materials for Solar Cells

	FY 1984	FY1985
	$3,200,000	$3,600,000

DOE Contact - Anthony Scolaro, FTS 252-5548
SERI Contact - Allen Herrmann, FTS 327-1311

This project performs applied research upon the deposition of $CuInSe_2$ and CdTe thin films for solar cells. Research centers upon improving solar cell conversion efficiency by depositing more nearly stoichiometric films, by controlling interlayer diffusion and lattice matching in heterojunction structures and by controlling the uniformity of deposition over large (1000 cm^2) areas. The films are deposited by chemical and physical vapor deposition, electrodeposition and sputtering. The long term goal for this effort is to develop the technology for 15% efficient solar cells with areas of about 1000 cm^2. Achieving this goal would enable polycrystalline thin film material to be a cost-effective electrical generator.

Keywords: Coatings and Films, Semiconductors, Chemical Vapor Deposition, Physical Vapor Deposition, Electrodeposition, Sputtering and Solar Cells

179. Deposition of High Purity Polycrystalline Silicon from Silane in a Fluidized Bed Reactor

	FY 1984	FY 1985
	$1,200,000	$700,000

DOE Contact - Anthony Scolaro, FTS 252-5548
JPL Contact - Andrew Morrison, FTS 792-7200

This project performs applied research upon the deposition of semiconductor grade silicon from high purity silane in a fluidized bed reactor. Research centers upon studying nucleation and growth of silicon particles and impurities in the deposited silicon. The goal of this research is to prove the feasibility of the fluidized bed reactor as an energy conservation means of forming semiconductor grade silicon from gaseous silicon bearing compounds. Achieving this goal would enable, upon the adoption of this technology, a great reduction in the required price for semiconductor grade silicon, a precursor for crystal silicon photovoltaics and integrated circuits.

Keywords: Semiconductors, Solar Cells

180. Growth of Silicon Ribbons for Solar Cells

	FY 1984	FY 1985
	$3,200,000	$4,000,000

DOE Contact - Anthony Scolaro, FTS 252-5548
JPL Contact - Andrew Morrison, FTS 792-7200

This project performs applied research upon the growth of silicon ribbons from a melt. Research centers upon understanding, from a physical perspective, exactly what happens during the growth of silicon ribbon. Questions to be answered include: what stresses do the sharp temperature gradients, inherent in high speed crystal growth, impose upon the ribbon; which stress relief modes improve solar cell performance and how can they be enhanced; how can buckling be prevented; and what is an acceptable level of residual strain. Attaining an understanding of the fundamentals of ribbon growth should enable the development of appropriate ribbon growth techniques necessary for highly efficient, cost-effective crystal silicon solar cells.

Keywords: Semiconductors, Crystal Growth, Solar Cells

181. Deposition of III-V Semiconductors for High-Efficiency Solar Cells

	FY 1984	FY 1985
	$3,500,000	$3,500,000

DOE Contact - Anthony Scolaro, FTS 252-5548
SERI Contact - John Benner, FTS 327-1396

This project performs applied research upon deposition of III-V semiconductors for high efficiency solar cells, both thin film for flat plate applications and multilayer cells for concentrator applications. Research centers upon depositing layers precisely controlled in terms of composition, thickness and uniformity and studying the interfaces between the layers. The materials are deposited by chemical vapor deposition, liquid phase epitaxial growth and molecular beam epitaxial growth. The long term goal of this area is to develop 35% efficient concentrator cells and 20% 100 cm^2 one-sun cells for flat plate applications. Achieving these goals would enable systems using these technologies to be cost-effective electrical generators.

Keywords: Semiconductors, Chemical Vapor Deposition, Solar Cells (Liquid Phase Epitaxial Growth, Molecular Beam Epitaxial Growth)

182. Materials and Device Characterization	FY 1984	FY 1985
	$2,500,000	$3,000,000

DOE Contact - Anthony Scolaro, FTS 252-5548
SERI Contact - Larry Kazmerski, FTS 327-1115
JPL Contact - Ram Kachare, FTS 792-4583

This project measures and characterizes materials and device properties. The project performs surface and interface analysis, electro-optical characterization and cell performance and material evaluation to study critical material/cell parameters like impurities, layer mismatch and other defects that limit performance and lifetime. Techniques that are used include deep level transient spectroscopy, electron beam induced current, secondary ion mass spectroscopy, scanning electron microscopy and scanning transmission electron microscopy.

Keywords: Semiconductors, Nondestructive Evaluation, Surface Characterization, Microstructure and Solar Cells

183. High-Efficiency Crystal Silicon Solar Cells	FY 1984	FY 1985
	$2,500,000	$1,800,000

DOE Contact - Anthony Scolaro, FTS 252-5548
JPL Contact - Ram Kachare, FTS 792-4583

This project performs applied research upon crystal silicon devices to improve solar-to-electric conversion efficiency. The project employs new coatings and/or dopants and other treatments to reduce electron-hole recombination at cell surfaces or in the bulk material. This project should attain an 18% efficient one-sun crystal silicon solar cell by the end of FY 1984 and a 20% efficient one-sun crystal silicon solar cell by the end of FY 1986. This result will be a major step in proving that crystal silicon can be a cost-effective generator of electricity.

Keywords: Semiconductors, Solar Cells

Wind Energy Technology Division

184. Wood Composite Material Fatigue	FY 1984	FY 1985
	$ 45,000	$ 0

DOE Contact - Peter Goldman, FTS 252-1776
NASA Contact - Art Birchenough, 216-433-4000, ext. 5207

The objective of this research is to characterize the static and cyclic fatigue properties of Laminated Douglas Fir veneer wood composite materials with applications to more efficient structure design of rotor blades. Epoxy resin wood laminate test specimens have been fabricated and are being subjected to ultra-high (approaching 4 X 10^8) cyclic fatigue loads. Data will be collected looking at a number of parameters, including wood grade, moisture content, butt joining gap, lamination clamping pressure and test temperature and humidity levels. Test results should be reported in FY 1985.

Keywords: Composites, Materials Characterization

Geothermal and Hydropower Technologies Division

The primary goal of the geothermal materials program is to ensure that the private sector development of geothermal energy resources is not constrained by the availability of technologically and economically viable materials of construction. This requires the performance of high risk GHTD-sponsored materials R&D.

185. High Temperature Elastomers for Dynamic Sealing Applications

FY 1984	FY 1985
$ 100,000	$ 125,000

DOE Contact - A.D. Allen, 202-252-5335
BNL Contact - L.E. Kukacka, 516-282-3065

This project performs applied research to optimize a Y-267 EPDM elastomer formulation, developed earlier by GHTD for static seal applications, for use in dynamic seal applications at temperatures up to 260 degrees C. Elastomers for these conditions do not currently exist, and a successful development could substantially reduce drilling and completion costs. The effects of compositional changes on the properties of the elastomer are being determined, and the formulation optimized to yield the specific sealing requirements. Prototype and full-scale testing is performed. Achieving the goal will result in significant improvements in the cost and reliability of geothermal components.

Keywords: Organics, Material Degradation, Stress, Drilling, High Temperature Service, Seals and Bearings

186. Advanced Materials for Lost Circulation Control

FY 1984	FY 1985
$ 75,000	$ 75,000

DOE Contact - A. D. Allen, 202-252-5335
BNL Contact - L.E. Kukacka, 516-282-3065

This project is investigating hydrothermally stable and pumpable chemical systems for use as lost circulation control materials. Control of lost circulation problems is a major contributor to the cost of geothermal wells, and high temperature materials that will yield permament repairs that can be made without removal of the drill string in order to set casing and cement, do not exist. The investigations include laboratory studies of interactions between bentonite-based drilling needs, reactive solid additives, and chemical fluids. The pumpability characteristics of the slurries and the properties of the cured materials are also determined. Success will result in significant reductions in drilling and completion costs.

Keywords: Organics, Fibers, Glass Ceramics, Strength, Bulk Characterization, Drilling, High Temperature Service

187. <u>Pitting Resistant Steels</u>

	FY 1984	FY 1985
	$ 50,000	$ 50,000

DOE Contact - R. LaSala, 202-252-8077
BNL Contact - D. van Rooyen, 516-282-4050

This project studies the mechanism whereby high corrosion resistance is obtained through alloying of stainless steels with molybdenum combined with nitrogen. Corrosion of tubulars is a major problem in geothermal systems, and the use of high chrome steels and nickel alloys is uneconomical. The work involves research to determine the required combinations of Mo and N needed to yield the required pitting resistance for specific environments. Achieving this goal will result in cost-effective alternatives for high chrome and nickel alloys in geothermal plants.

Keywords: Alloys, Coatings, Metals, Corrosion, Diffusion, Fatigue

188. <u>In-Situ Conversion of Drilling Fluids into Cements</u>

	FY 1984	FY 1985
	$ 25,000	$ 30,000

DOE Contact - A. D. Allen, 202-252-5335
BNL Contact - L. E. Kukacka, 516-282-3065

This applied research program involves studies of high temperature interactions between drilling mud constituents, reactive solid additives, and chemical fluids. Poor well completions occur due to the inability to displace drilling fluid from behind the well casing. If the goals of the program are attained, lower well completion costs and extended well life will be accrued.

Keywords: Cement, Glass Ceramics, Strength, Bulk Characterization, Drilling, High Temperature Service.

189. <u>Geothermal Waste Utilization and Disposal</u>

	FY 1984	FY 1985
	$ 100,000	$ 170,000

DOE Contact - R. LaSala, 202-252-8077
BNL Contact - L. E. Kukacka, 516-282-3065

This program involves the development of processes for converting toxic constituents of geothermal wastes into nonleachable forms which can be used as general construction materials. Methods for the utilization of biochemical techniques for concentration and subsequent separation of toxic components are also being considered. Before the large-scale development of geothermal energy can occur, environmentally and economically acceptable methods for the disposal of large quantities of waste must be developed. The program involves the selection of encapsulating or concentrating materials, and the fabrication and evaluation of waste forms. A successful program will result in significant improvements in the economic and environmental aspects of geothermal energy.

Keywords: Cements, Polymers, Bonding Agents, Material Degradation, Bulk Characterization, Waste Management

190. Materials for Non-Metallic Heat Exchangers

	FY 1984	FY 1985
	$ 75,000	$ 100,000

DOE Contact - R. LaSala, 202-252-8077
BNL Contact - L. E. Kukacka, 516-282-3065

This project is investigating thermally conductive polymer-based composites for use as corrosion resistant materials of construction for shell and tube heat exchangers in binary geothermal processes. Corrosion of the brine side of tubing in shell and tube heat exchangers has been a major problem in the operation of binary geothermal processes. Compared to the cost of high alloy steels, a considerable economic benefit could result from the utilization of a proven corrosion resistant polymer concrete material if sufficient heat transfer properties can be derived. The work consists of determinations of the effects of compositional and processing variables on the thermal properties of the composite, and measurements of the physical and mechanical properties after exposure to hot brine and isobutane. If the goals of the program are attained, the cost of geothermal power will be reduced considerably.

Keywords: Composites, Polymers, Corrosion, Strength, Extrusion, High Temperature Service

191. Corrosion Resistant Elastomeric Liners for Well Casing

	FY 1984	FY 1985
	$ 125,000	$ 150,000

DOE Contact - R. LaSala, 202-252-8077
BNL Contact - L. E. Kukacka, 516-282-3065

This program investigates the effectiveness of Y-267 EPDM elastomers as corrosion resistant liners on carbon steel well casing. Currently, casing corrosion is a major problem at many geothermal sites, and although the use of high chrome steels and nickel alloys extend casing life considerably, they cost 6 to 15 times as much as carbon steel. The R&D consists of the identification and evaluation of high temperature chemical bonding agents, development of lining methods, and performance of downhole corrosion tests on prototype sections. If successful, the cost of geothermal wells will be considerably reduced.

Keywords: Bonding Agents, Organics, Corrosion, Joining, Material Degradation, Casting, High Temperature Service

192. Downhole Testing of High Temperature Geothermal Well Cements

	FY 1984	FY 1985
	$ 100,000	$ 100,000

DOE Contact - R. LaSala, 202-252-8077
BNL Contact - L. E. Kukacka, 516-282-3065

Investigations are in progress to characterize the properties of promising high temperature well cements under placement and environmental conditions duplicating most of the well completion variables. The service life of a well is highly dependent upon the quality of the cement, but degradation and placement problems continue to plague the geothermal industry.

Candidate cements are pumped into downhole test modules, and cured under the downhole conditions. The modules are removed after various exposure times for evaluation. If the goal of the program is attained, durability data under pumping conditions and exposure to 300 degrees C brine will be available for the first time.

Keywords: Cements, Material Degradation, Strength, Transformation, Bulk Characterization, Drilling, High Temperature Service

193. <u>Corrosion in Binary Geothermal Systems</u>

	FY 1984	FY 1985
	$ 65,000	$ 50,000

DOE Contact - R. LaSala, 202-252-8077
BNL Contact - D. van Rooyen, 516-282-4050

This program yields corrosion data from laboratory and plant tests for metals presently used in binary plants and other more potentially resistive metals and nonmetals. In operating binary processes, brine leakage into the organic working fluid side of the plants has resulted in unanticipated corrosion problems. Data are not available on the effects of salt, oxygen, and water impurities in isobutane and/or isopentane on the corrosion rates of metals. The work involves the exposure of test coupons in operating plants and in a laboratory test loop in which the levels of water, oxygen and salt can be varied. When completed, the programs will yield quantitative information regarding the extent of corrosion that will occur upon contamination of the binary side of a plant, thereby allowing designers materials options.

Keywords: Alloys, Metals, Corrosion

194. <u>High Temperature Cathodic Protection Systems</u>

	FY 1984	FY 1985
	$ 60,000	$ 50,000

DOE Contact - R. LaSala, 202-252-8077
BNL Contact - D. van Rooyen, 516-282-4050

This project involves the development of methods for using electrochemical techniques in high temperature environments for the exterior protection of well casing and other geothermal components. Corrosion of carbon steel components is a serious problem in geothermal environments, and almost any alternative to the use of high alloy steels will be economically attractive. The work includes laboratory and field measurements of the electrochemical parameters required to protect well casing from external attack, design of protective equipment, and prototype testing. If successful, the program will yield electrochemical data which demonstrate the feasibility of using cathodic protection in geothermal processes.

Keywords: Metals, Corrosion, Electrochemical, High Temperature Service

195. <u>Field Tests of Advanced Monitoring Instruments</u>

	FY 1984	FY 1985
	$ 185,000	$ 185,000

DOE Contact - G. J. Hooper, 202-252-4153
PNL Contact - D. W. Shannon, 509-376-3139

This project involves field testing advance instrumentation to monitor brine chemistry, corrosion, scaling and suspended solids in geothermal waters to be used in geothermal power plants, with emphasis on wastewater treatment and injection systems. Advanced instruments are strategically located on selected geothermal power plants, and the results of the tests are monitored in order to detect adverse plant conditions. Current field tests associated with binary technology are being completed. Similar field tests will be initiated on a geothermal flash plant. Tests associated with the binary plant have already resulted in savings of many thousands of dollars in avoided well and equipment failures on the plant where the test equipment was installed. Through the development of this system, a similar system has been incorporated at the Heber Plant. It is expected that test results from a flash plant will also produce improved plant reliability and a reduction in cost through early detection of adverse plant conditions.

Keywords: Composites, Corrosion, High Temperature Service

196. Particle Measurement In-Line Instrument	FY 1984	FY 1985
	$ 275,000	$ 275,000

DOE Contact - G. J. Hooper, 202-252-4153
PNL Contact - D. W. Shannon, 509-376-3139

This project involves the development and testing of instruments to measure the total amount of solid material pumped into geothermal injection wells and to characterize these suspended solids by measuring the particle counts in each size range vs. time and total fluid injection. The need for improved continuous on-line instruments to detect adverse plant conditions is clear. Many of the plant shutdowns are often caused by components failing due to factors relating to the chemical nature of the brines. Currently two promising instruments are being examined, one based on a laser technique and the other using a sonic technique to characterize and measure these parameters. Successful development and testing of these instruments will result in improved plant reliability and a reduction in plant operation cost.

Keywords: Composites, Corrosion, High Temperature Service

Energy From Municipal Waste Division

The goal of the Energy From Municipal Waste (EMW) Division is to provide the technical information base from which industry can develop future technologies for the recovery of liquid and gaseous fuels and other usable energy products and materials from municipal solid waste, and to increase the energy efficiency of municipal wastewater treatment processes. DOE contact is Christopher Kouts, 202-252-1697.

197. Refuse Derived Fuel (RDF) Binder Research	FY 1984	FY 1985
	$ 72,000	$ 230,000

Argonne National Laboratory Contact - Ole Ohlson, 312-972-5593

The objective of this research study is to develop innovative densified refuse derived fuels (RDF) concepts for the processing of municipal solid waste (MSW) that can produce fuels of a desired quality, at lower cost, and with greater consistency than the RDF currently available. Research is aimed at improvement of previous work by examining the use of more appropriate binders for use in producing improved pelletized or briquetted densified RDF that are easily transportable and stable under long term storage conditions. Environmentally acceptable potential chemical binders are being identified and process concepts, including their economics, are being evaluated. In addition, alternative soil compaction techniques are being examined for producing an acceptable quality densified product.

Keywords: Alternate Fuels, Materials Degradation

OFFICE OF ENERGY RESEARCH

The Director of Energy Research is responsible for three major outlay programs: Basic Energy Sciences, High Energy and Nuclear Physics, and Magnetic Fusion Energy. The Director of Energy Research also advises the Secretary on DOE physical research programs, the Department's overall energy research and development programs, university-based education and training activities, grants, and other forms of financial assistance. The Director also carries out additional duties assigned to the office related to basic and advanced research, and monitors the well-being and management of the multiprogram laboratories under the jurisdiction of the Department.

Four multiprograms and seven single-purpose laboratories are administratively assigned to the Office of Energy Research. The single-purpose or specialized laboratories are the Bates Linear Accelerator Facility at the Massachusetts Institute of Technology, the Fermi National Accelerator Laboratory, the Notre Dame Radiation Laboratory, the Princeton University Plasma Physics Laboratory, the Michigan State University Plant Research Laboratory, and the Stanford Linear Accelerator Center. The multiprogram laboratories conduct significant research activities for other DOE programs (e.g., Environment) and other Federal agencies, while the seven specialized laboratories are funded almost totally by the Office of Energy Research.

The Office of Energy Research conducts materials research in the following offices and divisions:

Office of Health and Environmental Research: Division of Physical and Technological Research

Office of Fusion Energy

Small Business Innovation Research Program

Office of Basic Energy Sciences: Division of Engineering and Geosciences; Division of Materials Sciences

Office of Basic Energy Sciences

Division of Materials Sciences

This basic research program has several roles. One is to increase the understanding of materials properties, behavior, and phenomena in those classes of materials that either presently or in the future might be important to the mission of the Department of Energy. Another concerns the development of new forefront analytical instruments and facilities that are used to probe the structure and behavior of matter. Thus this program carries a major responsibility for many of the nation's premier research facilities including several neutron sources, a synchrotron radiation source, processing facilities, and frontier electron microscopes. Some of the materials research has a specific relationship to an identified energy technology (e.g., photovoltaic phenomena for solar energy conversion, fast-ion diffusion for solid electrolytes in fuel cells and batteries, etc.); some is related to many energy technologies simultaneously (e.g., hydrogen embrittlement, corrosion, high temperature structural metals and ceramics, etc.); and some to important fundamental understanding of new experimental and theoretical research tools.

This research is conducted at DOE laboratories, universities, and to a lesser extent at industrial laboratories by metallurgists, ceramists, solid state physicists, and materials chemists in about 100 different institutions.

There are three subprograms:

- Metallurgy and Ceramics seeks to understand the synergistic relationship between properties/behavior, structure, and processing parameters of materials.

- Solid State Physics is concerned with understanding the interactions of electrons, atoms, and defects and their role in determining the structure and properties of condensed matter.

- Materials Chemistry focuses on understanding the chemical properties of materials and their relationship to composition, structure, and specimen environment.

The DOE contact for this division is Dr. Louis Ianniello, 301-353-3427. For specific detailed information, the reader is referred to DOE publication Materials Sciences Programs Fiscal Year 1984 9DOE/ER-0143/2 dated September 1984). This publication contains: summaries of all funded programs at DOE laboratories; summaries of all funded grant programs in universities and private sector organizations; summaries of all Small Business Innovation Research programs; Collaborative Research Centers (descriptive information); and cross-cutting indices: investigators, materials, techniques, phenomena, environment. Limited copies may be obtained by calling 301-353-3428.

Division of Engineering and Geosciences

198. Damage Accumulation by Crack Growth Under Combined Creep and Fatigue

	FY 1984	FY 1985
	\$ 56,000	\$ 56,000

DOE Contact - Oscar P. Manley, 301-353-5822
Battelle-Columbus Laboratories Contact - C.E. Jaske, 614-424-4417

The objective of this study is to develop and evaluate methods for assessing creep/fatigue crack growth under inelastic straining. A fracture-mechanics approach implementing the J integral for fatigue and the C* integral for creep is being employed. A crack-tip-zone interaction model is used to account for the interactions between creep and fatigue during crack growth at high temperatures. Experimental studies on Type 316 stainless steel 593 and 649 degrees C are continuing. Experiments similar to those previously performed on Type 316 stainless steel are being conducted on modified 9Cr-1Mo steel at 538 and 593 degrees C. The range of the cyclic J integral has been shown to be a good parameter for characterizing fatigue-crack-growth rates when creep effects are negligible. The C* integral has been shown to be a good parameter for characterizing creep-crack-growth rates under static or slowly varying loading with steady state creep across the remaining uncracked ligament. Use of the MENT specimen configuration has been shown to provide a relatively simple and economic means of measuring creep-crack-growth at low propagation rates (near 1 mm per year). The general approach is being evaluated for cases where creep-fatigue damage may occur during dwell periods at some fraction (0 to 1.0) of the maximum cyclic load.

Keywords: Metals: Ferrous Including Steels, Creep, Fatigue

199. Electrochemical Wear Mechanism and Deposit Formation in Lubricated Systems

	FY 1984	FY 1985
	$ 66,000	$ 93,000

DOE Contact - Oscar P. Manley, 301-353-5822
Electrochemical Technology Corp. Contact - T.R. Beck, 206-632-5965

The objective of this research is to measure and determine the importance of electrokinetic- or zeta- corrosion and deposit formation in lubricated rolling and sliding systems. The approach of the present research is to compare measurements of wear for rolling and sliding lubricated systems to calculate zeta corrosion rates based on extensions of the valve wear model. The main challenge is distinguishing wear by zeta corrosion from abrasive and adhesive wear. Required physical properties were measured for eight common lubricating oils and measurements were made of wall current density generated and size of wear scars. The wear scars consist of furrows with parallel scratches and furrows with micropits. With a nylon cloth attached to the shaft wear scars are about the same size but virtually all pitted furrows. Zeta corrosion caused by passage of metal surface roughness or the roughness of the nylon weave over the journal surface is indicated. Experiments to distinguish unambiguously zeta corrosion are underway.

Keywords: Corrosion-Aqueous, Lubrication, Wear

200. Engineering Analysis of Elastic-Plastic Fracture

	FY 1984	FY 1985
	$ 165,000	$ 175,000

DOE Contact - Oscar P. Manley, 301-353-5822
Idaho National Engineering Laboratory Contact - W.G. Reuter, 205-526-0111

The objective is to improve design and analytical techniques for predicting the integrity of flawed structural components. The research is primarily experimental, with analytical evaluation guiding the direction of experimental testing. Tests are being conducted on a material (a modified ASTM A-710) exhibiting a range of fracture toughness but essentially constant yield and ultimate tensile strength. As test temperature increases, the specimen configuration-fracture toughness relationship compiles initially with requirements for linear elastic-fracture mechanics and extends beyond the range of a J-controlled field. Presently, compact tension (3-point bend specimens will also be used in the future) are being used to develop state-of-the-art fracture mechanics data on the lower shelf (K_{Ic}), transition zone (J_{Ic}, J-R curves, etc.), and on the upper shelf (J_{Ic}, J-R curves, etc.). Results from the lower shelf and transition region are being used to predict failure conditions for specimens containing surface flaws. Predictions are then compared with experimental test data. These comparisons are presently underway for 6.4 and 12.7 mm thick surface-flawed specimens. Metallographic techniques are being used to measure crack tip opening displacement for comparison with analytical models. Laser interferometry and infrared thermography techniques will be used to evaluate and quantify the deformation in the crack region.

Keywords: Fracture, Metals: Ferrous Including Steels

201. Continuous Damage Theory

	FY 1984	FY 1985
	$ 41,000	$ 43,000

DOE Contact - Oscar P. Manley, 301-353-5822
University of Illinois Contact - D. Krajcinovic, 312-996-7000

The study centers on the phenomenological description of the nucleation and growth of microdefects in a metallic solid and their influence on the mechanical response. The analytical work will proceed within the scope of the Continuous Damage Mechanics, according to which the distribution and density of microdefects can be represented by a set of appropriately selected internal variables.

Present investigations focus on the basic aspects and definitions to prepare the groundwork and reconcile several different models. It was, for example, found that in case of a general microcrack field a distinction must be made between the microcrack distribution and the damage consistent representation of a field of flat microcracks. The projection of these vectors on a plane through the observed point is a physically reasonable measure of damage.

Subsequently the focus will shift on the investigation of the interaction of viscuous effects (reflecting the boundary slip) and the brittle effects (growth of microcracks). The established continuum model will be used to study problems such as creep rupture, fatigue, etc.

Keywords: Metals: Ferrous Including Steels, Fracture, Fatigue, Creep

202. Loss Characteristics of Cord-Rubber Composites

	FY 1984	FY 1985
	$ 60,000	$ 75,000

DOE Contact - Oscar P. Manley, 301-353-5822
University of Michigan Contact - S.K. Clark, 313-764-4256

The research is divided roughly into two phases, the first being completion of data acquisition on the loss characteristics of cord-rubber composites under both uniaxial and multiaxial stress states. This effort will utilize information currently available as well as measurements made here. The effects of prestrain, frequency, strain amplitude, and temperature will be included in the assessment of the viscoelastic properties of these materials.

The major activity during the latter part of the work will be analysis and measurement of the rolling loss of a relatively simple pneumatic tire. The tire geometry will be essentially cylindrical in form, similar to the type of tire used in vehicles transversing soft or marshy terrain. These are essentially cylindrical rollers, but with end closures making it possible to inflate them. Analysis will be carried out using the visco-elastic material properties previously obtained, as well as finite element codes suitable for this type of problem. Comparison of calculated and measured rolling resistance values will give valuable insight into the types of finite element models best suited for this computation, and should give confidence to the tire industry in its efforts to apply finite element techniques to the calculation of tire operating properties.

Keywords: Composites

203. <u>A Study of the Chemical Mechanism in Lubrication</u>

	FY 1984	FY 1985
	$ 50,000	$ 60,000

DOE Contact - Oscar P. Manley, 301-353-5822
NBS Contact - S.M. Hsu, 301-921-3113

Chemical mechanisms in concentrated contacts under lubricated conditions are largely not understood. This project will study systematically the nature and the extent of influence of chemical reactions in the contact zone on friction and wear. Surface topography of worn surfaces will be characterized to predict oil film thickness under different speed, load ranges in a NBS-developed four-ball wear tester. Micro-asperity temperatures and the wear film temperatures of the oil film will be calculated using Archard-Jaeger equations as well as finite-element analysis techniques. Pure model structures will be used as lubricants to test the effects of chemical functional groups on friction and wear. Chemical kinetic studies on tribochemical reaction rate constants for various classes of compounds under wearing conditions will be compiled. A theoretical model linking elastohydrodynamic theories to tribochemical rate constants with materials properties will be attempted to predict lubrication effectiveness a priori.

Keywords: Lubricants, Tribology

204. <u>Effects of Crack Geometry and Near-Crack Material Behavior on Scattering of Ultrasonic Waves for QNDE Applications</u>

	FY 1984	FY 1985
	$ 55,000	$ 59,000

DOE Contact - Oscar P. Manley, 301-353-5822
Northwestern University Contact - J.D. Achenbach, 312-491-5527

This project is concerned with applications of the scattered field approach to the detection of a cracklike flaw, and to the determination of its location, size, shape, and orientation. Interior, as well as surface-breaking and near-surface cracks are considered. The usual mathematical modeling of ultrasonic wave scattering by cracks is adjusted to account for several typical characteristics of fatigue and stress-corrosion cracks, and the environment of such cracks. Effects due to crack-face roughness, crack-closure and crack-face interactions are considered, as well as global anisotropy. Local anisotropy and inhomogeneity due to near-tip voids, and the effect of a zone of plastic deformation near a crack tip will also be investigated. Parametrical studies are expected to display the masking of characteristic "crack-like" features of the scattered field by a spectrum of signals due to deviations from an idealized crack geometry and idealized material behavior. Progress has been made on the effects of crack-face interactions and global anisotropy.

Keywords: Metals: Ferrous and Non-Ferrous, Fracture, NDE

205. <u>Crack-Tip Fields for Materials with Exponential-Law Creep Behavior at High Stress</u>

	FY 1984	FY 1985
	$ 67,000	$ 0

DOE Contact - Oscar P. Manley, 301-353-5822
University of Pennsylvania Contact - John L. Bassani, 215-898-5632

This research is concerned with elastic-viscoplastic analyses of cracks under creep conditions, with particular emphasis on the influence of the assumed stress dependence on the creep strain-rate. The total strain-rate is taken as the sum of linear elastic and hyperbolic-sine-creep rates. Around the tip of a sharp notch in a material described by this law the creep strain-rates are much greater than the elastic ones. The spatial asumptotic analysis based upon a hodograph transformation demonstrates that the notch-tip stress intensification is weaker and the strain-rate intensification is stronger than for a power-law creeping material. The complete time-dependence of the crack-tip fields under Mode III small-scale-yielding conditions has been investigated numerically. This research will conclude with an analysis of crack-tip fields under plane-strain Mode I conditions.

Keywords: Creep, Fracture

206. <u>Mechanical Interactions of Rough Surfaces</u>

	FY 1984	FY 1985
	$ 100,000	$ 130,000

DOE Contact - Oscar P. Manley, 301-353-5822
SKF Industries Inc. Contact - J.I. McCool, 215-265-1900

This program is aimed at developing fundamental information and resolving a number of issues that impact the design of mechanical systems in which surface microtopography per se or events which occur on the microgeometric scale play a critical role.

In Task I, an apparatus designed and built by SKF is being used to provide optical interferograms of the lubricated contact of rough surfaces along with measurements of the traction transmitted under conditions of combined rolling, sliding, and spinning. These tests will serve to explore the limitations of predictive models of film thickness, traction, and the frequency of asperity contact interactions and micropitting in the so called partial EHD regime wherein the thickness of the lubricant film separating the bodies is of the same order as the surface roughness amplitude.

The objective of Task II is to develop guidelines and techniques for the digital processing of surface roughness data generated in analog form by a stylus profile instrument.

Issues to be addressed are: filter bandpass selection, record length and sample spacing, spatial vs. frequency domain estimation, type of digital filtering, and the effects of preprocessing.

Keywords: Tribology

207. Improvement of Reliability of Welding by In-Process Sensing and Control

	FY 1984	FY 1985
	$ 170,000	$ 145,000

DOE Contact - Oscar P. Manley, 301-353-5822
MIT Contact - K. Masubuchi, 617-253-6820

The main focus of this project is to develop closed-loop control of welding variables in a cost-effective approach to improving weld quality. This research program includes the following tasks: demonstration of the measurement of weld size using mechanical impedance as a sensing technique for one of the two weld geometry measurements; demonstration of a single variable control system using the above measurement; demonstration of the ability to gain independent control of two weld geometry measures as described, for example, by the front and back bead widths of the weld metal; demonstration of closed-loop geometry control with these two control variables; expand the variables to be controlled from two geometry measures to include temperature history of the weldment; implement the geometry control system on a mechanized welding system; and provide one formal framework for implementation of welding control.

Keywords: Welding

208. Crack Characterization With Ultrasonic NDE

	FY 1984	FY 1985
	$ 110,000	$ 110,000

DOE Contact - Oscar P. Manley, 301-353-5822
Idaho National Engineering Laboratory Contact - J.A. Seydel, 208-526-0111

The purpose of this research is to develop the instrumentation and analytical models that can predict and identify the frequency dependence of the amplitude and phase of ultrasonic echoes from defects. The approach treats the transducer/media/defect combination as a linear system which allows separation of the individual contributions to the signal detected at the transducer. A model based on the numerical solution of the partial differential wave equations has been developed to provide "snapshots" of the transducer field both before and after it has interacted with the flaw. This information is then compared to experimental data collected at a large number of transducer positions. Since the objective is to characterize defects, a number of techniques are being developed to display frequency-domain information which relates to the type of defect. One method is to display the phase and amplitude spectra values as a function of frequency and transducer position.

Keywords: Fracture, NDE

209. <u>High Frequency Transducers</u>	<u>FY 1984</u>	<u>FY 1985</u>
	$ 20,000	$ 110,000

DOE Contact - Oscar P. Manley, 301-353-5822
Stanford University Contact - G.S. Kino, 415-497-0205

This year, a new theory has been developed for cross-coupling in acoustic transducer arrays, used for acoustic imaging. Cross-coupling changes the pulse response and the angular response of the arrays. This entirely new theoretical technique is applicable to acoustics devices for NDT, medical and sonar arrays, as well as to electromagnetic and antenna arrays. Techniques for reducing cross-coupling have also been suggested and tried with some success.

New developments have been made of air transducers operating at 1 and 2 MHz in air. These are used for precision measurements of distance in air. This is of great importance for diamond turning, robotic applications, nondestructive testing, and profile measurements in precision manufacturing.

Keywords: NDE

210. <u>A Composite, Multiviewing Transducer</u>	<u>FY 1984</u>	<u>FY 1985</u>
	$ 200,000	$ 250,000

DOE Contact - Oscar P. Manley, 301-353-5822
Iowa State University Contact - D.O. Thompson, 515-294-5320

The objective of this project is to demonstrate a composite, multiviewing ultrasonic transducer suitable for detecting, characterizing, and reconstructing flaws in structural materials for various applications. Development of this transducer utilizes a combination of recent advances in ultrasonic scattering and inversion theories with new concepts in transducer configurations and excitation methods. An experimental model of a composite transducer has been used as an aid in developing the semi-automated data acquisition and protocol. It has been determined that seven transducer elements which are multiplexed using both pulse-echo and pitch-catch modes are sufficient to produce good flaw reconstructions. Effects of limited aperture on the reconstruction have also been examined. The reconstruction protocol fits the acquired data to an "equivalent" ellipsoid of general shape (3 axes, 3 angles), a shape that is compatible with a fracture mechanics description of growing flaws and thus suitable for failure prediction. Criteria have also been established for individual transducer selection using experimentally determined scattering results. It is suggested that this procedure may form an approach for the further development of new transducer standards.

Keywords: NDE

Office of Health and Environmental Research

The Office of Health and Environmental Research supports a broad multidisciplinary program in basic and applied life sciences research for the purpose of achieving a comprehensive understanding of the health and environmental effects associated with energy technologies. Research is conducted to characterize and measure energy-related hazards, study transport and transformations in the environment, determine the biological and ecological response and define the potential impact on human health. In addition, new applications of nuclear science and energy technologies are developed for use in the diagnosis and treatment of human disease. Materials interests are primarily in development of sensors for radiation and chemical detection.

Division of Physical and Technological Research

The Physical and Technological Research Division conducts physical, chemical, and instrumentation research related to the health and environmental aspects of energy technology development. Included are support of physical and chemical characterization studies, atmospheric sciences research, research on measurement and dosimetry techniques, and fundamental radiation biophysics.

211. Development of Mercuric Iodide and Other New Concepts for the Detection and Spectroscopy of Ionizing Radiation

	FY 1984	FY 1985
	$ 250,000	$ 260,000

DOE Contact - G. Goldstein, 301-353-5348, FTS 233-5348
University of Southern California Contact - G. Huth, 213-822-9184

Crystalline mercuric iodide and other semiconductor compounds are developed for detection and spectroscopy of ionizing radiation. Successful development will enable fabrication of high resolution, room temperature x-ray spectrometer systems which can be used in radiation research, space sciences, elemental analysis, and other applications. Current research includes studies of crystal growth techniques, basic physics of the interaction with x-rays, detector design, low noise electronics packages, and potential biomedical applications.

Keywords: Semiconductors, Radiation Effects, Instrumentation or Technique Development

212. Semiconductor Radiation Detector Technology

	FY 1984	FY 1985
	$ 360,000	$ 360,000

DOE Contact - G. Goldstein, 301-353-5348, FTS 233-5348
LBL Contact - F. S. Goulding, 415-486-6432, FTS 451-6432

This project is designed to develop the technology of radiation detectors with emphasis on semiconductor and other solid-state detectors. The work includes basic detector material studies, development of new types of detectors, and specialized electronic signal processing techniques. The foundation of modern spectroscopy using semiconductor detectors has been laid by this project. Recent work has focused on native defects in germanium and silicon and on defects produced by radiation damage and the relationship of these defects and detector performance. Work is in progress on multielement silicon detectors and "on-chip" techniques for readout from these detectors. Recent work has also resulted in some very significant developments in signal processing that improves both the energy resolution and counting-rate performance of spectrometers. The results produced by this project are rapidly used by a number of United States companies involved in materials, detector, and spectrometer systems development.

Keywords: Semiconductors, Radiation Effects, Instrumentation and Technique Development

213. Avalanche Photodiodes for Positron Emission Tomography

	FY 1984	FY 1985
	$ 248,000	$ 248,000

DOE Contact - G. Goldstein, 301-353-5348, FTS 233-5348
Radiation Monitoring Devices Contact - G. Entine, 617-926-1167

Modern nuclear medicine instruments provide fast and accurage data for clinical diagnosis and medical research. Many of these instruments, including Positron Emission Tomography (PET) scanners, require an array of radiation sensors which consist of a photomultiplier tube coupled to a scintillator crystal. The cost and complexity of this valuable instrument could be significantly reduced if the phototubes could be replaced by a solid state sensor. Standard solid state devices do not have enough sensitivity to be used in such applications.

This research demonstrated the feasibility of using a new sensor, the large area avalanche photodiode for PET applications. This new sensor has an internal signal gain which provides higher sensitivity than standard sensors. Research will continue to investigate and improve the avalanche photodiodes by increasing their sensitivity. Devices of suitable size and shape will be fabricated and tested for state-of-the-art PET instruments. Both of these areas represent significant commercial markets. By developing a new solid state photosensor of this type, a significant reduction in PET scanner size and complexity will be possible. This will make the instruments more practical, reliable, and less costly for both research and medical diagnostics. This would accelerate the propagation of these valuable instruments to a larger number of facilities. These detectors are also well suited to high energy physics research for applications where phototubes cannot be used, such as in high magnetic fields, or when the bulk of the phototubes makes large arrays impractical to assemble.

Keywords: Semiconductors, Surface, Instrumentation or Technique Development

Office of Fusion Energy

214. Plasma Materials Interaction and High Heat Flux Component Development Programs

	FY 1984	FY 1985
	$5,970,000	$5,140,000

DOE Contact - M.M Cohen, 301-353-4253
Sandia Contact - W. Gusster, 415-422-1648

Strategy

The strategy of the PMI and HHF programs are to develop and maintain a basic long range technological capability which can be utilized by all confinement communities. Focusing of this technology is accomplished through performance of specific component development projects on present and future confinement facilities and experiments. This program represents a vital resource utilized by all confinement concepts.

Existing fusion plasma experimental devices do not operate under conditions which allow for development and testing of plasma interactive materials necessary for future devices. This program develops and utilizes modest off-line facilities (such as PISCES and PMTF) for materials testing and development for future devices with careful consideration being given to the relation between developmental testing in off-line devices to materials operation in actual devices.

The PMI Program participates in on-going and future fusion plasma experiments to the degree required to support the experimental programs of all confinement schemes and to carry out the materials proggram objectives. Examples of this type of activity are: (1) the on-going joint D&T/TFTR program to develop improved coatings and determine projected tritium inventories for TFTR with and without coatings; (2) the development of halo scraper for TMS; and (3) the development of diagnostics for the alternate concepts program. The technical assessment of critical issues and problem areas in the PMI field is given in UCLA-PPC765, 815, January 1984.

This program interacts, cooperates, and participates with programs in other countries where mutually beneficial. Examples of such cooperations are: (1) the Alt I program; (2) the JET beryllium (Be) limiter fabrication; and (3) the utilization of the ORNL surface cleaning station in TEXTOR and JET (in the future). A joint U.S./Japan workshop on PMI data needs for an ignition device is scheduled for June 1985. A programmatic strategy for international collaboration in the PMI area is given in UCLA-PPG816, "Strategy for International Collaboration in the Area of Plasma Materials Interaction and High Heat Flux Materials and Component Development."

The institutional Program Participants and funding for PMI and HHF (jointly) are:

	FY 1984	FY 1985
Hanford Engineering Development Laboratory	80	80
Sandia National Laboratory - Albuquerque	3500	3080
Westinghouse	700	0
University of Wisconsin	65	40
University of California - Los Angeles	540	700
Oak Ridge National Laboratory	775	700
Sandia National Laboratory - Livermore	600	600

Radiation Interaction Materials Program

The central issue for this program is to establish the theoretical and experimental basis to characterize and predict the special effects of the fusion reactor neutron environment on materials and to develop new and improved materials to meet the requirement of fusion. The basic strategy is to conduct a program of materials research and development with a primary focus on radiation effects, making optimum use of existing irradiation testing facilities and to develop and use such special facilities that are required to adequately approximate the fusion reactor environment. Increased effort will be placed on theoretical understanding and computer modeling of radiation damage effects in materials to aid in assessment of end-of-life effects and in the development of reduced activation, radiation tolerant materials.

International collaboration is a significant aspect of these program elements including present U.S.-Japan on the use of HFIR, ORR, and the RTNS-II and multinational collaboration under the IEA Implementing Agreement on Radiation Damage in Fusion Materials. Future plans are docused on expanded use of HFIR and FFTS (MOTA) fission reactors and a restart of the now frozen action to establish international collaboration to construct and operate an FMIT-like test facility.

The neutron interactive materials program is organized in five sub-elements: Alloy Development for Irradiation Performance (ADIP), Damage Analysis and Fundamental Studies (DAFS), Special Purpose Materials (SPM), Analysis and Evaluation (A&E), and Radiation Facilities Development and Operation (RF).

Keywords:

215. Alloy Development for Irradiation Performance (ADIP)

	FY 1984	FY 1985
	$5,080,000	$4,270,000

DOE Contact - T.C. Reuther, 301-353-4963
ORNL Contact - A. Rowcliffe, FTS 624-5057

The scope of the ADIP program covers R&D on structural alloys and is focused on neutron irradiation efforts. Principal materials are developmental variations of austenitic stainless and 9-12Cr ferritic/martensitic starts and vanadium alloys. Reduced activation alloys are a priority development goal. The participating institutions and funding are:

	FY 1984	FY 1985
Argonne National Laboratory	440	300
Auburn	25	50
GA Technologies, Inc.	350	275
Hanford Engineering Development Laboratory	1000	900
Massachusetts Institute of Technology	280	150
NRL	175	0
Oak Ridge National Laboratory	2700	2550
Sandia National Laboratory - Livermore	110	0

Keywords: Alloy Development, Neutron Radiation Effects, Reduced Activation Alloys, Steels

216. <u>Damage Analysis and Fundamental Studies (DAFS)</u>

FY 1984	FY 1985
$2,490,000	$1,990,000

DOE Contact - T.C. Reuther, 301-353-4963
Hanford Engineering Development Laboratory Contact - D.G. Doran, FTS 444-3187

The scope of the DAFS program is to establish the mechanistic basis to evaluate and project to the effect of the fusion radiation environment from currentlay available irradiation facilities, to do dosimetry and damage analysis and in general to establish the fundamental response of materials to the fusion environment. Participating institutions and funding are:

	FY 1984	FY 1985
Argonne National Laboratory	250	250
University of California - Los Angeles	70	80
University of California - Santa Barbara	240	200
Hanford Engineering Development Laboratory	840	800
Lawrence Livermore National Laboratory	300	250
Oak Ridge National Laboratory	150	80
PNL	100	100
Rockwell	125	80
University of Wisconsin	345	150

Keywords:

217. <u>Special Purpose Materials (SPM)</u>

FY 1984	FY 1985
$ 790,000	$1,100,000

DOE Contact - M.M. Cohen, FTS 233-4253
ORNL Contact - J.L. Scott, 624-4834

The scope of SPM covers radiation effects on magnet system materials (superconductor, stabilizer, insulator) ceramic applications for insulators, diagnostics, etc., Be for neutron multipliers, etc. The program participants and funding are:

	FY 1984	FY 1985
Lawrence Livermore National Laboratory	120	80
Los Alamos National Laboratory	370	350
Massachusetts Institute of Technology	75	75
NBS	55	50
Oak Ridge National Laboratory	170	130
Reserve	0	415

Keywords:

218. Tritium Breeding Materials

FY 1984	FY 1985
$1,100,000	$ 800,000

DOE Contact - M.M. Cohen, 301-353-4253
ANL Contact - C.E. Johnson, FTS 972-7533

The scope of the Tritium Breeding Materials program is focused on establishing the properties, behavior, and tritium breeding and release characteristics of lithium bearing oxides. It includes in-reactor and post-irradiation studies and laboratory preparations and characterization. Participating institutions and funding are:

	FY 1984	FY 1985
Argonne National Laboratory	590	400
Hanford Engineering Development Laboratory	510	4090

Keywords:

219. Analysis and Evaluation

FY 1984	FY 1985
$ 150,000	$ 150,000

DOE Contact - T.C. Reuther, 301-353-4963
McDonnell Douglas Astronautics Co. Contact - J. Davis, FTS 314/234-4826

The scope of the Analysis and Evaluation program is to provide a bridge between the materials and design communities. This task develops and publishes the Materials Handbook for Fusion Energy Systems.

Keywords:

220. Radiation Facilities Operation

FY 1984	FY 1985
$4,200,000	$3,900,000

DOE Contact - M.M. Cohen, 301-353-4253
LLL Contact - C. Henning, FTS 532-0235

This task covers the U.S. share of the joint U.S./DOE and Japanese operations of RTNS-II, or 14 MeV DT neutron source.

	FY 1984	FY 1985
Lawrence Livermore National Laboratory	2000	1900

Keywords:

221. Operation of Oak Ridge Research Reactor — FY 1984 $2,000,000 — FY 1985 $2,000,000

DOE Contact - T.C. Reuther, 301-353-4963
ORNL Contact - J.L. Scott, FTS 624-4834

This task covers the operating cost of the ORR for Energy Research users.

	FY 1984	FY 1985
Oak Ridge National Laboratory	2000	2000

Keywords:

Small Business Innovation Research Program

222. Rapidly Solidified, Spherical, Fine Ceramic Powders
FY 1984
$ 49,670

Micromaterials Technology Contact - Richard F. Cheney, 717-888-6505

The research will determine the feasibility of making rapidly solidified ceramic powders using a unique new concept which should result in spherical powders less than 3 micrometers in average diameter. Rapid solidification technology has been applied to metals with significant improvements in electrical, mechanical, corrosion, and wear-resistant properties. It is hoped that equally significant improvements will be found for ceramics. Properties of the new powders will be evaluated and their densification behavior will be determined using press/sinter and hot-pressing techniques. The properties of selected densified parts will be evaluated.

223. Brazing of Machinable Glass-Ceramics — FY 1984
$ 48,649

Hittman Materials & Medical Components, Inc. Contact - Harold N. Barr, 301-730-7800

This research program will investigate the metallization of machinable glass-ceramics by the low-temperature sputter deposition of thin film active metals, which will then permit brazing of ceramic-to-metal and ceramic-toceramic assemblies for electronic and mechanical applications. The conventional ceramic metallization process (i.e., "moly-manganese") cannot be used due to the high temperatures required for bonding of the moly-manganese coating and active metal brazing has not produced acceptable joints because of excessive active metal content in the braze and undesirable reaction of the braze with metal components. It is expected that through proper selection and control of the thin film active metal metallization it will be possible to overcome the problems cited and prepare brazed assemblies of machinable glass-ceramics to selected metals and ceramics, which will meet electrical, mechanical, and hermetic requirements. The primary technical objective of the Phase I program is to establish and demonstrate the feasibility of thin film active metal metallization of the machinable glass-ceramics for the brazing of ceramic-to-metal and ceramic-to-ceramic assemblies.

224. Growth of BaF_2 Crystals by the Heat Exchanger Method (HEM) with Enhanced Fast Component for Scintillator Applications FY 1984
$ 49,751

Crystal Systems, Inc. Contact - Chandra P. Khattak, 617-745-0088

The fast component in BaF_2 is due to emission at 220mm wavelength. The research will adapt the Heat Exchanger Method (HEM) for the growth of BaF_2 crystals. It is intended to grow 5cm diameter, 4cm high crystals during the proposed 6-month period. Crystal growth experiments will be tailored to evaluate the effect of impurities (such as oxide phase, hydroxyl ions and secondary phases), crystal quality, size, and crystal growth parpmeters on the scintillation properties of BaF_2. The crystal grown will be characterized at Brookhaven National Laboratory for scintillation properties. At the end of the proposed 6-month program, technology will be in place to grow BaF_2 crystals in which the fast component is optimized so that the crystal can be used in fast timing scintillation applications.

225. Shape Memory Alloy Seals for Geothermal Applications
FY 1984
$ 47,104

Memory Metals, Inc. Contact - Dewa Adnyana, 203-358-0437

The program will study the application of shape memory alloy seals (Ni-Ti alloys) to provide a quantum improvement in the operating capability of geothermal systems. Since pressures encountered are high, seals must be capable of accommodating flange distortion, which may occur in service. Shape memory seals offer both extremely high seal pressure and an ability to adjust their shape to small dimensional changes, which can occur as a result of differential temperatures and pressures. Seal design and fabrication methods will be optimized and, following laboratory tests of seal integrity, downhole evaluation in geothermal brine will be carried out.

226. Wear-Resistant Ferrous Metal Matrix Composites for Municipal Solid Waste (MSW) Processors FY 1984
$ 49,921

Waste Energy Technology Corporation Contact - David B. Spencer, 617-275-6400

New materials are needed for the solid-waste-processing industry that will provide improved erosion and corrosion resistance. The objective of the proposed research is to determine the technical feasibility of producing ferrous metal/ceramic composites by high-technology, direct-casting methods -- termed rheocasting and compocasting -- resulting in material which is expected to combine the strength and impact-resistance properties of iron with the abrasion-resistance properties of ceramic materials. Conventional direct-casting methods for entraining ceramic particles in liquid metal have been largely unsuccessful. Experimental tests aimed at embedding ceramic materials in aluminum alloys using compocasting have proven successful. The research will determine whether the compocasting technology can be extended to ferrous metal/ceramic composites to achieve wear properties never before attainable in metal alloys. Abrasion-resistance testing will be conducted using ceramic materials obtained from commercial resource recovery facilities.

227. Horizontal Growth of Silicon Sheet Crystals via Edge-Supported Pulling (ESP) from a Melt Contained in a Cold Crucible

FY 1984
$ 285,019

Ceres Corporation Contact - Joseph F. Wenckus, 617-667-3000

The Phase I portion of this program focused on determining the feasibility of adapting the edge-supported technique to horizontal ribbon growth utilizing the cold crucible. The Phase II program will continue to explore the feasibility and scale-up of the horizontal growth of silicon sheet crystals using the edge-supported pulling (ESP) process from silicon melts contained in an RF-coupled cold crucible. Research has shown that it is possible to confine large, high-purity silicon melts in a cold crucible while maintaining the liquid surface well over 1cm above the rim of the container with a high degree of stability. Since the solid feed material is introduced continuously in the bottom of the crucible, precise control of the melt level can be maintained during crystal growth.

228. Fabrication of Amorphous Metallic Films and Coatings for Industrial Applications Using High-Energy Ion Beam Mixing

FY 1984
$ 495,202

Universal Energy Systems, Inc. Contact - Peter P. Pronko, 513-426-6900

The objectives of this research project are to develop stable amorphous metallic alloy coatings by energetic ion beam processing. It is anticipated that these coatings will exhibit superior properties with respect to corrosion pitting and surface erosion in fluid dynamic and electrohydrodynamic environments. Fabrication of these surface films and coatings will be done using high-energy (MeV) heavy ion bombardment of predeposited layers or surface alloy combinations. Alloy components will be chosen to take advantage of the so-called structural difference rule in producing amorphous layers by ion beam mixing. The stability of these glassy metal layers will be investigated as well as their passivation and control characteristics relative to corrosive pitting and oxidative surface reactivity.

229. Growth of Bismuth Germanate ($Bi_4Ge_3O_{12}$, BGO) Using the Heat Exchanger Method (HEM)

FY 1984
$ 417,522

Crystal Systems, Inc. Contact - Chandra P. Khattak, 617-745-0088

The feasibility of growth of BGO crystals by HEM has been demonstrated during Phase I. It has been shown that the quality of BGO crystal grown by HEM is equivalent to that of crystals grown by the Czochralski and Floating Zone methods. Square cross-section crystals have been grown by HEM, and the reusability of platinum for crucibles has been demonstrated. The objective of the Phase II project is to establish technology for economic growth of large, high-quality BGO crystals for nuclear and high-energy physics applications. It is intended to grow 25cm x 25cm x 12cm BGO ingots by HEM.

230. <u>Superplastic Forging of Structural Ceramics</u> <u>FY 1984</u>
$ 50,000
Jupiter Technologies Contact - Prakash Panda, 607-257-4514

Superplastic forming is currently the preferred method of fabricationg gas turbine engine components from high-performance, metallic nickel-base superalloys. It should be possible to apply similar techniques to net-shape and near net shape forming of strucural ceramics. The feasibility of superplasic deformation in model ceramic materials has been demonstrated at Cornell University. In Phase I the project will ascertain the feasibility of superplastic forming of engineering ceramic materials, namely, silicon nitride, and glass-ceramic/silicon-carbide-fiber composites. In Phase II, the work will be extended to other candidate materials such as silicon-carbide, zirconia, alumina, spinels, and other ceramic-ceramic composites. Also in Phase II, CAD/CAM techniques will be developed and applied to superplastic forming of structural ceramics.

231. <u>Titanium Nitride Coating of High-Speed Steel and Carbide Metal Cutting Tools Using Fluid Bed Furnace Technology</u> <u>FY 1984</u>
$ 49,580
Procedyne Corporation Contact - Joseph E. Japka, 201-249-8347

In the past few yoears, a considerable increase in performance has been achived from high-speed steel and carbide metal cutting by the addition of hard durface coatings, such as titanium nitride, silicon nitride, titanium carbide, aluminum oxide, and various combinations of the above. These coatings are difficult to apply uniformly, particularly in the case of complex geometries and are expensive, requiring high-cost equipment at long cycles at high-energy cost. Various heat-treating methods , using fluid bed heat-treating furnaces have been under development and commercialization. Preliminary R&D with titanium nitride coatings indicates that the hard coatings may be applied more effectively and at lower cost using lfuid bed furnaces. This R&D program has as its objective to study the feasibility of using fluid bed technology for putting a hard titanium nitride coating on carbide and steel tools to determine optimum coating conditions on carbide and the characteristics of the TiN coating. It is anticipated that this effort will lead to a comprhensive R&D program in Phase II of hard coating using fluid bed technology and to major commercialization in Phase III.

232. <u>Reduction of Surface Recombination in Silicon Solar Cells</u>
<u>FY 1984</u>
$ 49,173
Spire Corporation Contact - Mark B. Spitzer, 617-275-6000

The next generation of high-efficiency silicon solar cells will require very low surface recombination at both front and back surfaces. One approach to reducing surface recombination is by growth of an epitaxial heterojunction "window" of a higher bandgap material which is transparant and offers both low interface recombination and low resistance contact. Transparancy requires a bandgap of at least 3 eV, while a low density of interface states may be obtained by epitaxial growth of the window layer. This requires a semiconductor with face-centered cubic (FCC) lattice and a lattice constant near 5.431A. Of the semiconductor materials available, only ZnS, with a bandgap of 3.6 eV and a lattice constant 5.406A, appears to meet the criteria fuuly. In collaberation with Brown University, this program will investigate growth of epitaxial alyers of zinc slufide on high-efficiency solar cell substrates by chemical vapor transport. Material quality of the deposited layers will be evaluated by x-ray diffraction, SEM, EDAX, and Hall measurements. Electrical characterization will be done on silicon wafers with ion implanted p-n junctions. by measuring the spectral response of the cell when illuminated both from front and back. Diffusion length and surface recombination can be determined. Once low-recombination velocity epitaxial alyers can be grown and characterized, representative high-efficiency solat cells will be made. The end result of Phase I will be the demonstration of making silicon solar cells passive by epitaxial zinc sulfide or zinc selenide/sulfide layers. Thus, the research will result in a means of lowering the surface recombination of silicon solar cells snd make possible the production of solar cells of greatly increased efficiencies. This will be followed in Phase II by the application of this technique to the manufacture of extremely high-efficiency solar cells, and in Phase III by the commercialization of the technology.

233. Eddy Current Non-Destructive Evaluation of Laser-Glazed Metallic Surfaces FY 1984
$ 49,873

American Research Corporation of Virginia Contact - Russell J. Churchill, 703-731-0655

This project proposes the application of eddy current non-destructive evaluation (NDE) techniques to achieve control of surface layers and to identify defects. Eddy current methods rely on the interaction of a time-varying electromagnetic field with the material under test with the results obtained by probes mounted external to the material surface. The target of opportunity is the combination of eddy current NDE methods with laser-glazing techniques to achieve the objectives of establishing a suitable laser-glasing model, determining the applicability of eddy current techniques, measuring properties of laser-glazed layers in known alloys and in cast iron and high-speed tool steels of interest in energy related industries, and optimizing the system parameters. The anticipated result is a research tool for monitoring and controlling the depth of melt and for characterizing defects in surface layers and adjacent substrate materials.

234. Processing and Characterization of Silicon Carbide-Aluminum Oxycarbide Ceramics

FY 1984
$ 49,983

Ceramatec, Inc. Contact - Raymond A. Cutler, 801-486-5071

Silicon carbide (SiC), Aluminum oxycarbide (Al_2OC), and aluminum nitride (AlN) all have the same 2H wurzite crystal structure and form a complete solid solution. Research in the SiC-AlN solid solution system has shown that the creep characteristics of this material are very desirable for high-temperature applications. It is believed that the low creep rate is the result of grain boudaries devoid of low melting phases. To date it has not been possible to densify the AlN-SiC solid solutions without hot pressing. Recent research at Ceramatec using pressureless sintering techniques has shown that it is possible to obtain dense SiC-Al_2OC polycrystalline materials which appear to form a complete solid solution. It is believed that the aluminum oxycarbide keeps the oxygen tied up in the lattice and the grain boundaries will be devoid of low melting phases. The purpose of this research effort is to characterize the microstructure and mechanical properties of the sinterable SiC-Al_2OC materials to determine if they are candidates for use in heat engines, cutting tools, wear parts, and other high-temperature components.

235. Containerless Sinter/Hot Isostatic Pressing (HIP) of a SIALON

FY 1984
$ 49,952

Gorham International Inc. Contact - Andrew C. Nyce, 207-892-2216

The objective of the study is to determine the feasibility of fully densifying a SIAlON via sinter/HIP processing. Sinter/HIP incorporates sintering and containerless HIP'ing into a single, uninterupted cycle conducted in a HIP system. In the proposed process technology, green preforms are sintered under moderate N_2 pressure to high density and closed porosity in the HIP vessel; following completion of the designated sintering phase of the cycle, the vessel is rapidly pressurized to a suitable HIP'ing pressure (e.g., 30 KPSI), and the HIP phase of the cycle is then conducted. The study will aim at fully densifying a 92wt% Si_3N_4 + 6wt% Y_2O_3 + 2wt% Al_2O_3 SIAlON via sinter/HIP. Room temperature modulus of rupture (MOR) values for sinter/HIP'ed specimens will be generated and compared with MOR values for compositionally similar sintered and sintered + containerless HIP'ed specimens.

236. Evaluation of Metal-Matrix Composites Based on Fe-Nd-B Alloys for Improved Permanent Magnets

FY 1984
$ 48,608

KJS Associates Contact - Reinhold M. W. Strnat, 513-879-0114

Research concerns the improvement of a class of high-energy permanent magnets now under development: heat-bonded composites of hard magnetic alloy powders in a ductile metal matrix. The applicability of Sn/Pb-solder bonding to iron-neodymium-boron alloys will be explored. Powders of different particle sizes will be prepared from presintered Fe-Nd-B; compacts of these with solder powder additions will be made and heat bonded by immersion in a solder bath. The quality at the bond will be studied metallographically and by compression tests. Magnetic properties and their stability at environmental temperatures up to 150°C will be investigated. Aging behavior will be compared with that of sintered Fe-Nd-B and $Sm-Co_5$, and with polymer and solder-matrix magnets made from Sm-Co and other rare earth transition metal alloys.

237. Rapidly Solidified Magnetic Alloys for High-Frequency, High-Power Applications FY 1984
$ 50,000
Marko Materials, Inc. Contact - Dr. Ranjan Ray, 617-663-2210

Metallic glasses show outstanding promise as low-loss, high-magnetic-induction core materials for the growing high-frequency, high-power applications markets. However problems exist with loss resonances in toroids of certain glassy alloys and a newly developed model of coupling should aid in designing transformer cores of lower loss. A simple series of measurements will be taken which should indicate whether the better way to avoid these losses is through uses of nonmagnetostrictive, cobalt-base glass or through more careful heat treatment of the higher induction but magnetostrictive iron-base amorphous alloys. Specifically, research will focus on fabricationg amorphous alloys of low magnetoelastic coupling and compare their performance with that of commercially available magnetostrictive amorphous compositions.

238. ODS Tungsten Carbide-Cobalt FY 1984
$ 49,718
Technical Research Associates, Inc. Contact - Guy B. Alexander, 801-582-8080

Research will focus on improving the properties of WC-Co alloys, and thus improve the life of such alloys in cutting tools, mining tools, etc. It is expected that WC-Co alloys of higher hardness at a fixed rupture strength and/or higher strength at fixed hardness can be prepared. It is further expected that the life of such new materials will be grossly improved. These improvements will occur because of the following modifications: (a) the tungsten carbide will be slightly finer grained than in conventional alloys; (b) carbon content will be very tightly controlled; and (c) the cobalt will be oxide dispersion strengthened.

239. "In-Situ" Evaluation of Electrocatalytic Materials with a Surface-Impedance Technique FY 1984
$ 50,000
Energy Conversion Devices, Inc. Contact - William M. Ayers, 201-231-9060

An "in situ" surface characterization technique is developed to evaluate electrocatalytic materials. The technique utilizes the propagation of high-frequency surface electromagnetic waves (SEW) along, rather than perpendicular to, the electrocatalyst surface. Electron scattering from various surface phases of the electrocatalyst (surface oxides, hydrides, and adsorbates) attenuates the SEW as it propagates along the surface. Calculation of a transfer function for the input and attenuated SEW provides a frequency-dependant surface impedance. In a refinement of the SEW impedance technique, cross-power and fast Fourier transform functions are used to calculate the simultaneous surface-impedance response to a multiple-frequency input signal. This approach allows the rapid examination of a wide frequency spectrum of surface-impedance features associated with the electrocatalyst stability and surface phases important to efficient electrocatalysis.

240. Fracture Mechanics Investigation of Grinding of Ceramics
FY 1984
$ 215,976
Ceramic Finishing Company Contact - Henry P. Kirchner, 814-238-4270

Recent advances in contact fracture mechanics have created an opportunity to apply contact fracture mechanics to investigate mechanisms of material removal and damage penetration during abrasive machining of ceramics. Because the mechanisms of material removal influence the magnitudes and distributions of the residual stresses induced by elastic relaxation against the irreversibly deformed zone on unloading, and they, in turn, influence the damage penetration, emphasis will be on investigation of the mechanisms of material removal. These mechanisms include crushing by mixed mode fracture ahead of, beneath, and behind the diamond point and chipping at lateral cracks propagating in response to the residual stresses. Material also may be displaced from the groove by plastic flow. By modifying available mathematical models for stress distributions and crack propagation at staic indentations, mathematical models will be developed to predict the extent of crushing and lateral cracking in the elongated grooves formed during grinding. The objective is to determine the relative importance of crushing and chipping alongside the track as a result of lateral cracking, as mechanisms of material removal, for various material properties and grinding conditions. The role of crushing in reducing the residual stresses that are responsible for lateral cracking will be investigated.

241. Mathematical Modeling of Electrochemistry of Stress Corrosion Cracking
FY 1984
$ 331,735
Electrochemical Technology Corporation Contact - Theodore R. Beck, 206-632-5965

The work in this project is directed at quantitatively understanding the electrochemistry of localized corrosion in aqueous energy production and conversion facilities. The first quantitative mathematical model for stress corrosion cracking (SCC) of titanium accounted for many aspects of SCC but did not desctibe the events in the most important region, the crack tip. Subsequent research on pitting corrosion showed the important role of salt films on the corroding surface. In Phase I, models were formulated for an analogous system with apparent salt films at the active end, tunnel corrosion of aluminum. Based on these results, in Phase II we will reformulate and test the titanium SCC model, formulate SCC models for iron and nickel alloys, and formulate a model for concentration of anions in an occluded anode site.

242. <u>An Investigation to Determine the Commercial Feasibility of "In-Situ" Cu-Nb Composites for High-Strength, High-Conductivity Applications</u>

FY 1984
$ 350,000

Supercon, Inc. Contact - James Wong, 617-655-0500

Information obtained during Phase I is used to evaluate the commercial feasibility of fabricating "in-situ" Cu-Nb multielement composites for high-strength, high-conductivity applications. In Phase II work will focus on optimizing the high-strength, high-conductivity properties of multielement "in-situ" composites and will increase the quantity of material fabricated. Additional material properties will be characterized, such as fatigue, wear resistance, spark resistance, corrosion, high and low temperature strength, etc. Other forms of "in-situ" composite, such as plate and strip, will be fabricated and tested. Prototype material will be made available for customer evaluation.

243. <u>High-Temperature and/or High-Speed Thickness Gauging of Metals</u>

FY 1984
$ 469,262

Materials Engineering Associates Contact - Bruce W. Maxfield, 509-375-0663

Phase I of this project demonstrated that Electromagnetic Acoustic Wave Transducers (EMATs) could be constructed that would operate continuously at temperatures of at least 1400^{o}F and for periods up to 1 minute near surfaces of 1750^{o}F. Shear wave EMATs were used to make ultrasonic velocity, attenuation, and EMAT insertion loss measurements up to the Curie temperature for a number of different types of steel. Phse II will evaluate improved, rugged, reliable EMAT designs for the generation and detection of longitudinal and shear waves up to 2000^{o}F. The most promising of these designs will be selected for construction as an engineering prototype for trial evaluation within a steel plant. Sensitivity improvements are expected to lead to practical methods for the detection of internal defects at high temperatures. The decision to proceed with Phase III, production engineering of an automated, high-temperature EMAT apparatus for thickness gauging and internal defect detection, will be based on the performance of the prototype.

244. <u>Superconductiong Magnetic Shields for Neutral Beam Injectors</u>

FY 1984
$ 49,818

Applied Sciences Consultants, Inc. Contact - Ahmad Waleh, 415-497-7450

Large, high-energy deuterium neutral beams, which must be made from negative ions, require extensive magnetic shielding against the intense fringing fields surrounding a magnetic fusion power plant. Conventional shielding by iron, steel, or alloys leads to either low saturation limits or becomes exessively massive. Multilayer sheets of copper-superconducting laminated materials, reinforced by nonmagnetic stainless steel support, will provide the necessary shielding for neutral beams and should withstand the magnetically induced forces. A feasibility study of the design, material characteristics, strength analysis, fabrication techniques, subscale test definitions, and economics of this superconducting shielding technique will be conducted. Improved magnetic shielding should result in closer mounting of the neutralizer to the reactor and smaller aperture requirement in the reactor wall, leading to a more compact neutral beam injector and saving of floor space in the vicinity of the reactor.

245. Development of a New Process for the Production of Very Fine Filamentary Superconducting Nb-Ti Composite FY 1984
$ 50,000

Supercon, Inc. Contact - James Wong, 617-655-0500

The present interest in the Nb-Ti composite conductors with very fine filaments has developed because of the advent of plans for superconducting super collider as a very large new machine for use in high-energy physics. The work involves the making of wire with individual filaments as small as 3 microns, using a new technique that avoids the laborious assembly of thousands of rods and tubes. This technique also avoids the necessity for multiple extrusions, and it is hoped that uniform individual filaments will be achieved. Through this research, Supercon will develop a new manufacturing method for the production of multifilamentary superconducting niobium-titanium wire with very large numbers of fine filaments. The superconducting wire would be used in magnets for high-energy particle accelerators at fields up to 8 Tesla.

246. Method and Device for Non-Destructive Inspection of Noibium to Improve Superconductivity FY 1984
$ 50,000

Sonoscan, Inc. Contact - Lawrence K. Kessler, 312-766-7088

A non-destructive test device will be developed to inspect niobium plates and niobium welds for defects causing its superconducting properties to be quenched. High-quality niobium is required for advanced machines such as future generation radio frequency particle accelerators. At presesnt, there is no established technique for locating and differentiating the types of defects critical to superconduction. The feasibility of acoustic microscopy will be investigated for locating critical size defects (50-500 m), and differentiating critical from noncritical defects. An initial library of typical flaw characteristics will be established and this will be compared with theoretical expectations. The feasibility of automatic recognition of flaws by computer-based image processing also will be established. This study is a prerequisite to the development of automatic inspection processes for use by government and industry to assure the quality of high-reliability materials.

247. Improvement of Carbon Foils and Applications FY 1984
$ 306,464

Arizona Carbon Foil Company Contact - Stanley Bashkin, 602-621-6814

In this project, we will make improved carbon and carbon-hydrogen foils, to develop a neutral-density filter for the near-infrared spectral region, to make a proton detctor useful for high proton energies and beam currents, and to protect surfaces from both abrasion and corrosive action.

For our carbon deposits used as optical attenuators in fiber-optics communications, we need improved methods of making and selecting satisfactory products to bring the proce down. Carbon-hydrogen polymers made from an electric discharge in ehtylene are particularly affective for targets and ion stippers in work with particle accelerators, but no commercial source is available currently; we will make such items. A neutral-density filter in the 0.8 - 1.6 micron range would be ecpecially helpful in fiber-optics communications, and our work so far indicates that we can make such a device whicn would be based on our carbon research. We will use a form of the ethylene deposits for the development of a proton detector, for which the Air Force has indicated a serious need. Finally, we will develop a commercial service for the coating of surfaces with protective films of fluorocarbon substances.

248. <u>Research on Advanced Cell Designs for High-efficiency Flat-Plate Applications</u> <u>FY 1984</u>
$ 489,854

Spire Corporation Contact - Mark B. Spitzer, 617-275-6000

The commercial viability of a photovoltaic system depends critically on system cost and efficiency. Although cost is in general the most important factor, balance-of-systems costs require a minimum operating module efficiency of about 15% to compete in the U.S. energy market. This project comprises improvements to coalr cell design that address this requirement. During Phase I, the feasiblity of using the ion implantation process for fabrication of cells with unusually high efficiency on small-area (4 cm^2) cell was designed. Phase II comprises research on the fabrication of prototype large-area cells. In addition, Phase II research addresses reduction of process cost, and includes applicaiton of the cell design and fabrication process to fabrication of solar cells made form a number of presentday Si sheet materials. Fabrication of prototype highly efficient solar cells from each material is an interim goal fo the project; achievement of reproducibility and uniformity is the final goal.

249. <u>Extreme Ultraviolet and Soft X-Ray Instrumentation for Microcharacterization of Materials</u> <u>FY 1984</u>
$ 499,550

Altex Corporation Contact - Herbert Pummer, 312-372-3440

There exists a continuously increasing body of experimental evidence that demonstrates that high-quality, short-pulse, excimer laser systems are prime candidates for the generation of spectrally bright coherent radiation in the extreme ultraviolet and soft x-ray spectral regions. Such excimer systems consist of (1) a unit generating a short, high-quality pulse at visible wavelengths, (2) a frequency shifter, and (3) a chain of ultraviolet amplifiers. Research during Phase I has led to the identification of two schemes suitable for satisfying the requirements of points (1) and (2) which involve approximately 75% of the present system's complexity and cost. The objective of Phase II research is to develop a prototype laser system that delivers a tunable, high-quality pulse of about 10psec duration in the range of < 450 to 700nm. This radiation will then be converted to 248nm and serve as the seed radiation for a KrF amplifier.

OFFICE OF NUCLEAR ENERGY

The Office of Nuclear Energy conducts research projects in the Office of Converter Reactor Development, the Office of Terminal Waste Disposal and Remedial Action, the Office of Uranium Enrichment, the Breeder Reactors Program, and the Office of Naval Reactors. Summarized below are the areas of research in which the Department is currently engaged.

- Conducts the Light Water Reactor R&D Program to improve the operation and availability of LWR's, extending plant lifetimes, enhancing plant safety (utilizing Three Mile Island information, as appropriate) and improving plant licensability, and plans and carries out R&D to provide base technology in High Temperature Reactors.

- Conducts R&D programs which support the development of converter reactors to exploit state-of-the-art and encouraging technologies to meet future requirements. This includes advanced LWRs, HTGRs, and innovative LMRs.

- Develops advanced Breeder Reactor Technology to determine the optimum economic, environmental, and safety qualities in plants, systems, and components preparatory to commercial application in the power plant market.

- Conducts programs to develop and apply Advanced Nuclear System technology to space and terrestrial application requirements including defense applications.

- Conducts the Naval Reactor Program to meet the nation's military requirements.

- Conducts programs to fulfill the Federal Government's responsibility for providing uranium enrichment services and for supporting low-level waste management and waste technology development.

- Conducts programs to fulfill the department's responsibilities for remedial action to protect public health and safety or to fulfill specific legislative requirements.

- Determines obstacles which stand in the way of increased use of Nuclear Energy and the steps needed to overcome them and implements other programs as directed by the Secretary.

Office of Converter Reactor Deployment

The overall mission of this office is to undertake activities which will resolve technical and institutional obstacles to the further deployment of converter reactors by private industry. This office includes the following divisions: High Temperature Reactor Development; Light Water Reactor Projects; Nuclear Regulation and Safety; and Nuclear Reactor Economics and Financing. The major materials interests of this office include those required for the following reactor applications: fuels; fuel cladding; moderators; structural components; and heat exchangers.

Division of High Temperature Reactor Development

The objective of this division is to develop the base technology, systems concepts, and reactor designs which will permit the Government, in cooperation with utilities and private industry, to commercialize the High Temperature Reactor. The materials interests of this division include those required for the development of coated particles fuels, graphite moderator and reflector blocks, graphite core support blocks and posts, pre-stressed concrete reactor vessels, thermal barrier pads and insulation, and heat exchanger tubing and tube sheets. The DOE contact for these projects is J.E. Fox, 301-353-4162.

250. Fuel Process Development	FY 1984	FY 1985
	$ 600,000	$ 695,000

DOE Contact - J.E. Fox, 301-353-4162
GA Technologies Contact - E.C. Winkler, 619-455-4200

This work includes establishing, characterizing, and qualifying fabrication processes and equipment for the preparation of microsphere fuel particles of uranium-oxycarbide (UCO) coated with layers of pyrolytic carbon (2) and silicon carbide (1). Major processing operations include solution mixing, kernel forming, drying, calcining, and sintering. Coatings are applied in a fluidized-bed furnace at temperatures up to 1600 degrees C. The objective is to develop kernel fabrication and coating specifications, which have very low defective particle yields.

Keywords: Fuels, Ceramics, Sintering, Coatings, Chemical Vapor Deposition

251. Fuel Materials Development	FY 1984	FY 1985
	$ 585,000	$ 510,000

DOE Contact - J.E. Fox, 301-353-4162
GA Technologies Contact - O.M. Stansfield, 619-455-2895

This work includes development of the technology base required to design, qualify, and license the fuel systems for near-term steam cycle/cogeneration and advanced process heat HTRs. These efforts are focused primarily on the low enriched uranium-oxycarbide/thorium-oxide fuel system, with limited work on advanced fuels. Major elements of the work include the preparation, testing, and evaluation of irradiation experiments, performance of post-irradiation fission product release tests, development and verification of fuel performance models, and preparation and updating of fuel specifications and a design data manual.

Keywords: Fuel, Ceramics, Coatings, Microstructure, Radiation Effects, Diffusion, High Temperature Service

252. <u>Fuel Development and Testing</u>	<u>FY 1984</u>	<u>FY 1985</u>
	$ 650,000	$ 920,000

DOE Contact - J.E. Fox, 301-353-4162
ORNL Contact - M.J. Kania, 615-576-4856

This work supports development of the technology base required to design, qualify, and license the fuels systems for near-term steam cycle/cogeneration and advanced process heat HTRs. These efforts are focused primarily on the low enriched uranium-oxycarbide/thorium-oxide fuel system, with limited work on advanced fuels. Major elements of the work include services associated with the design, assembly, and irradiation of fuel capsules, and post-irradiation examination work in support of qualification and licensing of the reference fuel system.

Keywords: Fuel, Ceramics, Coatings, Microstructure, Radiation Effects, Diffusion, High Temperature Service

253. <u>Graphite Development</u>	<u>FY 1984</u>	<u>FY 1985</u>
	$ 635,000	$1,095,000

DOE Contact - J.E. Fox, 301-353-4162
GA Technologies Contact - H. Jones, 619-455-2360

This work includes the selection, characterization, and qualification of graphite materials for applications in HTRs. These efforts are focused on the development of an improved fundamental understanding of the behavior of graphite under representative HTR environmental and loading conditions. Major goals of this work are to develop high strength graphites with sufficient stability under irradiation to be qualified for core components, and with sufficient oxidation resistance to be qualified for reflector components. The major elements of this work are the identification, selection, and characterization of candidate materials, and the development of graphite materials behavior and failure criteria required for reliable design analyses.

Keywords: Graphite, Ceramics, Irradiation Effects, Strength, Corrosion, High Temperature Service

254. <u>Graphite Development and Testing</u>	<u>FY 1984</u>	<u>FY 1985</u>
	$ 635,000	$ 845,000

DOE Contact - J.E. Fox, 301-353-4162
ORNL Contact - W.P. Eatherly, 615-574-5220

This work supports the selection, characterization, and qualification of graphite materials for applications in HTRs. These efforts are focused on the development of an improved fundamental understanding of the behavior of graphite under representative HTR environmental and loading conditions. Major goals of this work are to develop high strength graphites with sufficient stability under irradiation to be qualified for core components, and with sufficient oxidation resistance to be qualified for reflector components. The major elements of this work include characterization of the mechanical, physical, and chemical properties of candidate graphites and determinations of the effects of irradiation on mechanical and physical properties.

Keywords: Graphite, Ceramics, Irradiation Effects, Strength, Corrosion, High Temperature Service

255. Metals Technology Development	FY 1984	FY 1985
	$1,030,000	$1,225,000

DOE Contact - J.E. Fox, 301-353-4162
GA Technologies Contact - D.I. Roberts, 619-455-2560

This work includes testing activities to characterize and qualify the metallic materials selected for applications in the near-term steam cycle/cogeneration HTR system, and development efforts to provide the base technology required for selection of alloys for advanced HTR systems. Both tasks involve major evaluations of the effects of extended high temperature exposure in simulated helium environments on structural integrity. Other significant objectives of the work are to identify the database required for code qualifications, determine the welding and heat treating procedures for all bimetallic joints, and evaluate the friction and wear behavior of candidate protective coatings. Principal alloys include 2 1/2 Cr-1 Mo steel, Alloy 800H, Hastelloy X, Inconel 718, and developmental Ni-base alloys.

Keywords: Alloys, Coatings, Strength, Corrosion, Erosion and Wear, Joining, Microstructure, High Temperature Service

256. Structural Materials Development	FY 1984	FY 1985
	$ 660,000	$ 660,000

DOE Contact - J.E. Fox, 301-353-4162
ORNL Contact - P.L. Rittenhouse, 615-574-5103

This work includes testing activities to characterize and qualify the metallic materials selected for application in HTGR-SC/C plant components and structures. The emphasis of the work is to support the design of components which operate in the primary coolant circuit, where the service temperatures are the highest and the materials may be adversely affected by trace amounts of impurities in the helium coolant. The primary testing activities include evaluations of the effects of extended high temperature exposures in simulated helium and air environments on mechanical properties, development of steam generator tube welding procedures, and determination of the fracture toughness of concrete reactor vessel penetration steels.

Keywords: Alloys, Strength, Corrosion, Joining, Microstructure, High Temperature Service

257. Advanced Gas Reactor Materials Development

	FY 1984	FY 1985
	$1,070,000	1,070,000

DOE Contact - J.E. Fox, 301-353-4162
General Electric Co. Contact - O.F. Kimball, 518-385-1427

This work includes the identification, evaluation, and development of the high temperature alloys required for application in advanced HTRs that will operate at temperatures above 750 degrees C. The primary activity is operation of a major alloy testing laboratory specifically designed for extended high temperature exposures of mechanical property specimens and corrosion samples in simulated helium reactor environments. Major work elements include screening mechanical property and corrosion testing of commercially available and developmental candidate alloys, selection of candidate reference alloys for continued testing, and the generation of a database for development of high temperature design criteria and code qualification rules.

Keywords: Alloys, Strength, Corrosion, Joining, Microstructure, High Temperature Service

Division of Light Water Reactor Projects

The mission of the Division of Light Water Reactor Projects is to develop and demonstrate advanced technology for use in light water reactors in accord with national policies and goals. Although no separately identified materials program exists within the projects being sponsored by the division, materials testing and developmentwork is underway within several projects of the division's extended burnup program. DOE contact is P.M. Lang, 301-353-3313.

Office of Terminal Waste Disposal and Remedial Action

Division of Storage and Treatment Projects

The mission of the Division of Storage and Treatment Projects is to facilitate development of a reliable national system for managing low-level waste and to develop acceptable technologies for the treatment and immobilization of nuclear fuel cycle and special types of radioactive waste.

258. Technical Support to West Valley Demonstration Project

	FY 1984	FY 1985
	$2,600,000	$2,500,000

DOE Contact - J.A. Turi, 301-353-4728
PNL Contact - H.C. Burkholder, 509-375-2860

Provide technical assistance in supernate treatment and borosilicate glass formulation for West Valley Demonstration Project waste.

Keywords: Radioactive Waste Host

259. Materials Characterization Center Testing at West Valley Formulation Glass

	FY 1984	FY 1985
	$ 0	$ 200,000

DOE Contact - H.F. Walter, 301-353-5510
PNL Contact - J.E. Mendel, 509-375-2905

Evaluate, using various MCC test methods, samples of glass having the expected composition of West Valley borosilicate glass incorporating high-level waste.

Keywords: Radioactive Waste Host

260. Nuclear Waste Treatment

	FY 1984	FY 1985
	$6,900,000	$6,500,000

DOE Contact - J.B. Zorn, 301-353-4728
PNL Contact - H.C. Burkholder, 509-375-2860

Develop acceptable technologies for treatment and immobilization of waste from the nuclear fuel cycle and special waste.

Keywords: Radioactive Waste Host

261. West Valley Joule Heated Ceramic Melter Design and Fabrication

	FY 1984	FY 1985
	$2,000,000	$ 0

DOE Contact - J.A. Turi, 301-353-4728
PNL Contact - H.C. Burkholder, 509-375-2860

Working closely with the West Valley Demonstration Project, design and fabricate a liquid fed joule heated ceramic melter capable of making about 0.8 cubic meters per day of borosilicate glass incorporating West Valley high-level waste. Specific components include the melter, the canister loading and unloading turntable, and the enclosing turntable shroud.

Keywords: High Temperature Service, Radioactive Waste Host

262. Special Waste Form Lysimeter for Arid Regions

	FY 1984	FY 1985
	$ 400,000	$ 250,000

DOE Contact - J.L. Smiley, 301-353-4728
EG&G Idaho Contact - E. Jennrich, 208-526-9490

Conduct waste form leaching tests in a field facility in order to determine typical source terms generated by commercial solidified low-level waste in an arid climate, identify the chemical and physical processes that control the concentrations of radionuclides in the surrounding soil, and determine methods for representing the source term boundary conditions for transport models.

Keywords: Radioactive Waste Host

263. Special Waste Form Lysimeter for Humid Regions

	FY 1984	FY 1985
	$ 200,000	$ 250,000

DOE Contact - J.L. Smiley, 301-353-4728
EG&G Idaho Contact - E. Jennrich, 208-526-9490

Conduct waste form leaching tests in a field facility in order to determine typical source terms generated by commercial solidified low-level waste in a humid climate, identify the chemical and physical processes that control the concentration of radionuclides in the surrounding soil, and compare radionuclid emigration from solidifed commercial low-level waste in order to evaluate the benefits of solidification.

Keywords: Radioactive Waste Host

Office of Uranium Enrichment

The goal of the uranium enrichment program is to meet the requirements of domestic and foreign customers and the U.S. Government for uranium enrichment services in an economical, reliable, safe, and environmentally acceptable manner. The Office of the Deputy Assistant Secretary for Uranium Enrichment, reporting to the Assistant Secretary for Nuclear Energy, is responsible for the management of DOE resources to attain the program goal. Uranium Enrichment is composed of four major offices: Marketing and Business Operations, Operations and Facility Reliability, Enrichment Expansion Projects, and Advanced Technology Projects. Operations and Facility Reliability is responsible for oversighting all aspects of the Gaseous Diffusion Plants including the electrical power contracts which are a major cost element. The Enrichment Expansion Projects Office is responsible for construction of the Gas Centrifuge Enrichment Plant (GCEP) at Portsmouth, Ohio, and the procurement and installation of baseline centrifuges and other plant process equipment. Advanced Technology Projects is responsible for all research/development/demonstration of a higher capacity Advanced Gas Centrifuge and the Atomic Vapor Laser Isotope Separation Process. Both of these advanced processes are now being critically evaluated to determine which will be the recommended enrichment technology for further development and potential future deployment.

Revenues received by DOE for the enrichment of uranium are retained and used for the specific purposes of offsetting costs incurred by the Department in providing uranium enrichment service activities as authorized by Section 201 of Public Law 95-238, not withstanding the provisions of Section 3617 of the Revised Statutes (31 USC 484). The sum appropriated is reduced as uranium enrichment revenues are received during a fiscal year so as to result in a final fiscal year appropriation estimated at $0. Total obligations for all uranium enrichments in FY 1984 was $1.94 billion and is expected to be $1.83 billion in FY 1985.

Uranium as found in nature contains about seven-tenths of 1 percent uranium 235 which is fissionable. The remainder is essentially uranium 238 which is nonfissionable. The fissionable characteristics of uranium 235 make it desirable to enhance its concentration for use as nuclear fuel. Light water reactors typically require uranium 235 concentrations in the 2 to 4 percent range. Presently uranium is enriched to the desired uranium 235 product assay levels in gaseous diffusion plants located at Oak Ridge, Tennessee; Portsmouth, Ohio; and Paducah, Kentucky. These plants were built in the 1940's and 1950's and were operated initially to satisfy defense requirements for uranium 235. They are now operated primarily to provide enrichment services to domestic and foreign utility customers. In these plants, the Department enriches customer-provided natural uranium in the uranium 235 component for a fee which recovers the cost of providing the services. The Department is the sole provider of enrichment services in the United States. The specific statutory authority which established this role is the Atomic Energy Act of 1954, as amended.

Materials activities within the Office of Uranium Enrichment are varied and, for the most part, especially the test results, classified Restricted Data. The following summarizes most of these activities for the purpose of this report. The total outlay in FY 1984 was $55,229,000 and in FY 1985, due to the Technology Decision, about $77,708,000 will be expended. The DOE contact is A.P. Litman, 301-353-5777.

	FY 1984	FY 1985
264. Gaseous Diffusion: Barrier Quality	$1,770,000	$1,073,000

Studies of the short- and long-term changes in the separative capability of the diffusion barrier. Methods to recover and maintain barrier quality and demonstration in the production facilities. This activity is a long-term undertaking and will be maintained at the appropriate levels of effort in the future.

	FY 1984	FY 1985
265. Gaseous Diffusion: Barrier Science	$1,010,000	$ 875,000

Fundamental aspects of the diffusion barrier, Work on barrier theory is performed and assistance is given to the barrier quality activities.

	FY 1984	FY 1985
266. Gaseous Diffusion: Materials and Chemistry Support	$2,865,000	$2,291,000

Routine materials and chemistry support of the diffusion plants. Characterization of contaminant-process gas cascade reactions, physical/chemical properties of UF_x substances, corrosion of materials, failure analyses, trapping technology, alternative materials replacement.

	FY 1984	FY 1985
267. Advanced Gas Centrifuge: Set V	$34,584,000	$33,469.000

DOE is currently constructing a Gas Centrite Enrichment Plant (GCEP) within the perimeter of the gaseous diffusion complex at Portsmouth, Ohio. The baseline gas centrifuge developed for GCEP is designated as Set III. Also, the Department is currently funding development of an Advanced Gas Centrifuge (AGC), designated as Set V, which may ultimately replace Set

III machines. Assuming AGC is the recommended enrichment technology for further development and potential future deployment, this method could be available for GCEP beginning in FY 1987. The goal of the AGC is to design and qualify a machine capable of producing 600 separative work units (SWU) of enriched uranium per machineyear, as compared with the nominal 200 SWUs per machine-year obtained from the Set III centrifuge.

The increase in separative performance for Set V is based primarily on the use of improved materials for the rotor. These permit the rotor to operate at substantially higher speeds of rotation to take advantage of the marked improvement in separative work performance with speed increase. The rotor materials being assessed for potential use are commercially available or in a limited production stage. Hence, the emphasis is not on materials development but on the utilization of existing materials. The funding below is for the development of Set V components and materials as can best be reported in an unclassified manner.

	FY 1984	FY 1985
Rotor Tubes	$10,091,000	$14,492,000
Caps and Baffles	4,582,000	2,386,000*
Advanced Materials	6,961,000	5,000,000
Assembly Integration	950,000	0
Characterization of Test Specimens	12,000,000	11,591,000
	$34,584,000	$33,469,000

* End Caps, Transitions, and Column

268. Atomic Vapor Laser Isotope Separation (AVLIS) Process Separator Development

	FY 1984	FY 1985
	$15,000,000	$40,000,000

The AVLIS process is based on utilizing the differences in the electronic spectra of atoms of uranium isotopes to induce the selective absorption required for isotopic separation. The process utilizes the controlled vaporization of uranium atoms followed by selective excitation and ionization of uranium 235 using tunable lasers in the visible regions of the spectrum. The resulting plasma of uranium enriched in uranium 235 ions can then be removed from the vapor using electromagnetic methods.

As noted earlier, DOE plans in May 1985 to select either AGC or AVLIS for further development and possible future deployment. The primary emphasis for AVLIS in FY 1984 and FY 1985 was to provide a significant demonstration for this selection decision. Available resources were focused to this goal and also to the operation of existing testbeds to conduct and evaluate key subsystems. The ultimate goal is to develop an AVLIS plant module point design, fully supported by experimental results, which will produce enriched uranium at low cost in accordance with the uranium enrichment enterprise. Most of the AVLIS materials activities in FY 1984 revolved around the process separator development

Coating development for various substrates to contain uranium and development/demonstration of engineering subcomponents. Approximately $12,000,000 of the amount shown was and will be used for materials selection, property evaluation, analysis, and testing.

Keywords: Enrichment, Gaseous Diffusion, Uranium, Gas Centrifuge, Laser Isotope Separation

Office of Breeder Reactor Programs

Office of Special Nuclear Projects

The Office of Special Nuclear Projects is responsible for the development, system safety, and production of radioisotope thermoelectric generators (RTG) and dynamic power systems for NASA and DoD space and terrestrial applications and advancing base technologies for these power systems. Thus, applied materials research programs are supported in the areas of thermoelectric materials and devices, high temperature heat source materials, materials systems compatibility, and safety related materials characterization and testing.

269. Development of Improved Thermoelectric Materials for Space Nuclear Power Systems

	FY 1984	FY 1985
	$ 0	$ 850,000

DOE Contact - W.J. Barnett, 301-353-3097 (FTS 233-3097)
General Electric Co. Contact - P.D. Gorsuch, 215-354-5047

The prime objective of this program is to optimize the thermoelectric performance of silicon-germanium type materials by a systemmatic study of compositional (i.e., alloy and dopant additions) and processing parameters (i.e., powder preparation techniques, including rapid solidification powder particle size, hot pressing, variables, etc.). Property characterization shall include the following: electrical resistivity, Seebeck voltage, thermal conductivity, Hall effect, and density measurements. Structural characterization shall employ the following evaluation techniques: optical microscopy, x-ray diffraction, SEM, STEM, EDAX, ESCA, and EXAFS. A statistical experimental design shall be employed. The goal is an average figure of merit, Z, of 1 X 10^{-3} degrees C^{-1} over the temperature range of 300 to 1000 degrees C.

Task 2 of this program is comprised of exploratory studies of advanced refractory candidate thermoelectric materials. The goal is a potential average figure of merit, Z, of 1.3 X 10^{-3} degrees C^{-1} over the temperature range of 300 to 1000 degrees C. Principal candidates include beta-boron and boron carbide.

Improved thermoelectric materials are required to enhance the performance of advanced radioisotope thermoelectric generators, the primary space power system employed in NASA spacecraft for deep space exploration.

Keywords: Semiconductors, Consolidation of Powder, Solidification-Rapid, Structure, Thermoelectric

270. Development of an Improved Process for the Manufacture of DOP-26 Iridium Alloy Blanks

	FY 1984	FY 1985
	$ 350,000	$ 525,000

DOE Contact - W.J. Barnett, 301-353-3097 (FTS 233-3097)
ORNL Contact - R.L. Heestand, 615-574-4352 (FTS 624-4352)

An iridium alloy, DOP-26 (i.e., Ir-0.3 wt.% W with Th and Al dopant additions), serves as the fuel clad or capsule material for isotope heat sources employed in recent and contemporary space power systems for NASA deep space missions such as Voyager and Galileo. This program is aimed at the development of an improved process route for the production of DOP-26 iridium alloy sheet, namely a consumable arc cast/extrusion/"warm" rolling route. Thermomechanical process parameters shall be optimized with respect to uniformity of product grain morphology.

It is anticipated that the consumable arc cast/extrusion route process will replace the currently employed arc drop cast ingot/warm roll sheet process and shall yield a significant improvement in process yields and product quality. A prime goal for the new process is a 50% reduction in reject rate (i.e., from 30% to 15% or below) due to ultrasonic indications (i.e., laminar type defects).

Keywords: Metals - Non-ferrous, Extrusion, High Temperature Service

271. Carbon Bonded Carbon Fiber Insulation Manufacturing Process Development and Product Characterization

	FY 1984	FY 1985
	$ 405,000	$ 330,000

DOE Contact - W.J. Barnett, 301-353-3097 (FTS 233-3097)
ORNL Contact - W.P. Eatherly, 615-574-5220 (FTS 624-5220)

Carbon-bonded carbon fiber (i.e., CBCF) type thermal insulation material is employed in Isotopic General Purpose Heat Source Module assemblies for use in current GPHS-RTG (i.e., radioisotope thermoelectric generator) which will power the spacecraft for the NASA Galileo and ESA Ulysses missions. This CBCF process development program is intended to accommodate a replacement carbon fiber (note: present specified fiber is no longer available), improve process controls, and optimize process parameters. The product shall meet prior flight quality CBCF specification. Product characterization shall include chemical purity, density, compressive strength, and thermal conductivity. A valid correlation shall be developed between thermal conductivity and thermal diffusivity of both new and previously produced CBCF products.

Keywords: Insulators/Thermal, High Temperature Service, Fibers

272. Characterization of State-of-the-Art Thermoelectric Device/Materials and Exploratory Studies of Rare Earth Sulfide Thermoelectric Materials

	FY 1984	FY 1985
	$ 350,000	$ 400,000

DOE Contact - W.J. Barnett, 301-353-3097 (FTS 233-3097)
Iowa State University Contact - B. Beaudry, 515-294-1366

This program is concerned with the evaluation and characterization of state-of-the-art Si-Ge/GaP and other "improved" silicon-germanium type thermoelectric materials. Also the compatibility of materials employed in the manufacture of the multicouple (i.e., close packed arrays of couples) device is being studied. Long-term stability of thermal and electrical properties of thermoelectric materials and devices will be studied.

In addition, exploratory studies of the thermoelectric properties of rare earth chalcogenides are being studied. Fabrication techniques are being developed. Particular attention is being directed toward rare earth ternary sulfides.

Improved thermoelectric materials are required to enhance the performance of advanced radioisotope thermoelectric generators, the primary space power system employed in NASA spacecraft for deep space exploration.

Keywords: Semiconductors

Office of Space Reactor Projects

Investigation of fundamental material properties and resolution of compatibility issues are critical for the successful development of space nuclear reactor power systems. Feasibility of using refractory metals in a reactor concerns the material transport fluid/cladding/fuel chemical interaction. Knowledge of the creep strength, ductility, fracture toughness, and fabricability of refractory alloys is an important factor for this selection. The candidate structural materials include molybdenum, niobium, tantalum, and tungsten-based alloys.

One objective is the measurement of the high temperature creep strength and the DPTT of refractory alloy, wrought and weldment specimens, for use in early structural alloy selection decisions. A second objective is to analyze the available high temperature creep data for candidate refractory alloys.

Office of Breeder Technology Projects

The applied research and development technology activities, conducted at several national laboratories, industrial organizations, universities, and through bilateral and trilateral technology programs and exchanges with foreign nations, relate to current and advanced reactor systems. The scope of these activities include the following areas: fuel cycles; design and performance of high quality core components for fuels, blanket, and control systems; development of the structural materials used in these components and systems; development and demonstration of equipment, processes, and procedures for fabricating, processing, handling, and producing mixed oxide bearing fuels, materials, and components; sodium technology; standards and quality assurance; assuring a reliable high quality economical fuel supply for LMRs; destructive and non-destructive testing, examination, and evaluation of core components and the facilities and capabilities for conducting such examinations; responsibility for engineering and supporting facilities; associated safety, safeguards, and non-proliferation; maintaining competent capabilities in the several contractor organizations that conduct the pertinent R&D activities and programs. These activities are responsive to the administration's policies and goals and to the DOE programs that support them.

In-reactor and out-of-reactor property evaluations are being conducted on core materials, clad/ducts, fuels, and absorber materials. Through irradiation testing in FFTF and EBR-II, the Fuels and Core Materials Program is developing, qualifying, and verifying the use of reference, improved, and advanced mixed oxide fuels and boron carbide absorbers, including full size driver and blanket fuel, and absorber element pins and assemblies--same for carbide fuels. Fabrication development, evaluation, qualification, and verification (raw material processing, melting, hot working, cold working, and finishing) are conducted on reference, improved, and advanced alloys including in-reactor qualification of pins, ducts, and assemblies; surveillance assemblies of reference materials now in FFTF Core 1. Improved and advanced materials are being tested for use in future cores.

The objectives of the Materials and Structures Program are to develop procedures that will assure economic and safe components and systems while providing designers with sufficient flexibility in components and systems design to facilitate optimization. Materials being evaluated are low alloy and stainless steels as well as ferrous superalloys. Major areas include materials characterization, radiation effects, mechanical properties, joining methods, non-destructive testing, tribology, corrosion and wear, and materials data documentation. The DOE contact for the Fuels and Core Materials Division is Dave Nulton, 301-353-5004, and Nick Grossman, 301-353-3405 for the Materials and Structures Program. Project summaries were not submitted.

Office of Naval Reactors

The Materials Research and Development Program is in the Reactor Materials Division under the Deputy Assistant Secretary for Naval Reactors. The program supports the development and operation of improved and longer life reactors and pressurized water reactor plants for naval nuclear propulsion. The objective of the materials program is to develop and apply in operating service materials capable of use in the high power density and long life required of naval ship propulsion systems. This work includes irradiation testing of reactor fuel, poison, and cladding materials in the Advanced Test Reactor at the Idaho National Engineering Laboratory. This testing and associated examination and design analysis demonstrates the performance characteristics of existing materials as well as defining the operating limites for new materials.

Corrosion, mechanical property, and wear testing is also conducted on reactor plant structural materials under both primary reactor and secondary steam plant conditions to confirm the acceptability of these materials for the ship life. This testing is conducted primarily at two Government laboratories: Bettis Atomic Power Laboratory in Pittsburgh; and Knolls Atomic Power Laboratory in Schenectady, New York.

One result of the work on reactor plant structural material is the issuance of specifications defining the processing and final product requirements for materials used in naval propulsion plants. These specifications also cover the areas of welding and non-destructive testing.

Funding for this materials program is incorporated in naval projects jointly funded by the Department of Defense and the Department of Energy. This funding amounts to approximately $60 million in FY 1984 including over $28 million as the cost for irradiation testing in the Advanced Test Reactor. The Naval Reactors contact is Robert H. Steele, FTS 557-5565.

OFFICE OF DEFENSE PROGRAMS

The Assistant Secretary for Defense Programs directs the Nation's nuclear weapons research, development, testing, production, and surveillance programs. In addition, the Assistant Secretary coordinates a safeguards and security program to provide accountability and physical protection of special nuclear materials, including research and development for improvements, testing, evaluation, and implementation of safeguards systems. Additional responsibilities include management of the inertial fusion development and nuclear materials production programs, classification and declassification of sensitive weapons information, and analysis and coordination of international activities related to nuclear technology and materials.

Materials activities in Defense Programs are concentrated in the Offices of Inertial Fusion, Military Application, and Nuclear Materials Production.

Office of Inertial Fusion

Fusion Research Division

The task of the Inertial Fusion Target Fabrication Program is to make, test, and evaluate targets for current inertial fusion experiments and develop techniques for making targets to meet future requirements. Many of the experiments and targets are classified but some aspects of the program can be described here.

273. Target Fabrication	FY 1984	FY 1985
	$1,000,000	$1,000,000

DOE Contact - Carl B. Hilland, 301-353-3687
LNL Contact - Richard Mah, 505-667-3238
KMS Fusion, Inc. Contact - Timothy Henderson, 313-769-8500, ext. 302
Lawrence Livermore Contact - Irving Stowers, 415-422-5343

Hydrocarbon polymer (CH) is applied by plasma polymerization to glass microspheres to act as an ablator. These targets represent a unique fabrication capability that combines micromachining, plasma etching, and plasma polymerization. The targets are filled with a deuterium-tritium gas mixture during the process of making the glass microspheres. The targets are irradiated with a laser or particle beam to produce a fusion burn for various military and energy applications. Other techniques are classified.

Keywords:

Office of Military Applications

Solid State Sciences Directorate, 1100

Ion Implantation and Radiation Physics Research Department, 1110

274. Ion Implantation Studies for Friction and Wear

	FY 1984	FY 1985
	$	$ 250,000

DOE Contact - Y. Song, 301-353-5350
SNL (Contract No. DE-AC04-76DP00789) Contacts - D.M. Follstaedt, 505-844-2102; S.T. Picraux, 505-844-7681; L.E. Pope, 505-844-5041

Ion implantation is used to modify the surface and near-surface regions of metals and these implantation-modified materials are evaluated for their improved friction and wear characteristics. Of particular interest is the implantation of Ti + C into stainless steels to concentrations sufficient to form amorphous layers in the near-surface region. These amorphous layers have been found to yield significantly improved friction and wear behavior for stainless steels, independent of the structure and composition of the starting material.

Keywords: Ion Implantation, Friction, Wear, Amorphous Metals

275. Silicon-Based Radiation Hardened Microelectronics

	FY 1984	FY 1985
	$	$ 500,000

DOE Contact - Y. Song, 301-353-5350
SNL (Contract No. DE-AC04-76DP00789) Contacts - H.J. Stein, 505-844-6279; K.L. Brower, 505-844-6131

Optical and electrical measurements, in conjunction with electron paramagnetic resonance and related techniques are used to determine the fundamental defect structures and materials properties required for radiation-hardened Si-based microelectronics. Recent studies have concentrated on amorphous silicon nitride, which is the charge storage medium for radiation-hard nonvolatile semiconductor memories, and defects at the $Si-SiO_2$ interface, which markedly affect the radiation tolerance of MOS devices. Relationships between the materials composition, chemical bonding, and defect configurations and the electrical performance are evaluated to permit long-term prediction of the performance of devices in a radiation environment and to develop new structures with particular properties.

Keywords: Silicon Nitride, Silicon, Silicon Dioxide, Defects

Condensed Matter and Surface Science Department, 1130

276. Shock Chemistry

	FY 1984	FY 1985
	$	$ 500,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - R.A. Graham, 505-844-1931

Both organic and inorganic solids are being investigated to determine the influence of molecular structure on shock-induced bond scission, and the influence of line and point defects on the observed enhanced, shock-induced solid state reactivity. The work also provides insights about the nature of the shock process itself.

Keywords:

277. Initiation of Granular Explosives

	FY 1984	FY 1985
	$	$ 350,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - R.E. Setchell, 505-844-5459

Experimental and theoretical efforts are being directed at developing a fundamental understanding of the mechanisms involved in the shock wave initiation and growth to detonation of heterogeneous granular explsives. Materials of current interest include hexanitrostilbene and PBX 9404.

Keywords:

278. Strained-Layer Superlattices for IR Detectors

	FY 1984	FY 1985
	$	$ 300,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - G.C. Osbourn, 505-844-8850

Strained-layer superlattices based on the InAs/InSb/AlSb systems are being investigated as attractive alternatives to the difficult HgCdTe alloys for IR detector applications in the 8-12 micron and 3-5 micron wavelength ranges.

Solid State Research Department, 1150

279. Materials Growth by MOCVD

	FY 1984	FY 1985
	$	$ 150,000

DOE Contact - Y. Song, 301-353-5350
SNL (Contract DE-AC04-76DP00789) Contact - R.M. Biefield, 505-844-1556

The growth of a number of novel compound semiconductors and device structures is being explored by MOCVD. The primary effort is on the growth of GaP/GaAsP strained layer superlattices (SLSs) both conventionally and modulation doped for application in a variety of typical and novel device structures. Preliminary work is also being done in the InGaP and InSb/InAsSb alloys.

Keywords:

280. Materials Growth by MBE

	FY 1984	FY 1985
	$	$ 300,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - T.J. Drummond, 505-844-9677

The major efforts here center on the AlGaAs/AlAs system and the InGaAs system. Detailed studies of the mobilities and optical properties of devices fabricated from these materials have led to new understandings of the band offset and band alignment rules. New devices including bistable optical switches, rad-hard photodiodes, and the first p-channel SLS MODFET have been grown.

Keywords:

281. <u>Conducting Organic Materials</u>

	FY 1984	FY 1985
	$	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - D.S. Ginley, 505-844-8863; P.J. Nigrey, 505-846-8985

A variety of charge transfer organic superconductors and polymeric organic conductors are being synthesized. Potential applications lay in areas of catalysis, batteries, conductors, and sensors. Synthesis efforts center on using wet chemical and electrochemical techniques to make novel materials with unique structural and chemical properties.

Keywords:

282. <u>Passivation of Semiconductor Grain Boundaries and Defects</u>

	FY 1984	FY 1985
	$	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - D.S. Ginley, 505-844-8863

Extensive work has been done on the chemistry and kinetics of the passivation of polycrystalline silicon grain boundaries and devects with monatomic hydrogen. One-D and Two-D models have been demonstrated as has been their utility for process optimization. The first detailed infrared spectra of grain boundary hydrogen has been obtained and its dependence on treatment conditions evaluated. The extension of the passivation process to other materials systems is being evaluated.

Keywords:

<u>Organic and Electronic Materials Department 1810</u>

<u>Chemistry of Organic Materials Division, 1811</u>

283. <u>Polysilanes, Photoresists, and Non-Charring Dielectrics</u>

	FY 1984	FY 1985
	$ 100,000	$ 150,000

DOE Contact - W.G. Collins, 301-353-5494 (FTS 233-5494)
SNL (Contract No. DE-AC04-76DP00789) Contacts - R.L. Clough, 505-844-3492; J.M. Zeigler, 505-844-0324; L.A. Harrah, 505-844-6847

Some alkyl substituted polysilanes undergo depolymerization-volatilization when irradiated with UV light. These new polymers are being investigated as potential positive-working non-solvent-developed photoresists for use in microelectronic circuit manufacture. Emphasis is being placed on developing an understanding of the polymer photochemistry and on answering application-oriented questions of achievable resolution, etchant stability, and e-beam patternability. Significant progress has been made in testing of polysilanes with a variety of alkyl substituents, and successful candidate materials have been identified. Polysilanes with a different structgure, together with polysilane-polysiloxane copolymers, are being synthesized for use as potential non-charring encapsulants and molding compounds with higher strength than the corresponding silicones. Both of these applications require meltable crosslinkable materials and current efforts are directed toward polysilanes with these properties.

Keywords: Polymers, High Temperature Materials

284. Sulfonated Aromatic Polysulfones	FY 1984	FY 1985
	$ 100,000	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - R.L. Clough, 505-844-3492; C. Arnold, Jr., 505-844-8728; R.A. Assink, 505-844-6372

Sulfonated aromatic polysulfones are being synthesized and evaluated as chemically-stable, thin-film cation-permeable membranes for batteries. The new materials have been shown to exhibit significantly enhanced coulombic efficiencies and stabilities compared with inexpensive commercial membranes, but have a large cost advantage compared with fluorinated materials. Aging and resistivity tests are continuing. To create an improved membrane, an attempt is being made to impregnate the polysulfone into a microporous material.

Keywords: Polymers, Coatings and Films, Batteries

285. Radiation Hardened Dielectrics	FY 1984	FY 1985
	$ 150,000	$ 150,000

DOE Contact - W.G. Collins, 301-353-5494 (FTS 233-5494)
SNL Contacts - R.L. Clough, 505-844-3492; S.R. Kurtz, 505-844-5436; C. Arnold, Jr., 505-844-8728

Polymer dielectrics are being developed that display a minimum radiation-induced conductivity (RIC). These materials will be used in capacitors and cables exposed to high dose rate radiation so that little charge is lost due to RIC in this environment. Emphasis is placed on material preparation, testing, and the study of charge carrier transport and generation mechanisms. X-ray and electron induced photoconductivity measurements, optical and magnetic measurements, and chemical analysis techniques are utilized in this work. Mylar doped with an electron acceptor complex (TNF) has been shown to be a very effective rad-hard material. Studies on the aging behavior of this material are underway. A large production run on the material has been completed, and another is planned. Capcaitors made from this material have been fabricated and successfully tested.

Keywords: Radiation Effects, Polymers, Weapons

286. Effects of Material and Processing Variables on the Mechanical and Thermal Expansion Behavior of Graphite/Epoxy and Kevlar/Epoxy Composites

	FY 1984	FY 1985
	$ 350,000	$ 300,000

DOE Contact - Y. Song, 301035305350
SNL Contacts - L.A. Harrah, 505-844-6847; T.R. Guess, 505-844-5604

Two types of high performance composites are being investigated for a number of Sandia programs. Graphite/epoxy has the high specific stiffness and low coefficient of thermal expansion that make it a prime contender for the dimensionally stable platforms for pointing and tracking components being developed as part of the SDI Program. Both graphite/epoxy and Kevlar/epoxy are being considered as a lightweight composite case for the advanced strategic bomb because of high specific strength and impact resistant properties. These same two materials are being characterized to assess the vulnerability of solid-fuel, composite rocket motor cases. The research on these two classes of composites falls into three broad categories: (1) processing; (2) material properties testing; and (3) mathematical modeling. The processing of composite materials and structures involves many variables and we are trying to determine the influence of process variables (such as time, temperature, pressure, layup, resin system, etc.) on visual appearance, residual stresses, CTE, mechanical properties, and dimensional and environmental stability of finished parts. Material properties testing involves characterization of mechanical and CTE properties as a function of processing parameters, fiber and matrix type, layup pattern, and thermal conditioning history. The mathematical modeling concentrates on the nonlinear bending behavior of Kevlar composites that results from the low compressive strength of the Kevlar fiber. The goal of the modeling is to develop a constitutive model that can be incorporated into structural analysis computer codes.

Keywords: Processing, Composite Materials, Graphite/Epoxy, Kevlar/Epoxy, Coefficient of Thermal Expansion, Residual Stresses, Mechanical Properties, Nonlinear Bending Behavior

287. The Chemical Characterization of Plasma Deposited Thin Films

	FY 1984	FY 1985
	$ 100,000	$ 150,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - L.A. Harrah, 505-844-6847; R.J. Buss, 505-844-7494

The process by which plasma deposited thin films of organic and inorganic material are formed is being studied in order to expand our control of the material properties of the films. Current understanding of the mechanism is so poor that it is almost impossible to alter the film in desirable ways without extensive experimentation. This situation is becoming intolerable with the rapidly expanding applications of these films. This project is a combined effort to answer specific programmatic needs while building a sufficient fundamental understanding of the process mechanism that future questions will be more easily answered. Among the immediate problems being studied are the observed embrittlement of carbon-hydrogen films on exposure to air, the production of a thin film dielectric which can planarize a rough substrate and has good thermal stability, and the control of gas permeation through the films. The method used here is a molecular beam technique which allows control of the plasma-species participating in the deposition. The plasma-beam apparatus is a new facility unique to Sandia which has already answered several mechanistic questions about the deposition process and has yielded results which suggest solutions to the aging problem. It is expected that this project will result in the production of improved thin films for the current applications and will also lead to the use of these films in a variety of new ways.

Keywords: Plasma Chemistry, Plasma Polymerization, Thin Films, Molecular Beam, Glow Discharge, Coatings

288. Materials Structure and Properties by NMR Spectroscopy

	FY 1984	FY 1985
	$ 60,000	$ 70,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - L.A. Harrah, 505-844-6847; R.A. Assink, 505-844-6372

NMR studies are being used to characterize the microstructure and reaction kinetics of polymers and the transport characteristics of polymeric membranes. Magic angle spinning high resolution Si solid NMR spectroscopy is being used to define the structure of rigid polymers formed by plasma deposition. The silicon was found to be incorporated primarily as mono, di, tri, and tetrafunctional methylsiloxane groups. The heat aging behavior of these polymers is being understood in terms of the change in functionality of the silicon atom as additional oxygen is incorporated into the material. Fourier transform 1H studies at high fields are being used to follow the reaction kinetics of sol-gels prepared from various reactants. An expanded kinetics model is being developed and tested. The mobility of the fluid phase in ionic membranes is being studied by pulsed decay experiments. The electrical transport properties of the membrane are being related to the fluid phase mobility and the membrane's structure.

Keywords: Polymers, Organics, Coatings, Films

289. Electron and Photon Stimulated Desorption from Organic Surfaces

	FY 1984	FY 1985
	$ 50,000	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - L.A. Harrah, 505-844-6847; J.A. Kelber, 505-844-3408

Neutral and ionic species desorbed by low energy (<1000 eV) electron or photon bombardment of organic surfaces under ultra high vacuum conditions are measured as a function of the wavelength of the exciting radiation. Desorbed species are detected using a quadropole mass analyzer or by monitoring laser-induced fluorescence. The target materials are condensed thin films of hydrocarbon and partially substituted hydrocarbon molecules (e.g., CH_4 and CH_3F). The purpose of these experiments is to understand the nature of the radiation-induced processes which lead to bond rupture by observing ion and neutral appearance potentials and cross sections. The effects of chemical structure on the bond rupture and desorption processes are observed through a systematic variation of the chemical structure of the target material.

Keywords: Electron Stimulated Desorption, Photon Stimulated Desorption, Desorption, Organic

290. <u>Surface Chemistry and Bond of Plasma-Aminated Polyaramid Filaments</u>

	FY 1984	FY 1985
	$ 50,000	$ 50,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - L.A. Harrah, 505-844-6847; R.E. Allread, 505-846-5538

The mechanical properties of fiber-matrix composites are limited by poor adhesion between the resin matrix and the fiber reinforcement. We have shown that plasma modification of the fiber surface can lead to chemical bonding between the curing resin system and the reinforcing fiber phase with a much higher fiber-matrix adhesion. Amine functionality has been introduced onto poly(p-phenylene terephthalimide) fibers by amine and ammonia plasma treatments. Composites formulated from these treated fibers show substantially increased transverse strength and improved moisture resistance in aging experiments. The stability of treated fibers before incorporation into composites is being investigated to establish processing requirements. These materials are being considered for structural applications and as materials for printed wiring boards. Similar studies will be carried out on other fiber-matrix pairs of interest in high performance composites.

Keywords: Composites (Structural), Fibers, Insulators/Dielectrics (Polymeric), Molding, Weapons

<u>Physical Properties of Polymers Division, 1813</u>

291. <u>Microcellular Foams for X-ray Laser</u>

	FY 1984	FY 1985
	$ 100,000	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - P.B. Rand, 505-844-7953

Ultra-low density (<0.005 g/cc) microcellular foams have been developed for the Narya pulsed-power-driven x-ray laser development program. These foams, which are molded into rods, have been successfully used in gas puff implosion experiments on the Proto-II accelerator.

Keywords: X-Ray, Laser, Accelerator

292. <u>Cure Kinetics of Thermosets By DSC</u>

	FY 1984	FY 1985
	$ 100,000	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - M.R. Keenan, 505-844-6631

Isothermal differential scanning calorimetry (DSC) has been used to obtain the cure kinetics of a commercial epoxy film adhesive. The kinetic model can be used to determine cure times and temperatures at lower temperatures. Good correlation was obtained with mechanical property measurements.

Keywords: Thermosets, Films

293. Creep Rupture of Kelvar Composites	FY 1984	FY 1985
	$ 300,000	$ 300,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - R.H. Ericksen, 505-844-8333

We have found a variation in stress-rupture life of fibers from nominally identical Kevlar 49. There is evidence that long fiber life correlates with high initial modulus, a relationship that will provide further insight into microstructural features controlling stress-rupture.

Keywords: Fibers, Polymers, Fracture, Creep

Electronic Property Materials Division, 1815

294. High Electric Field Varistors	FY 1984	FY 1985
	$ 100,000	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - R.G. Kepler, 505-844-7520; G.E. Pike, 505-844-7562

ZnO varistors are polycrystalline materials which switch from insulators to conductors with increasing applied voltages. New varistors are being made from fine powders precipitated from ZnCl solutions. This powder is then sintered at a low temperature near 700 degrees C. Since the switching is controlled by the grain boundaries, the small size powder yields a high switching electric field, from 30 to 100 kV/cm.

Keywords: Powder Synthesis, Consolidation of Powder

295. Microelectronic Aluminum Metallizations	FY 1984	FY 1985
	$ 100,000	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - R.G. Kepler, 505-844-7520; J.S. Arzigian, 505-846-2465

Aluminum and aluminum alloy thin films processed in both a research type ultra high vacuum electron beam evaporator, and in microelectronic-oriented production equipment are being studied for small geometry, multiple level integrated circuit metallizations. Accelerated aging tests, in-situ failure analysis using a cryopumped SEM and electrical characterization techniques are used to evaluate the electromigration resistance, patternability, compatibility of these films for VLSI devices. Alternative metallizations departing from the traditional aluminum alloys are also being evaluated.

Keywords: Metals: Non-Ferrous, Electromigration, Semiconductor Devices

296. High Resistivity Thin Film Polycrystalline Silicon

	FY 1984	FY 1985
	$ 100,000	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - R.G. Kepler, 505-844-7520; W.K. Schubert, 505-846-2466

Resistivity measurements, spreading resistance profiles, and transmission electron microscope examinations have been conducted on thin films of high resistivity polycrystalline silicon such as is used to manufacture integrated circuit resistors. The goal of this work is to gain a better understanding of processing effects on the electrical properties and thus enable tighter process control. We have found ion implantation and thermal annealing steps to be critical steps through their effects on dopant diffusion in the grain boundaries and grain growth processes. Understanding gained has allowed the development of tighter process specifications. Work is continuing to understand microscopically what is happening in the grain boundaries and to perhaps tailor the dopant diffusion process.

Keywords: Semiconductors, Grain Boundaries and Grain Growth, Ion Implantation, Diffusion

Materials Characterization Department, 1820

Analytical Chemistry Division, 1821

297. Development of Automated Methods for Chemical Analysis

	FY 1984	FY 1985
	$ 300,000	$ 350,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - N.E. Brown, 505-844-2747

New automated methods for chemical analysis of materials are being developed to meet new or anticipated needs and to improve accuracy and efficiency. New facilities include a new automated multichannel electronic recording emission spectrometer which will be used for metals and alloy analysis in support of numerous weapons programs. Another new facility is an automated optical densitometer used for analysis of photographic spectra. The densitometer provides the new capability of converting qualitative photographic data into quantitative figures. New software programs for data reduction and search/match routines are being developed for the gas chromatography/mass spectroscopy to enhance our ability to identify and quantify unknown contaminants in weapons systems.

Keywords: Automation, Chemical Analysis

298. Thermomechanical Treatment of U Alloys

	FY 1984	FY 1985
	$ 80,000	$ 80,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - K.H. Eckelmeyer, 505-844-7775

Strengthening mechanisms are being investigated in U-Ti and U-Nb alloys with the goals of simplifying processing procedures and increasing strength-ductility combinations. It has been found that decreasing Ti content from the conventional 0.75% to 0.60% results in a factor of 3 decrease in the quench rate required to suppress diffusional decomposition of the y-phase and get age-hardenable martensite, thus enabling processing of thicker parts and minimizing quenching-induced residual stresses. A deformation strengthening mechanism has also been developed whereby parts of any thickness can be processed to yield strengths as high as 125 ksi without the need for quenching. In addition, a combined solid solution-deformation strengthening approach has been developed which permits yield strengths as high as 165 ksi to be obtained with reductions-in-area in excess of 45%. This represents significant simultaneous increases in both yield strength and ductility (from 130 ksi and 32%, respectively), a very unusual metallurgical accomplishment.

Keywords: U-Alloys, Strengthening Mechanisms, Thermomechanical Processing

299. Advanced Methods for Electron Optical X-Ray and Image Analysis

	FY 1984	FY 1985
	$ 230,000	$ 240,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - W.F. Chambers, 505-844-6163

Advanced methods of automated electron and x-ray instrumental analysis are being developed to improve resolution, accuracy, and efficiency and to allow us to undertake and solve more difficult problems. Advances in our in-situ electron diffraction pattern search/match routine (for approximately 30,000 diffraction patterns) has resulted in the identification of an intermetallic phase in a weldment that another weapons lab could not identify. A new program has been initiated for FY 85 to develop an advanced image analysis system which will be used for quantification of geometric, structural, and chemical information and also for image enhancement. This capability will permit more accurate determinations of processing/structure, composition/property relationships.

Keywords: Automation, Electron Optics, Transmission Electron Microscopy, X-Ray Analysis, Electron Diffraction

300. Advanced Methods for Surface and Optical Analysis

	FY 1984	FY 1985
	$ 230,000	$ 240,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - J.A. Borders, 505-844-8855

New facilities, methods, and software are being developed to improve our capabilities for surface and optical analysis. Recent accomplishments include improved software for data acquisition and reduction for the laser Raman microprobe, which is being used for glass structure studies and contaminant identification. Another accomplishment is improvement in the multivariate least squares software package for quantitative Fourier transform infrared spectroscopy. This allows quantitative analysis of infrared spectra of mixtures with overlapping peaks and non-Beer's Law behavior. Improvements planned for FY 85 include an upgrade of the data acquisition and reduction system for the x-ray photoelectron spectrometer, which is used for surface analysis on a broad range of materials, and the design and fabrication of a traversing stage for the laser Raman system. This will enable us to do molecular mapping, an important capability for contamination identification.

Keywords: Laser Raman Spectroscopy, Fourier Transform Infrared Spectroscopy, X-Ray Photoelectron Spectroscopy

301. Design and Fabrication of a Gamma-Ray Attenuation Spectrometer

FY 1984	FY 1985
$ 0	$ 150,000

DOE Contract - Y. Song, 301-353-5350
SNL Contact - W.D. Drotning, 505-844-7934

A new system based on the attenuation of monochromatic gamma rays from a cadmium radioisotope is being developed to analyze special materials for a strategic defense initiative program. This is a non-destructive method that will yield quantitative elemental analysis with an estimated precision of approximately 1/2%. Preliminary measurements have demonstrated feasibility, and calibration standards are presently being analyzed. An automated stage has been designed and is presently being built that will allow the samples to be scanned for homogeneity. This system will act as a backup for photoradiography, which is faster but less quantitative.

Keywords: Gamma-Ray Spectrometer, Non-Destructive Analysis

302. Infrared Reflectometer Development

FY 1984	FY 1985
$ 0	$ 150,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - H.L. Tardy, 505-846-6548

An infrared reflectometer system is being developed for the purpose of making absolute spectral reflectance measurements in the wavelength range, 2-15 microns. The spectral reflectance is used to calculate the thermal emittance of a wide range of materials used in weapons systems. Examples of applications of these measurements include: materials for strategic defense initiative programs; composite materials for reentry vehicle construction; surfaces of calorimeters used in nuclear testing; and tokamak fusion reactor wall materials. The reflectometer is being designed for high throughput in order to facilitate rapid development of materials with desired thermal emittance properties.

Keywords: Infrared Reflectometer, Reflectance Emittance

Metallurgy Department, 1830

Cleaning and Coating Technology Division, 1831

303. Plasma Deposition of Amorphous Metal Alloys

FY 1984	FY 1985
$ 40,000	$ 130,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - A.K. Hays, 505-844-9996

A technique is being developed to deposit amorphous metal alloys using a radio frequency discharge. Amorphous metals can be formulated that have outstanding strength, corrosion resistance, and abrasion resistance. Their use in industrial applications has been limited by the techniques presently employed to obtain them (rapid-solidification, sputtering, etc.). Present studies include the plasma-deposition of amorphous Ni-P-C films from $Ni(CO)_4$ and PH_3 in a H_2 carrier gas. Future work will include the development of a technique to deposit amorphous metal alloys using plasma-enhanced chemical vapor deposition.

Keywords: Coatings and Films, Metallic Glasses, Plasma Synthesis, Radio Frequency Synthesis

304. Electrophoretically-Deposited Coatings

FY 1984	FY 1985
$ 10,000	$ 110,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - A.K. Hays, 505-844-9996; D.J. Sharp, 505-844-8604

Electrophoresis as a technique has been used for some time to apply organic and ceramic coatings to large, irregularly-shaped objects. Our research has been directed towards the application of electrophoretically-deposited organic and organic/ceramic composite coatings as insulators and IEMP hardeners for electronic component packages. Present systems under study are acrylic/fluorocarbon co-polymers and acrylic/titanium dioxide composites. Future work will include the development of insulator/conductor composites.

Keywords: Coatings and Films, Insulators/Dielectrics - Polymeric, Insulators/Dielectrics - Ceramic, Electrophoretic-Deposition

305. Near-Net-Shape Processing of Nickel-Based Alloys

FY 1984	FY 1985
$ 120,000	$ 150,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - A.K. Hays, 505-844-9996; A.W. Mullendore, 505-844-6833

Near-net-shape processing allows for reductions in cost, time, and raw material usage in metallurgical processing. A technique is being developed to produce nickel-based alloys from the chemical vapor deposition of $Ni(CO)_4$ and selected metalloid hydrides. Future work will include the characterization of these alloys with respect to mechanical properties and microstructure.

Keywords: Metals - Ferrous, Including Steels, Coatings and Films, Chemical Vapor Deposition

306. High Temperature Semiconductors

	FY 1984	FY 1985
	$ 0	$ 20,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - A.K. Hays, 505-844-9996; A.W. Mullendore, 505-844-6833

Present microelectronics using silicon or germanium have limited use temperatures due to the fact that these materials are intrinsic conductors at temperatures above 500 degrees C. Boron-based compounds have been suggested for use as high temperature semiconductors. Present studies include the growth of single crystals of B_4C using CVD. Future work will be directed towards the development of a technique for growing boron carbide crystals suitable for device fabrication.

Keywords: Coatings and Films, Semiconductors, Chemical Vapor Deposition

307. Surface Modification of Coating Morphology Using Ion Bombardment

	FY 1984	FY 1985
	$ 70,000	$ 40,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - A.K. Hays, 505-844-9996; D.J. Sharp, 505-844-8604

Many coatings applications require fine-grain size materials. A technique is being developed to modify coating morphology of sputtered films by ion bombardment during deposition. This technique is presently capable of producing Be films with 20 nm grain size. Future work will include the development of techniques to reduce stress in these as-deposited films.

Keywords: Coatings and Films, Surface Modification, Sputtering

308. Optical Diagnostics for Metallurgical Processing

	FY 1984	FY 1985
	$ 130,000	$ 440,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - A.K. Hays, 505-844-9996; H.C. Peebles, 505-844-1647

Optical diagnostics are being developed to map the temperature, composition, and velocity profiles as a function of time of species present in the atmosphere during standard metallurgical processes (e.g., welding, vacuum arc remelting, and plasma spraying). This information is necessary to obtain a scientific understanding of the phenomena that govern these processes. Present efforts include the study of laser light extinction by the plume formed during the Nd:YAG laser welding of aluminum. Future plans include developing optical diagnostics for plasma spraying and vacuum arc remelting.

Keywords: Optical Diagnostics, Welding

309. Plasma Removal of Metal Oxides

	FY 1984	FY 1985
	$ 30,000	$ 115,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - A.K. Hays, 505-844-9996; R.R.Sowell, 505-844-1038

Metal oxide formation during glass-to-metal sealing processes often hinders further component fabrication processes such as metal joining. A technique is being developed to remove these oxides using plasma etching. The specific application involves cleaning metal oxides off of Inconel 718 by plasma etching with fluorocarbons. Future work will include the identification of the volatile species responsible for this process.

Keywords: Plasma Etching, Refractory Ceramics (Oxides)

Physical Metallurgy Division, 1832

310. Toughness of Ductile Alloys

	FY 1984	FY 1985
	$ 330,000	$ 350,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - R.J. Salzbrenner, 505-844-5041; J.A. VanDenAvyle, 505-844-1016

The elastic-plastic fracture toughness (J_{Ic}) has the potential to allow a fracture-related material property to be used in the design of structures using ductile alloys. For this to come about, valid testing procedures need to be developed and candidate materials need to be studied. Single specimen J-testing procedures are being studied and the fracture behavior of ductile cast irons is being examined. The goal of the current work is to have the fracture behavior of this alloy well enough characterized and understood that nuclear material shipping casks can be designed with it using a fracture toughness methodology.

Keywords: Metals - Ferrous, Fracture, Predictive Behavioral Modeling

311. Analytical Electron Microscopy of Engineering Alloys

	FY 1984	FY 1985
	$ 150,000	$ 150,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - A.D. Romig, 505-844-8358

Analytical Electron Microscopy (AEM) allows the local chemistry with high resolution within a thin foil to be determined. This cannot be done in engineering (complex) alloys in a straightforward manner because of the difficulty in interpreting x-ray peaks in multicomponent systems. Techniques have been developed using Monte Carlo simulations on a computer to sort out all of the measured effects and allow quantitative analysis. This has been applied to uranium alloys (where the high Z values create problems) and in stainless steel weldments. These quantitative measurements allow diffusion properties to be measured and, in turn, the kinetics of such metallurgical phenomena as precipitation to be determined.

Keywords: Metals - Ferrous and Non-Ferrous, Joining and Welding, Transformation, Electron Beam Methods, Weapons

312. Friction and Wear of Modified Surfaces

	FY 1984	FY 1985
	$ 200,000	$ 230,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - R.J. Bourcier, 505-844-6638; A.D. Romig, 505-844-8358

The improvement of friction and wear behavior using surface modification has been a very productive approach that includes many traditional methods (e.g., carburizing or nitriding). Recent work in ion implantation has shown that this technique can both decrease friction and improve wear, although the mechanism by which this occurs is not understood. It is known that an amorphous layer is formed and current work is aimed at understanding the metastable metallurgy of near-surface regions. Microhardness historically has been used to characterize these modified surfaces but this has been without a thorough understanding of low-load indentation testing. Finite element modeling techniques are being used to help separate artifacts caused by very low loads from the influence of a modified surface layer. Successful modeling will allow us to begin to model the friction process itself. Work has been conducted on nitrogen-implanted stainless steel and aluminum-implanted nickel.

Keywords: Metals - Ferrous and Non-Ferrous, Erosion/Wear/Tribology, Ion Implantation, Weapons

313. Alloy Deformation Response and Constitutive Modeling

	FY 1984	FY 1985
	$ 250,000	$ 300,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - W.B. Jones, 505-844-4026; R.J. Bourcier, 505-844-6638

All complex structures are now designed using finite element computer codes which can now handle both exotic geometries and plastic/creep deformation. Constitutive models which embody both time-dependent and time-independent inelastic behavior need to be developed which have a basis in the metallurgy and dislocation substructural characteristics of the alloys used. Also important is the long time microstructural stability of alloys and how to incorporate this into the models. Stainless steels are being studied using both uniaxial and biaxial testing techniques in order to characterize alloy response. Models are being developed which represent the deformation mechanisms operating and can be formulated for inclusion into finite element codes.

Keywords: Metals - Ferrous, Creep, Fatigue, Nuclear Reactors, Predictive Behavorial Modeling, Weapons

Process Metallurgy Division, 1833

314. Vacuum Arc Remelting

	FY 1984	FY 1985
	$ 170,000	$ 75,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - F.J. Zanner, 505-844-7073

Both fluid flow and arc plasmas during vacuum arc remelting are being studied with the goal of reducing inhomogeneities and defects in structural alloys and uranium alloys. Improvements in the control of melting and solidification are being incorporated into production processes to increase production yields and improve the ingot quality. This work involves experimental verification of models. Currently the heat energy balance in the plasma arc is being evaluated on the basis of boundary temperatures. Future work will include spectrographic studies to characterize the plasma.

Keywords: Metals - Ferrous, Non-Ferrous, Solidification-Conventional

315. Toughness of Inertia Welds

	FY 1984	FY 1985
	$ 120,000	$ 60,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - G.A. Knorovsky, 505-844-1109

The fracture toughness of alloy steel inertia welds is being determined with the goal of optimizing weld schedules as a function of alloy chemistries. Initial screening experiments have utilized impact type specimens and have shown that minor impurity levels have a pronounced influence on fracture toughness at excessive weld energies. Production weld schedules have been adjusted to minimize the effect of compositional differences. Future work will involve the use of valid plane strain fracture toughness specimens for selected composition-weld energy combinations.

Keywords: Metals - Ferrous, Joining/Welding, Fracture

316. Metallurgical Characterization of TiCode 12 Resistance Welds

	FY 1984	FY 1985
	$ 50,000	$ 40,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - G.A. Knorovsky, 505-844-1109

TiCode 12 is the primary candidate material for canisters containing radioactive Defense High Level Waste. A metallurgical study has been performed to determine the effect that resistance upset welding has on this material. One purpose was to determine whethr extensive corrosion tests would be required to qualify these welds. Analysis of the phases present, and their relative amounts, suggest that weld properties should be similar to that of the base metal and additional testing is not proposed.

Keywords: Metals - Non-Ferrous, Corrosion-Aqueous, Joining/Welding, Microstructure

317. Aluminum Laser Welding

	FY 1984	FY 1985
	$ 50,000	$ 80,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - M.J. Cieslak, 505-846-7500

Designers are selecting aluminum alloys for many new components. Welding methods for joining these alloys are limited, particularly where heat input must be minimized. Laser welding processes are being characterized. Current emphasis is on determining the role of metal evaporation on composition, mechanical properties, and hot-cracking. Future work will be directed towards minimizing melt-freeze cycles during welding and is dependent on the development of improved laser systems.

Keywords: Metals - Non-Ferrous, Joining/Welding, Solidification-Conventional

318. Low Temperature, Solid State Welds of Copper	FY 1984	FY 1985
	\$ 30,000	\$ 60,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - F.M. Hosking, 505-844-8401

Assembly of copper flexible circuits often requires sequential joining processes and/or rework. To produce joints that resist damage during subsequent soldering or de-soldering operations, a study of the mechanical properties of solid state welds of copper produced with indium or indium-silver alloy interlayers has been evaluated. Mechanical tests and fractographic analysis indicate that this process produces high quality joints. The resistance to thermal damage is increased by raising process temperatures so that indium is diffused into the base metal.

Keywords: Metals - Non-Ferrous, Joining/Welding, Fracture

319. Dissimilar Metal Welds	FY 1984	FY 1985
	\$ 60,000	\$ 120,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - M.J. Cieslak, 505-846-7500; G.A. Knorovsky, 505-844-1109

Weapon components typically include several alloys that must be welded to one another. As high performance alloys are incorporated into new designs, significant welding problems are encountered. Studies have been initiated to define the solidification mechanics in complex alloy systems with the goal of avoiding compatibility problems, particularly hot-cracking. Studies involving CO laser welding of high alloy martensitic steels to martensitic stainless steels have been completed. Additional studies are in progress involving pulsed Nd:YAG laser welding of Kovar to a number of ferrous and nickel-based alloys. Future studies will emphasize the welding compatibility of precipitation strengthened nickel-based alloys.

Keywords: Metals - Ferrous and Non-Ferrous, Joining/Welding, Solidification-Conventional

320. Welding of Nickel-Based Alloys	FY 1984	FY 1985
	\$ 150,000	\$ 225,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - M.J. Cieslak, 505-846-7500; G.A. Knorovsky, 505-844-1109

The combination of advanced design requirements and recent progress in glass-to-metal sealing technology has stimulated a program to obtain higher strength hermetic seals than is afforded by conventional austenitic stainless/steel-borosilicate glasses. Both solid solution strengthened and precipitation strengthened nickel-based alloys are being considered as replacements for stainless steel. Studies have been initiated to identify the constituents responsible for hot-cracking in these classes of alloys. Initial results indicate that solidification in these alloys generally terminates with the formation of one or more topologically-close-packed phases. Fundamental alloy studies remain to be completed for both Inconel 625 and Inconel 718 to determine the roles of minor alloying components. Also, future work will include solidification studies in the Ni-Cr-Mo system.

Keywords: Metals - Non-Ferrous, Joining/Welding, Solidification-Conventional

	FY 1984	FY 1985
321. Plasma Arc Welding	$ 75,000	$ 230,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - P.W. Fuerschbach, 505-846-2464; J.L. Jellison, 505-844-6397

Few fusion welding processes are suitable for joining aluminum alloys in the vicinity of heat sensitive components. Initial experiments suggest that plasma arc welding can markedly reduce heat input compared to conventional gas tungsten arc welding. A design specification has been developed for a variable polarity plasma arc welding power supply. Future studies will evaluate cathodic cleaning, welding efficiency, and arc stability as a function of the current-voltage characteristics.

Keywords: Metals - Non-Ferrous, Joining/Welding, Solidification-Conventional

	FY 1984	FY 1985
322. Laser Welding	$ 150,000	$ 150,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - J.L. Jellison, 505-844-6397

Pulsed Nd:YAG laser welding is a complex process both in terms of the number of control parameters and materials-process interactions. To improve the understanding of the process with the ultimate goal of developing weld schedules on the basis of process modeling, process characterization studies are being conducted. These include calorimetry experiments, plume characterization studies, and experimental validation of heat transfer codes. Future work will continue to emphasize beam-plume interactions and will include the development of a weld pool reflectivity test.

Keywords: Joining/Welding, Process Modeling

	FY 1984	FY 1985
323. Electrode Gap Controller	$ 50,000	$ 75,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - F.J. Zanner, 505-844-7073

One of the fundamental variables controlling vacuum arc remelting (VAR) is electrode gap. The electrode gap strongly influences arc plasma uniformity, melting rate, and fluid flow in the melt. Current VAR equipment does not permit direct control of electrode gap; electrodes are simply advanced at a rate that is believed to correspond to melting rate. Recent SNLA research has shown that the frequency of drop shorts is inversely proportional to the electrode gap. Drop shorts are signatures on the voltage waveform that result from the transfer of metal during VAR. Statistically designed experiments are being conducted to evaluate the influence of arc power, gas pressure, and electrode gap on the frequency of drop shorts. Future work will continue to refine a control algorithm based on the relationship between electrode gap and drop short frequency. This experimental verification will involve both uranium and structural alloys.

Keywords: Metals - Ferrous and Non-Ferrous, Melting, Process Control

Surface Metallurgy Division, 1834

324. Deposition of Amorphous Materials With a Dual Beam Ion System

	FY 1984	FY 1985
	$ 20,000	$ 80,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - J.K.G. Panitz, 505-844-8604

Amorphous films can reduce friction, wear, and corrosion susceptibility. A dual beam system has been developed to sputter-deposit amorphous film material onto selected substrates with concurrent ion bombardment with inert and reactive gas ions (hydrogen and argon have been used). Preliminary coatings have been deposited, and system parameters have been defined. The mechanical properties of the sputter-deposited amorphous material, specifically hardness, are dependent on the conditions of deposition. Future work will emphasize the development of hard, wear resistant coatings for mechanical applications.

Keywords: Metallic Glass, Erosion/Wear/Tribology, Coatings and Films

325. Modification of Mechanical Properties by Ion Implantation

	FY 1984	FY 1985
	$ 25,000	$ 25,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - L.E. Pope, 505-844-5041; D.M. Follstaedt, 505-844-2102; S.T. Picraux, 505-844-7681; J.A. Knapp, 505-844-2305

Stainless steel parts which undergo relative motion and which function in inert atmospheres have large coefficients of friction and can experience severe wear, specifically galling. The dual implantation of titanium and carbon into stainless steels produces an amorphous film on the surface which decreases both the friction coefficient and the wear rate; the implantation process is effective for austenitic and maretnsitic stainless steels and permits self-mating wear couples, 304 rubbing on 304 stainless steel, for example. Future work will emphasize the implantation of other elements and will attempt to optimize the chemical composition for maximum wear performance.

Keywords: Ion Implantation, Coatings and Films, Erosion/Wear/Tribology, Structure, Surface

326. Development of Materials for Magnetic Fusion Reactors

	FY 1984	FY 1985
	$ 500,000	$ 500,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - M.F. Smith, 505-846-4270; J.B. Whitley, 505-844-5353; J.M. McDonald, 505-846-7735

Materials used in magnetically confined fusion energy devices experience severe environments. Two materials have been developed for these applications. A beryllium limiter assembly was designed, fabricated, delivered to the ISX-B tokamak experiment at Oak Ridge National Laboratory. Performance has met design expectations. Secondly, a low-pressure chamber plasma spray process has been successfully developed to deposit ceramic/metal (SiC/Al) coatings. The ceramic/metal coatings may be used for low atomic number, low activation armor coating for first wall surfaces or for a graded thermal expansion transition coating to accommodate large thermal expansion differences. Tests to evaluate these materials are continuing.

Keywords: Magnetic Fusion, Coatings and Films

327. Ion Beam Reactive Deposition System

	FY 1984	FY 1985
	$ 175,000	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - D.E. Peebles, 505-844-1647

The properties of deposited films depend on stoichiometry, temperature of deposition, system pressure, and ionization state. A system has been constructed for reproducible reactive ion beam deposition of compound films; the system can control stoichiometries, energy input of each ion/atom/molecule, gas phase composition, and deposition rates. The system will be used to study mechanisms of compound film formation in addition to friction and wear responses of films for wear parts. Future studies will involve deposition of TiN, but eventually this method will be used to study complex film deposition of compounds not readily obtainable by current deposition methods.

Keywords: Coatings and Films, Erosion/Wear/Tribology, Surface

328. In-Situ Friction, Wear, and Electrical Contact Resistance Systems

	FY 1984	FY 1985
	$ 70,000	$ 80,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - L.E. Pope, 505-844-5041; D.E. Peebles, 505-844-1647

Friction, wear, and electrical contact resistance can depend critically on the surface composition of the outer 2.5 nm of material. The surface composition is easily masked by exposure to ambient conditions between testing and analysis. A device has been assembled in a scanning Auger analytical system to complete oscillatory or unidirectional sliding friction experiments while monitoring electrical contact resistance. Auger surface analysis is completed in-situ. A gas handling/introduction capability has been added for atmosphere control; the dynamic gas partial pressure can be controlled from 10^{10} to 10^{5} torr or at static pressures up to one atmosphere. Future modifications will allow kinetic friction coefficients to be measured in-situ.

Keywords: Surface, Erosion/Wear/Tribology, Structure

Chemistry and Ceramics Department, 1840

329. Ceramic Processing	FY 1984	FY 1985
	\$2,380,000	\$2,580,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - R.K. Quinn, 505-844-1933

High purity, homogeneous ceramic powders are being prepared by sol-gel chemistry techniques. Materials prepared include ZrO_2, PNZT, ZnO, Al_2O_3, and titanate catalyst supports. The first three materials are utilized in ceramic electronic components at Sandia. Alumina is being toughened by coprecipitation with ZrO_2. The catalysts are used in our coal liquefaction program currently, and may find more general application. Novel glasses are also being prepared by sol-gel techniques. Our studies include basic research on precursors as well as applied development. Experimental techniques include small angle x-ray scattering, nuclear magnetic resonance, and several spectroscopic techniques to characterize precursor solutions and products. Glasses have been successfully evaluated on solar thermal receiver tubes and on photovoltaic cells. Dielectric barriers for a number of weapon applications have also been developed and are being evaluated.

Keywords: Ceramics, Glasses, Chemistry, Surface Treatment

330. Fracture of Ceramics	FY 1984	FY 1985
	\$ 580,000	\$ 680,000

DOE Contact - Y. Song, 301-353-5350
SNL Contact - F.P. Gerstle, Jr., 505-844-4304

The fracture properties of ceramics often limit their application in weapon and energy systems. Our program includes basic research to better understand fracture processes and to develop tougher ceramics based on this understanding. The effects of microstructure in glass ceramics, phase separation in glasses, and of the environment are presently being studied. Basic studies on the effect of environment in crack propagation of glasses have led to an atomistic model which explains the chemical interaction between a wide range of environments and strained silicate bonds in glasses. A program to develop tough ceramic composites and glass ceramics is also underway.

Keywords: Ceramics, Glasses, Fracture, Strength, Corrosion

331. Glass and Glass-Ceramic Development

	FY 1984	FY 1985
	$2,500,000	$2,500,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - F.P. Gerstle, Jr., 505-844-4304; R.K. Quinn, 505-844-1933

A family of glass ceramics is being developed to match the thermal expansion of a number of metal systems. We have developed a lithium silicate glass ceramic which is being used to make hermetic seals to Inconel alloys for actuator headers. A family of phosphate-based glasses are being used to form seals to Al, Cu, and stainless steels. We have also developed a new glass which is very corrosion resistant to Li ambient temperature battery environments. This glass is presently being used in batteries (active and reserve) and has an expected life of five years. We are developing new glasses with the goal of a 10 year life. Transformation toughened glass ceramics based on the precipitation of metastable ZrO_2 in a glass matrix have been developed. The objective of this program is to develop tougher glass ceramics for electrical insulator applications.

Keywords: Ceramics, Glasses, Electrical Insulators, Corrosion

332. Corrosion

	FY 1984	FY 1985
	$1,050,000	$1,150,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - R.B. Diegle, 505-846-3450; N.R. Sorensen, 505-844-1097

Glassy alloys can exhibit exceptionally good corrosion resistance. We are conducting a program to determine how certain glassy alloys derive this resistance to corrosion and why they require less alloyed chromium than conventional stainless steels. This understanding could lead to better utilization of chromium in conventional stainless alloys. By using ion implantation, we are also separating and identifying the relative contributions of alloy structure and composition to corrosion behavior. We have shown that P is detrimental to corrosion resistance at low Cr levels because it stimulates dissolution but the alloy cannot passivate. However, P is beneficial at higher Cr levels because this enhanced dissolution actually promotes passive film formation.

Studies are also underway to characterize a number of alloy systems for both weapon and energy applications. Titanium alloys are being studied in nuclear waste disposal environments; Inconel and Hastelloy materials are being investigated for use in molten glass and in high temperature gaseous environments to support our glass header development program; carbon and stainless steels are being studied in battery environments.

Keywords: Metals, Amorphous Materials, Glassy Alloys, Corrosion

333. Powder Metallurgy

	FY 1984	FY 1985
	$ 200,000	$ 250,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - J.A. Brooks, 415-422-2051; J.E. Smugeresky, 415-422-2910; R.M. Allen, 415-422-2861

The relationship between strength, toughness, microstructure, and fracture modes of blended elemental powder metallurgy (P/M) titanium alloys is being studied to optimize properties for near-net-shape processing applications. The strengths and toughness values of these alloys are lower than the corresponding ingot processed alloys due to inherent microstructural defects of pores and inclusions. With an SEM particle analysis program, the size and distribution of these defects in the microstructure and on the fracture surface for various alloy compositions is being correlated to corresponding strength and toughness values with theoretical models. Also included in the analyses are the effects of HIP cycles and heat treatments on defect populations and properties. These results will enable tailoring of blended elemental P/M titanium alloy compacting processes and heat treatments to provide properties comparable to corresponding ingot processed alloys for weapon applications. Additionally, techniques for the production of metal powders such as high alloy steels and uranium alloys by conventional inert gas atomization and by rapid solidification processing are being developed. In-house capabilities have been expanded with the installation of two inert gas atomizers. Emphasis will be placed on the effects of atomization parameters upon material characteristics and the development of new alloy systems utilizing AST. Emphasis is on material preparation and characterization. Dynamic consolidation is being investigated as a technique for the consolidation of metal powders while retaining unique microstructural modification.

Keywords: Alloys, Rapid Solidification, Metals, Hot Isostatic Pressing, Net Shape Processing, Sintering

	FY 1984	FY 1985
334. Advanced Electrodeposition Studies	$ 150,000	$ 150,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - R.W. Carling, 415-422-2206; J.E. Farmer, 415-422-3418; H.R. Johnson, 415-422-2822

Engineering applications, technology development, and basic studies are being pursued in the area of electrodeposition of metal from both aqueous and non-aqueous media. Electrodeposition of Cu, Ni, and Al is being studied with a focus on the relationship between critical process variables and the mechanical properties of the deposit as well as the role surface active agent play in this process. Techniques being used couple spectroscopic and transient electrochemical techniques and include the use of laser Raman and Fourier transform infrared spectroscopy. Process improvements and new and improved analytical techniques for electroplating baths will result.

Keywords: Metals, Electrodeposition, Mechanical Properties, Aqueous and Non-Aqueous Electrolytes, Spectroscopy, Surface Active Agents

335. Helium Induced Crack Growth in Metals and Alloys

	FY 1984	FY 1985
	$ 600,000	$ 700,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - S.L. Robinson, 415-422-2209; S.H. Goods, 415-422-3274; J.E. Costa, 415-422-2352

The effect of helium on the low temperature mechanical properties of fcc metals is being investigated experimentally. Tritium decay is used to introduce helium into metals without introducing radiation damage into the metal. A variety of experimental techniques are employed to study the resultant tritium and helium effects including transmission electron microscopy, autoradiography, tritium imaging, and thermal desorption spectroscopy. Mechanical properties of materials containing helium are studied in an effort to understand the plastic flow and fracture of metals as functions of helium concentration and distribution within the solid. The chemical similarity of tritium to hydrogen in addition to the embrittling effects of helium, makes these techniques relevant to a wide variety of technologies.

Keywords: Metals - Ferrous and Non-Ferrous, Crystal Defects/Grain Boundaries, Fracture

336. Welding Science and Technology

	FY 1984	FY 1985
	$ 500,000	$ 550,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - J.A. Brooks, 415-422-2051; J.C. Lippold, 415-422-2686; J.E. Smugeresky, 415-422-2910; J.R. Spingarn, 415-422-3307

We are directing considerable effort toward developing a science-based methodology for designing, analyzing, and optimizing welding processes, in order to control microstructure and thereby improve the performance of welded joints. Present activities include microanalytical analyses and computer modeling of weld microsegregation, heat flow, and deformation (in upset welds), during solidification; measurements of the characteristics of joining processes, evaluation of the weldability of specific alloys; measuring and modeling of complex brazed joints; and the joining and analysis of composite structures. Microstructural variables of interest in fusion welds include kinetics of microsegregation and phase transformations during solidification and cooling, hot cracking, the effects of heat flow, and residual stress development. In solid state welds, the primary variables under investigation include metal flow and flow line formation, bond development, and residual stresses. Alloy systems of current interest include austenitic and martensitic stainless steels (single phase and precipitation-hardenable), powder-processed alloys, and model binary alloy systems.

Keywords: Joining/Welding, Microstructure, Metals, Transformation, Solidification, Modeling

337. <u>High Strength Martensitic Stainless Steels</u>

	FY 1984	FY 1985
	$ 90,000	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - J.A. Brooks, 415-422-2051; N.R. Moody, 415-422-2622

The physical metallurgy and mechanical property microstructure relationships are being studied for three martensitic precipitation-hardened stainless steels (PH13-8, PH15-5, and Custom 450). This work emphasizes the role of microstructure in determining the strength, toughness, response to forging, crack growth in low pressure hydrogen, corrosion resistance, and weldability of these steels.

Keywords: Alloys, Corrosion, Hydrogen Effects, Joining, Microstructure, Strength

338. <u>Metal Forming</u>

	FY 1984	FY 1985
	$ 200,000	$ 250,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - J. Lipkin, 415-422-2417; T.C. Lowe, 415-422-3187; J.B. Woodard, 415-422-3115

Materials models and computer codes are being developed to model metal forming processes. The development of such codes will be extremely useful in the design of optimal metal forming processes, such as forging, hydroforming, and pressing. This will result in less scrap thus reducing the environmental impact, and reduce overall development time for die design. Present activities include development of advanced materials models, interfacing these models with finite element codes, measurement of materials properties needed for the models, and experimental verification of the code results.

Keywords: Metals, Forming, Forging, Pressing, Net Shape Processing, Materials Properties Characterization

339. <u>Composites: Stability and Compatibility</u>

	FY 1984	FY 1985
	$ 50,000	$ 100,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - J.B. Woodard, 415-422-3115; B.C. Odegard, 415-422-2789

The stability and compatibility of composites is being investigated in conjunction with efforts at Sandia National Laboratories, Albuquerque. This work includes the characterization of outgassing, measurement of coefficient of moisture expansion, and investigation of galvanic corrosion when in contact with specific metals.

Keywords: Composites, Corrosion, Materials Characterization

340. <u>New Surface Spectroscopy</u>

	FY 1984	FY 1985
	$ 200,000	$ 200,000

DOE Contact - Y. Song, 301-353-5350
SNL Contacts - L.A. West, 415-422-2475; M.R. McClellan, 415-422-2598

High Resolution Electron Energy Loss Spectroscopy (HREELS) is being developed by this laboratory as a sensitive means for probing gas-solid interactions. A specialized ultra-high vacuum chamber has been built to house this equipment and experiments on the adsorption of oxygen and water vapor on uranium begun. This apparatus should yield insight into the mechanisms governing the oxidation and corrosion of metals used within the DOE complex.

Keywords: Actinides, Corrosion-Gaseous, Nuclear Reactors, Predictive Behavior Modeling

341. Weld Molding — FY 1984: $ 250,000 — FY 1985

DOE Contact - Y. Song, 301-353-5350
Lawrence Livermore Laboratories (LLL) (Contract No. W-7405-Eng-48) Contacts - K.W. Mahin, E. Flower, 415-423-0740 (FTS 543-0740)

The overall objective of this program is to develop a general weld model for the prediction of penetration and distortion in fusion welds. The material under investigation is 304 SST. Our research has had two main thrust areas: (1) to evaluate and modify existing "state-of-the-art" finite elements codes to model the problem; and (2) to differentiate between errors due to coding problems vs. lack of accurate experimental input data. Our approach has been to select a well-defined axisymmetric 2-D problem, design experiments to provide input for the codes, as well as code verification, and to evaluate code predictions. We have incorporated vaporization into the heat transfer model to improve the predictions within the stress code. Our work to date has been limited to stationary Gas Tungsten Arc Welds, but modifications have already been made to the finite element codes to handle a traveling arc. Future improvements will include degradation of the heat transfer and stress code to allow simultaneous calculation of both temperature and stress at each time step and generation of controlled experimental mechanical stress data to better account for the cyclic thermal history of the weld.

Keywords: Joining Development, Modeling

342. Metal Deformation Modeling — FY 1984: $ 150,000 — FY 1985

DOE Contact - Y. Song, 301-353-5350
LLL Contacts - E. Flower, K.W. Mahin, 415-423-1572 (FTS 543-1572)

The purpose of this study is to develop LLNL existing finite element methods (FEM) codes (NIKE/DYNA) to accurately predict metal deformation during a forming operation. Forming operations require that the code account for a large elastic/plastic deformation and friction. The sample constitutive material models which exist NIKE and DYNA can predict first order results such as a final dimension and values for effective plastic strains. Improved material models which are computationally efficient and address adiabatic heating, prior strain-hardening and strain localization are being assessed. The intent is to develop this computer-aimed-simulation technology and transfer this analytical tool within DOE/MA complex while moving toward a total synthesis of design and manufacture. Long range goals include coupling of the "refined" mechanical code with the "refined" thermal code to improve the predictions of metal flow during fabrication.

Keywords: Metals, Modeling

343. <u>Liquid Pu Corrosion of Refractories</u>	<u>FY 1984</u>	<u>FY 1985</u>
	$ 150,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - J.E. Hanafee, 415-422-6928 (FTS 532-6928)

We are studying the relative corrosion resistance of refractory oxides W, Ta, Nb, V, Mo, and Ti to attack by molten plutonium in the temperature range of 800 to 1200 degrees C. This work is needed to determine the best materials to contain molten plutonium;refractory metals are good candidates. Problems involve rapid dissolution of some refractories in the temperature range 1000 to 1200 degrees C. We are using immersion tests of refractory metal coupons into molten plutonium and measuring weight loss after post-immersion leaching, to determine dissolution rate. We expect to characterize the corrosion resistance for the refractories listed.

Keywords: Corrosion, Materials Characterization, Radioactive Materials, Coatings and Films, Refractory Ceramics

344. <u>High Temperature Carbon Fiber Study</u>	<u>FY 1984</u>	<u>FY 1985</u>
	$ 75,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - J.R. Kolb, 415-422-7060 (FTS 532-7060)

For the study of how carbon fibers degrade under thermolytical conditions, all the tests to 2500 degrees C have been completed. The results of the C, H, and N analyses are as expected - the concentrations of HON decrease with increasing temperature. The microstructure becomes more crystalline at high temperatures and the strength goes down. A report is being prepared.

Keywords: Graphite, Composites

345. <u>Structure-Property Relations of Polymers and Composites</u>

	<u>FY 1984</u>	<u>FY 1985</u>
	$ 50,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - J.R. Kolb, 415-422-7060 (FTS 532-7060)

The work has progressed in two areas: (1) reliability theory for polymeric materials; and (2) modeling of the mechanical behavior of low density materials. The life prediction theory for polymeric materials has been used to characterize the effect of residual strength, after the application of steady load. The methodology will permit the prediction of the reliability level (probability of failure) of such materials under complex loading histories.

Very low density materials made from various polymer types are being mathematically modeled with respect to their mechanical properties. The effective moduli are determined in terms of the geometric microstructure of the materials. An optimal materials form is being sought to give the most dimensionally stable type of low density materials.

The failure modes of very low density materials are being investigated. Both theoretical modeling and direct experimental determination lines are being followed. Various failure modes are being considered such as the buckling of strut and/or membrane type microstructures and crushing of the pore space by large deformational compression.

Keywords: Polymers, Organics

	FY 1984	FY 1985
346. <u>Actinide Oxidation/Hydriding</u>	$ 100,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - C. Colmenares, 415-422-6352 (FTS 532-6352)

The kinetics and detailed mechanism of the reaction of uranium with dry oxygen, oxygen-free water vapor, and oxygen-water vapor mixtures are being studied using thermogravimetric electron paramagnetic resonance, positron annihilation spectroscopy, and surface-sensitive analysis techniques. A complete critical review of all the work on the oxidation of uranium carried out at LLNL and of unclassified published studies is being prepared for publication in "Progress Solid State Chemistry." An experimental study of the reaction kinetics of plutonium and plutonium alloys by nanometric techniques is being initiated. A critical review of classified and unclassified literature on the subject of plutonium hydriding will also be prepared. A detailed understanding of the oxidation and hydriding reactions and the availability of engineering data will make possible more accurate predictions on the service life of uranium and the definitions of the proper usage and hazards associated with plutonium use.

Keywords: Metals, Corrosion, Surface Characterization

	FY 1984	FY 1985
347. <u>Surface Preparation for Coating and Joining</u>	$ 150,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - D.M. Madkowiecki, 415-422-8007 (FTS 532-8007)

The use of energetically implanted ions of solute element and the use of laser or electron beam irradiation for rapid controllable melting and cladding are being investigated for applications to surface property enhancement. Resistance of nuclear and structural metals to reaction in hydrogen, high temperature oxygen-bearing gases, liquid metals, etc., is being tested and results are being related to the parameters of the directed energy processing and the underlying operative mechanisms of surface protection.

Keywords: Ion Implantation, Laser Surface Treatment, e-Beam Surface Treatment

348. <u>Pu Sputtering</u>

	FY 1984	FY 1985
	$ 370,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - H.F. Rizzo, 415-422-6369 (FTS 532-6369)

This is a study to explore the glass forming ability of various elements with plutonium by sputtering. Composite targets of Fe, Ta, V, Os, and Si with plutonium have been sputtered and the resulting binary coating compositions are being examined by x-ray and metallographic techniques. Several of these binary systems (Fe, Os, Si) show strong evidence for the formation of glassy alloys of plutonium and also show remarkable oxidation resistance under ambient glove box conditions. Scanning Calorimetry (DSC) measurements will be made to determine the stability and transformations of the plutonium metastable alloys as a function of composition.

Keywords: Amorphous Materials, Alloys, Plutonium, Sputtering, Corrosion, Microstructure

349. <u>Electrochemical Oxidation</u>

	FY 1984	FY 1985
	$ 900,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - R.R. McGuire, 415-422-7792 (FTS 532-7791)

The purpose of this work is to explore the electrochemical oxidation of nitrogen tetroxide (N_2O_4) to nitrogen pentoxide (N_2O_5) in 100% nitric acid. The resulting nitration agent is being used to synthesize explosive and propellant ingredients. The electrolysis technique is being scaled up to explore engineering and economic aspects of the process.

Keywords: Electrochemical Oxidation, Nitrogen Pentoxide, Explosives

350. <u>Adhesives Evaluation</u>

	FY 1984	FY 1985
	$ 200,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - D.M. Hoffman, 415-422-7759 (FTS 532-7759)

Short-term screening tests of segmented polyurethane adhesion, chemical structure, and molecular architecture are being used to select candidate adhesives for longer-term reliability evaluation. Depending on the success of a new short-term, adhesion-shear test, continuous and intermittent stress relaxation measurements based on this shear fixture design will be used to study the durability of promising adhesives as a function of temperature. This chemorheological methodology can identify the nature of the polymer degradation responsible for the deterioration of adhesive mechanical properties with time.

Keywords: Adhesives and Bonding Agents, Polymers, Structures

351. Electrochemical Corrosion Monitoring Techniques in Non-Condensing Environments

	FY 1984	FY 1985
	$ 200,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - J. Truhan, 415-422-6364 (FTS 532-6925)

We are extending AC and DC electrochemical techniques to study corrosion processes in gaseous environments containing humidity. Aqueous analogues to humid environments are commonly used to estimate corrosion rates and mechanisms; however, there is no reason to believe that this is an appropriate simplification. We have measured corrosion rates for a wide variety of metals and alloys such as steels, aluminum, copper, and uranium using DC techniques from 80-100% RH and found, in general, an increase in rate of about two orders of magnitude for most metals over this range. We are currently working on applying AC techniques to dryer environments and mixed gases.

Keywords: Corrosion, Gaseous

352. Microstructure Research

	FY 1984	FY 1985
	$ 250,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - Tomas Hirschfeld, 415-422-6364 (FTS 532-6364)

Structures and devices in the same range 100A-100 are too small for the traditional engineering techniques and too large for the methods of chemistry. The success of microelectronic design and fabrication procedures in this size range has suggested their extension to material science and device technology.

Our project focuses on a basic research effort and a feasibility demonstration effort run in parallel. The first studies the effects of size scale on physiochemical and engineering processes and uses them to create guidelines for work in the micro domain. Design studies for structures and devices are then undertaken. The feasibility demonstration effort assembles materials and devices following this guidance in response to indicated needs in the programs. Some of our first engineered microdevices are a microdryer, a recording temperature microsensor, a sensor for the HE decomposition, and a detector of mechanical degradation of polymers.

Keywords: Semiconductors, Coatings and Films, Metals, Catalysts, Diffusion, Surface Characterization

353. Tritium Facility Upgrade

	FY 1984	FY 1985
	$	

DOE Contact - Y. Song, 301-353-5350
LLL Contacts - P.C. Souers, 415-422-1301 (FTS 532-1301); M. Holda, 415-422-7240 (FTS 543-7240)

The Tritium Facility Upgrade consists of two parts: a clean-up system ($3.3M) and an office/mechanical technician shop addition ($1.6M). The clean-up system is to consist of custom-made airtight boxes which enclose the high tritium systems of our building. The high pressure pump will be completely rebuilt with a new minimum pressure of 30,000 psi. These boxes and all pump exhausts will be run into a conventional catalyst/zeolite molecular sieve clean-up system. The entire system will be passive and redundant. It is expected to cut tritium emissions by an order of magnitude and prevent large accidental releases. The office building will raise in-house occupancy from 17 to 31 people. Design is underway this fiscal year and construction is to begin next year.

Keywords:

354. Weapons Database Development

	FY 1984	FY 1985
	$ 240,000	

DOE Contact - Y. Song, 301-353-5350
LLL Contacts - T.M. Quick, D.D. Jackson, 415-422-8005 (FTS 532-8005)

We are developing a computer database system to facilitate the analysis of stockpile life data so that we can better assess the current condition of the stockpile and predict its probable future condition. The database(s) will contain information on selected critical materials and components for LLNL-designed weapons and is being developed to provide feedback of surveillance data into the design lab and production complex.

For each weapon system, we are generating the following documents: (1) critical components document; (2) handbook - describes how the data will be displayed and handled; and (3) Surveillance and Stockpile Return Summary (SSRS). We have completed all three documents for the B83 weapons system and will be generating these same documents for the W84 and W70 weapons systems in FY 85.

Keywords: Weapons, Stockpile, Database

355. Building 235 - Weapons Materials Research and Development Facility

	FY 1984	FY 1985
	$	

DOE Contact - Y. Song, 301-353-5350
LLL Contact - J.D. Balser, 415-422-8063 (FTS 532-8063)

A new facility under construction at LLNL will be dedicated to the development of advanced materials for weapons applications. This facility will house the specialized technologies, i.e., ion implantation, laser welding, etc., required for supporting materials development. Laboratory occupancy is scheduled for the end of FY 85 with an office wind to be occupied about one year later. This facility provides about 22,000 square feet of additional laboratory floor space with 30 new laboratories for materials research and will house 110 scientists. This facility is to be administered by the Chemistry and Materials Science Department.

Keywords: Weapons

OFFICE OF FOSSIL ENERGY

The mission of the Fossil Energy Program is to develop technologies that will increase domestic production of oil and gas or that will permit the Nation to shift from oil or gas to more abundant coal. Specifically, the Fossil Energy role is to develop technologies to support the following objectives:

- Provide a capability to convert coal to liquid and gaseous fuels;
- Increase domestic production of coal, oil, and gas;
- Ensure that current and new facilities that burn coal can do so in an economically viable and environmentally acceptable manner; and
- Allow more efficient and more economically attractive utilization of fossil energy resources.

The Fossil Energy activity includes fourteen major programs, which are grouped under seven program offices. One of these seven is the Advanced Research and Technology Development Program of the Office of Technology Coordination, which is the central point of contact for inquiries from universities concerning the Fossil Energy program.

Project execution and technical monitoring are administered in five energy technology centers and selected national laboratories.

Office of Technical Coordination

Advanced Research and Technology Development Program

The objectives of the Advanced Research and Technology Development program are to assess and identify long-range advanced research needs in coal processing, fossil fuels utilization and extraction, materials, components, and instrumentation; to provide oversight of on-going advanced research in fossil energy so as to ensure balance and proper priorities; to initiate and fund projects involving new, exploratory concepts or goal-oriented basic research; to manage the Materials Research and University Coal Research programs; and to provide policies for, and overview of, Fossil Energy-supported university activities. The Advanced Research and Technology Development program also is designed to provide an effective communications channel between the Fossil Energy program and academic institutions; to encourage these institutions to become involved in programs related to the DOE Fossil Energy mission; and to manage programs concerned with providing an adequate technical base for development of commercial construction materials and instrumentation for Fossil Energy pilot plants and demonstration plants.

The program supports workshops to identify research needs in all fossil energy technologies and manages related training programs for faculty and students at Energy Technology Centers. S.J. Dapkunas, 301-353-2784, is the DOE Contact for the following projects.

356. Evaluation of the Feasibility of Pressure Quenching to Produce Hard Metastable Materials

	FY 1984	FY 1985
	$ 130,000	$ 0

R&D Associates (Contract No.DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated, Subcontract No. 22X-72819C) Contact - Richard Latter, 213-822-1715

The purpose of this research is to design, build, and test a novel high-pressure press system to explore the scientific possibilities of "pressure quenching" of materials, that is, the retention of ambient conditions of metastable material phases normally observed only under extremely high pressures. The device will be capable of exerting pressures up to 60,000 atmospheres on small specimens of solids at room temperature and releasing the pressure so rapidly, on the order of 10 sec or less, that the high-pressure phases will be retained. It is possible that new materials, hitherto never seen, will result. Specific experiments on selected materials will be undertaken to demonstrate the capability of producing such materials.

Keywords: High Pressure, Materials, Decompression

357. Development of Refractory Composites with High Fracture Toughness

	FY 1984	FY 1985
	$ 135,000	$ 35,000

ANL (Contract No. W-31-109-eng-38) Contact - W.A. Ellingson, D.R. Diercks, 312-972-5068, FTS 972-5068

Refractories that are high in chromic oxide content have demonstrated superior resistance to corrosion by a variety of coal slags. However, these refractories possess poor resistance to thermal shock damage. The objective of this program is to fabricate refractories with improved thermal shock properties without sacrificing corrosion resistance. The spinel phase $MgCr_2O_4$ has been selected as the model refractory composition to be studied. The second-phase additions to be explored for the possible beneficial effects on thermal shock properties include ZrO_2, $FeCr_2O_4$, W, Mo, SiC, and Si_3N_4.

Keywords: Refractories

358. Short Fiber Reinforced Structural Ceramics

	FY 1984	FY 1985
	$ 250,000	$ 260,000

LANL (Contract No. W-7504-eng-36) Contact - F.D. Gac, 505-667-5126, FTS 843-5126

The purpose of this study is to investigate the utility of whisker reinforcement technology for producing structural ceramic composites of improved strength and fracture toughness. The program consists of two technical tasks. The first is to optimize an existing Los Alamos whisker growth process to produce alpha-phase silicon nitride whiskers and beta-phase silicon carbide whiskers of uniform size, optimum strength, and in quantities suitable for composite use. The second task will involve evaluating the contribution of the whiskers in selected ceramic-matrix composites.

Keywords: Ceramics

359. Silicon Carbide Powder Synthesis

	FY 1984	FY 1985
	$ 50,000	$ 0

ORNL (Contract No. DE-AC05-84OR21400) Contact - M.A. Janney, 615-574-4281, FTS 624-4281

The purpose of this work is to develop processes for synthesis of improved, highly pure, uniformly sinterable powders. The developmental and some selected commercial SiC powders will be characterized and evaluated.

Keywords: Powder Synthesis, Silicon Carbide

360. Ceramic Fabrication and Microstructure Development

	FY 1984	FY 1985
	$ 200,000	$ 0

ORNL (Contract No. DE-AC05-84OR21400) Contact - M.A. Janney, 615-574-4281, FTS 624-4281

The purpose of this work is to develop improved structural ceramics by developing techniques for fabricating powders into dense monolithic ceramics and ceramic-matrix composites with controlled microstructure. The task includes correlation of the properties of structural ceramics with their microstructure, crystal structure, microchemistry, and fabrication history.

Keywords: Fabrication, Microstructure, Ceramics

361. Fabrication of Fiber-Reinforced Composites by CVD Infiltration

	FY 1984	FY 1985
	$ 225,000	$ 340,000

ORNL (Contract No. DE-AC05-84OR21400) Contact - D.P. Stinton, A.J. Caputo, 615-574-4556, FTS 624-4556

The purpose of this task is to develop a ceramic composite having higher than normal toughness and strength yet retaining the typical ceramic attributes of refractoriness and high resistance to abrasion and corrosion. The desired toughness and strength are on the order of 20 MPs > m$^{1/2}$ and 350 MPa, respectively. In addition, a practical process capable of fabricating simple or complex shapes is desired. The ceramic fiber-ceramic matrix composites are fabricated by infiltrating low-density fiber structures with vapors, which deposit as solid phases on and between the fibers to form the matrix of the composite. The goal is to demonstrate that a ceramic composite can be prepared using materials of high interest to the fossil community. SiC fibers and matrices of SiC and Si_3N_4 have been identified as being most promising. Fiber dimensions, geometry, packing density, binder type and concentrations, and other processing variables have been evaluated experimentally.

Initial experimental efforts focused on the use of a vacuum-forming molding process to form a low-density fiber bed suitable for vapor infiltration. Once the fiber bed was formed, dried, and heat treated, the matrix of the composite was formed by CVD using a high-temperature furnace. A novel scheme (patent applied for) of forcing the coating gases to flow through the fiber bed was tested in an attempt to increase the deposition rate over rates normally obtained when flowing the deposition gases through the fibrous parts. Important variables of the CVD process, such as temperature, gas composition, flow rate, pressure, etc., are being systematically altered to maximize matrix density and to obtain a microstructure consistent with the goal of fabrication of high-toughness high-strength ceramic composites.

Keywords: Composites, Fiber-Reinforced, Ceramics

362. Transfer of CVD Infiltration Technology to Industry

	FY 1984	FY 1985
	$ 56,000	$ 100,000

ORNL (Contract No. DE-AC05-84OR21400) Contact - D.P. Stinton, A.J. Caputo, 615-574-4556, FTS 624-4556

An innovative joint research and development program with Babcock and Wilcox Research Laboratories (B&W) will be conducted to transfer AR&TD-developed CVD infiltration technology to B&W. This effort is supported about 50% by the AR&TD Fossil Energy Materials Program and 50% by B&W. Part of the work, including fabrication of dense fiber mats, will be conducted by B&W, Lynchburg, Virginia. The infiltration will be at ORNL with participation by B&W personnel.

Keywords: Composites, Fiber-Reinforced, Ceramics

363. Development of Advanced Fiber Reinforced Ceramics

	FY 1984	FY 1985
	$ 180,000	$ 180,000

Georgia Institute of Technology, Georgia Tech Research Institute (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-43369C) Contact - T.L. Starr, 404-894-3678

The purpose of this research effort is to conduct a theoretical and experimental program to identify new compositions and processing methods to improve the physical and mechanical properties of selected fiber reinforced ceramics. The ceramic matrix material to be used is amorphous "fused" silica or modified silica glass and the focus will be the development of fiber reinforced silica. Parameters to be studied will include: (1) differences in elastic modulus between matrix and fiber; (2) differences in thermal expansion; (3) nature of interfacial bond; (4) densification of matrix; (5) nature of fiber fracture/pull-out; (6) fiber diameter and fiber length-to-diameter ratio; (7) fiber loading; and (8) fiber dispersion and orientation. A model will be developed based on the information generated in the experimental phase of the program.

Keywords: Ceramics, Composites, Fiber-Reinforced

364. Design of Low Alloy Steels for Thick-Walled Pressure Vessels

	FY 1984	FY 1985
	$ 270,000	$ 0

University of California, Department of Materials Science (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Sub-Contract No. 19X-07843C) Contact - E.R. Parker, R.O. Ritchie, 415-642-0863

The objectives of this project are primarily aimed at producing a modification of 2 1/4 Cr-1 Mo steel (Ni, Cr, Si, and Mn additions) to improve hardenability, toughness, and resistance to temper embrittlement. Significant progress has been made in this direction but there has not been a great deal of industrial interest in the compositions currently being examined. Rather, concerns with respect to reaction vessel materials have produced interest in higher chromium materials that have good strength. Nevertheless, 2 1/4 Cr-1 Mo Steel could continue to be of interest providing that stable microstructures can be developed that are strong, tough, and resistant to hydrogen attack. Working in close contact with industry, this project has lead the AR&TD effort to produce a modified alloy acceptable to industry that can be used in reaction pressure vessels at temperatures as high as 540 degrees C. Alloys that have been produced and characterized through this task on design of low alloy steels will be examined in some detail to evaluate their adequacy with respect to strength, toughness, and resistance to hydrogen attack under dynamic loading.

Keywords: Alloy Development, Alternative Materials

365. Technical Monitoring of Coal Gasification Subcontracted Materials Projects for the AR&TD Fossil Energy Materials Program

	FY 1984	FY 1985
	$ 40,000	$ 40,000

ANL (Contract No. W-31-109-eng-38) Contact - W.A. Ellingson, 312-972-5068, FTS 972-5068

The purpose of this technical management activity is to assist DOE Oak Ridge Operations and Oak Ridge National Laboratory with technical monitoring of the subcontracts of the AR&TD Fossil Energy Materials Program which are related to high-temperature gaseous corrosion, corrosion of refractories and ceramics, and nondestructive evaluation methods.

Keywords: Technical Monitoring, Coal Gasification

366. <u>Assessment of Materials Needs for Advanced Steam Cycle Pulverized Coal Plants</u>

	FY 1984	FY 1985
	$ 10,000	$ 0

ORNL (Contract No. DE-AC05-84OR21400) Contact - P.L. Rittenhouse, 615-574-5103, FTS 624-5103

The purpose of this task is to assess the status of materials technology for advanced steam cycle pulverized coal plants and to identify materials research and development which would permit the design, construction, and reliable operation of more efficient power plants.

A pulverized coal power plant employing an advanced steam cycle to improve the overall plant efficiency has been defined by a consultant knowledgeable about pulverized coal power plants. The proposed system has been analyzed using existing computer codes to determine the net efficiencies achievable with various steam conditions, e.g., at temperatures between 1100 and 1200 degrees F and pressures between 4000 and 5000 psi. Through consultation with boiler and turbine-generator manufacturers, the ability of existing materials to meet the requirements for advanced steam cycles were determined. Materials research and development needs and areas of research which will provide the greatest payback in terms of improved efficiency and/or plant availability were identified. An assessment report documenting the findings and recommendations resulting from the study has been the findings and recommendations resulting from the study has been prepared. A draft of the report was sent to boiler manufacturers, turbine-generator manufacturers, and EPRI (and their contractors) for their review and comment. The final report will address the comments received in the review by industry.

Keywords: Combustion, Pulverized-Coal, Materials, Assessment

367. <u>Microstructure and Micromechanical Response in Austenitic Stainless Steel Overlays on Low Alloy Steel Plate</u>

	FY 1984	FY 1985
	$ 0*	$ 0

University of Cincinnati, Department of Materials Science and Metallurgical Engineering (Contract No. DE-AC05-84OR21400), Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-222279C) Contact - J. Moteff, 513-475-3096

The purpose of this research is to provide sufficient information to establish correlations between the weld overlay process, postweld heat treatment, microstructure, micromechanical response, and macroscopic mechanical behavior. Microhardness is being used to establish the material micromechanical behavior at various temperatures. This project will, in addition to furnishing an understanding of the reasons for existing weldment microcracking problems, help optimize the welding process and postweld heat treatment variables.

Keywords: Materials Processing, Materials Characterization

* Prefunded in FY 1983

368. <u>The Fatigue Behavior of Chromium-Containing Ferritic Steels at Elevated Temperatures</u>

	FY 1984	FY 1985
	$ 0*	0

University of Connecticut, Metallurgy Department (Contract No. DE-AC05-84OR-21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-22278C) Contact - A.J. McEvily, 203-486-2941

The objective of this research is to obtain a detailed understanding of the fatigue behavior of these alloys in terms of metallurgical and environmental effects. This understanding should provide a basis for the quantitative analysis of service lifetimes as well as for the optimization of the microstructure of fatigue resistance. Areas of research include fatigue crack initiation and propagation at elevated temperatures in chromium steels and their weldments with particular emphasis on the influence of oxidation.

Keywords: Materials Characterization

369. <u>Transformation, Metallurgical Response, and Behavior of the Weld Fusion and Heat Affected Zone in Cr-Mo Steels for Fossil Energy Applications</u>

	FY 1984	FY 1985
	$ 80,000	$ 100,000

University of Tennessee, Department of Chemical, Metallurgical, and Polymer Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 12B-07685CX77) Contact - C.D. Lundin, 615-974-5310

The objective of this research is to develop fundamental information on the metallurgical behavior of the heat affected zone of welds in chromium-molybdenum alloys. This is being accomplished by: (1) documenting transformation behavior under the welding conditions that involve rapid heating and cooling; (2) determining the metallurgical transformation products in the heat affected zone and weld fusion zone; (3) determining the sensitivity of the materials to phenomena such as reheat cracking and/or hot cracking; and (5) determining the influence of the various heat affected zone regions on the creep rupture behavior.

Keywords: Materials Processing, Materials Characterization

370. <u>Development of Iron and Nickel Aluminides</u>

	FY 1984	FY 1985
	$ 200,000	$ 200,000

ORNL (Contract No. DE-AC05-84OR21400) Contact - C.T. Liu, 615-574-4459, FTS 624-4459

New, improved alloys are needed for components in severe environments for applications such as coal gasifiers, fluidized bed combustors, and that will use Al_2O_3 as the main protective layer to prevent sulfidation attack and that will possess good mechanical properties at high temperatures. Aluminides based on the pseudobinary systems Ni_3Al-Fe_3Al and NiAl-FeAl

* Prefunded in FY 1983

will form the basis for development of materials with the required properties. Success in development of iron and nickel aluminides as structural materials could substantially improve the performance and reliability of advanced fossil energy conversion systems.

The development of iron and nickel alumindes for critical components in coal conversion systems would rely on understanding the structure-property relationships that determine the oxidation/sulfidation behavior and the mechanical properties. This will require a knowledge of the physical metallurgy of the alloy systems involved as well as the source of the grain boundary embrittlement and the oxide/sulfide formation. Compositional control by macro- and micro-alloying and microstructural control by processing techniques will be used to optimize the desirable properties.

The approach of this task is to develop aluminides based on the pseudobinary system Ni_3Al-Fe_2Al. Iron will be macroalloyed to Ni_3Al for solid solution hardening at elevated temperatures and for corrosion resistance in sulfidizing environments. Boron and other elements will be employed for controlling the chemistry and cohesion of grain boundaries. The development of aluminides will also include the FeAl-NiAl system which contains 50 at. % Al for better oxidation and corrosion resistance.

Keywords: Strength, Intermetallics, Alloys

371. <u>Hydrogen Attack in Cr-Mo Steels at Elevated Temperatures</u>

	FY 1984	FY 1985
	$ 170,000	$ 0

Cornell University, Materials Science and Engineering Department (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-07963C) Contact - Che-Yu Li, 607-256-4349

The objective of this program is to determine the kinetics of nucleation and growth of methane bubbles or cavities in 2 1/4 Cr-1 Mo steels at elevated temperatures under the influence of high pressure hydrogen and applied stress and to develop kinetic equations for estimating the number density and size distribution of grain boundary cavities as a function of time under conditions of interest to coal conversion processes. Currently, this is the only in-situ hydrogen attack work supported by the AR&TD Program. All other programs that address hydrogen attack involve autoclave exposure followed by an evaluation. The effect of constant stress and pressure on the nucleation and growth of methane bubbles in low alloy steels is studied. Models are being developed, based on experimental observations, to describe hydrogen attack in 2 1/4 Cr-1 Mo steel and the important metallurgical parameters are being identified.

Keywords: Hydrogen Effects

372. Analysis of Hydrogen Attack on Pressure Vessel Steels

	FY 1984	FY 1985
	$ 90,000	$ 120,000

University of California at Santa Barbara, Department of Chemical and Nuclear Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-22276C) Contact - G.R. Odette, 805-961-3525

The initial objectives of the program have been achieved and physical models have been developed that describe the initiation and development of methane damage in carbon steel, C-Mn-Si steels, 2 1/4 Cr-1 Mo steel, and weldments. Nelson diagrams have been predicted and appear to be reasonably consistent with available data. Additional work is needed to refine the analyses and confirm the adequacy of the basic thermodynamic information available in the literature. The model has been particularly useful in establishing the relative importance of microconstituents, deformation mechanisms, and fracture mechanisms to the hydrogen attack process. In this sense it will guide the development of modified low alloy steels for optimum resistance to hydrogen attack. The role that stress and plastic strain transients play in the hydrogen attack phenomena is being examined. Such information is vital because the current design rules for hydrogen service restrict the use of the Nelson curves to situations where the stresses do not exceed the primary stress intensities provided in the "ASME Boiler and Pressure Vessel Code."

Keywords: Hydrogen Effects

373. Deformation and Fracture of Low Alloy Steels at High Temperatures

	FY 1984	FY 1985
	$ 105,000	$ 100,000

University of Illinois, Department of Mechanical and Industrial Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-22239C) Contact - D.L. Marriott, 217-333-7237

The objective of this work is to investigate the microstructural changes and the mechanisms of damage accumulation that accompany, or arise from, high temperature deformation of a range of 2 1/4 Cr-1 Mo steels. The tests conducted under this program will provide a description of the microstructural changes in the chosen test materials under steady and cyclic loading. Progress toward understanding mechanisms of damage accumulation in the test materials for a spectrum of loading conditions should also result from this work. The results of the program will also provide a basis for the development of constitutive relations for correlation of damage and failure.

Keywords: Materials Characterization

374. Evaluation of 3 Cr-1.5 Mo Steel in a Simulated Coal Conversion Environment

	FY 1984	FY 1985
	$ 0*	$ 80,000

Westinghouse Electric Corporation Research and Development Center (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 86X-47977C) Contact - B.J. Shaw, 412-256-1201

The purpose of this work is to develop a fracture mechanics characterization of candidate materials for coal gasification pressure vessels. The apparatus to be used for the fracture characterization has unique capabilities for in-situ testing of steels in high-pressure high-temperature H_2-H_S environments. The study will be complemented with a physical metallurgical evaluation of the various degradation processes observed in the basic characterization. This effort will focus primarily on the simulated environmental properties of a candidate material (3 Cr-1.5 Mo-V steel) to be used in pressure vessel construction for coal gasification processes. The environments and conditions to which the steel will be exposed are: (1) a mixture of gases including H_2 and about 1% max H_2S; and (2) 10.4 MPa pressure at 315 degrees C (1500 psig at 600 degrees F). This is a laboratory simulation of the coal gasification environment, which, in addition, includes CO-CO_2 and H_2-H_2O. Because the selected steel will ultimately be welded, the following metallurgical considerations must also be evaluated: (1) weldability of the base metal; (2) weld metal composition, need for postweld heat treatment in field construction; and (3) HAZ. Thus, it will eventually be necessary to test both the weld metal and the HAZ. as well as the base metal, to ensure reliability. The current work will include the base plate metal only.

Keywords: Hydrogen Effects

375. Creep Rupture of High-Chromium Alloys in Mixed-Gas Environments

	FY 1984	FY 1985
	$ 95,000	$ 115,000

ANL (Contract No. W-31-109-eng-38) Contact - W.A. Ellingson, K. Natesan, 312-972-5068, FTS 972-5068

The purposes of this project are to: (1) experimentally evaluate the uniaxial creep rupture behavior of selected high-chromium alloys (e.g., Incoloy 800H, Type 310 stainless steel) and weldments exposed to complex gas mixtures typical of coal conversion process environments; and (2) correlate the creep properties such as rupture life, rupture strain, and minimum creep rate with the chemistry of exposure environment, temperature, and alloy chemistry.

Keywords: Creep Rupture, High-Chromium Alloys

* Prefunded in FY 1983

376. <u>Biaxial Stress-Rupture of Alloys in Coal Gasification Atmospheres</u>

	FY 1984	FY 1985
	$ 170,000	$ 0

EG&G Idaho, Incorporated, Idaho National Engineering Laboratory (Contract No. DE-AC07-76ID01570) Contact - G.R. Smolik, 208-526-8317, FTS 583-8317

The purpose of this program is to measure the biaxial stress-rupture strength and ductility of type 310 stainless steel, alloy 800H, Haynes alloy 188, and Inconel 657. Test temperatures range from 649 to 982 degrees C, and times of the texts are up to 500 h. Data from this continuing program will be used to supplement existing data on these alloys for coal gasification environments since little information exists on the structure of these alloys after exposure to coal gasification environments.

Keywords: Creep, Gasification

377. <u>Corrosion of Alloys for Internals and Heat Exchangers in Mixed-Gas Environments</u>

	FY 1984	FY 1985
	$ 120,000	$ 110,000

ANL (Contract No. W-31-109-eng-38) Contact - W.A. Ellingson, K. Natesan, 312-972-5068, FTS 972-5068

The work being conducted under this project provides a basic understanding of the corrosion behavior of commercial and model alloys after exposure to multicomponent gas mixtures. The information generated also provides a rational basis for the extrapolation of corrosion rates as a function of temperature, alloy composition, and chemistry of the gas environments. The corrosion experiments (conducted by using a thermogravimetric technique in mixed gas atmospheres) on selected commercial high-chromium alloys and on model alloys fabricated with compositional variations will establish the role of different alloying elements on the mechanisms of scale development and on the breakaway phenomena leading to scale failure.

Keywords: Corrosion, Gasification

378. <u>Screening and Study of Behavior of Materials Subjected to Combined Erosion and Corrosion</u>

	FY 1984	FY 1985
	$ 209,000	$ 0

The Metal Properties Council, Incorporated (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-40455C) Contact - A.O. Schaefer (MPC), 212-705-7693, G.L. Wire (IITRI), 312-567-4000

The purpose of this program is to obtain experimental information on the synergistic effects of corrosion and erosion. Complex laboratory experiments are carried out to evaluate the effects of corrosive environments on erosion behavior. These tests are carried out at high temperature (to 900 degrees C) and high pressure (to 0.7 MPa). Particle velocities of 60 m/s in a corrosive environment are studied. The results from this work will establish the critical erosion parameters for increased materials degradation in an erosion-corrosion environment at elevated temperatures.

Keywords: Erosion, Corrosion, Materials Characterization

379. Corrosion of Alloys in FBC Systems

	FY 1984	FY 1985
	$ 120,000	$ 110,000

ANL (Contract No. W-31-109-eng-38) Contact - W.A. Ellingson, K. Natesan, 312-972-5068, FTS 972-5068

The purposes of this project are to: (1) experimentally evaluate the high-temperature corrosion behavior of iron- and nickel-base alloys in gas environments with a wide range of oxygen, sulfur, and carbon potentials; (2) develop corrosion information in the temperature range 400 to 750 degrees C in mixed-gas atmospheres using internally cooled tube specimens of selected commercial materials; (3) evaluate deposit-induced corrosion behavior of heat-exchanger and gas-turbine materials after exposure to multicomponent gas environments; and (4) develop corrosion rate expressions, based upon experimental data, for long-term extrapolation to component design lives.

Keywords: Corrosion, Fluidized Bed Combustion

380. A Mechanistic Study of Low-Temperature Corrosion on Materials in the Coal Combustion Environment

	FY 1984	FY 1985
	$ 0*	$ 140,000

General Electric Company, Gas Turbine Division (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 86X-00224C) Contact - R.M. Johnson, 518-385-2873

The purpose of this work is to develop a mechanistic understanding of the low-temperature corrosion phenomena observed in the Long-Term Materials Test. The study will focus on: (1) a more detailed understanding of the corrosion morphology and interface chemistry on selected specimens after exposure to coal contaminants; (2) thermochemical calculations to establish the range of conditions for stability of the alloy phases, corrosion products, and chemical compounds formed; and (3) specific laboratory tests to correlate the experimental results with predictions from the thermochemical calculations. Specimens will be characterized with scanning electron microscopy, electron microprobe analysis, and X-ray diffraction. Specimens to be evaluated will include IN-738, FeCrAlY-coated IN-738, RT-22-coated In-738, and two different CoCrAlY coatings on IN-738. The thermochemical calculations will include: (1) the minimum partial pressure of SO_3 required to form a K_2SO_4-$CoSO_4$ liquid and an Na_2SO_4-K_2SO_4-$CoSO_4$ liquid; and (2) the thermochemistry of low-temperature attack in the coal combustion environment on iron- and aluminum-rich coatings. Laboratory tests will be performed to determine the agreement between the experimental results and the thermochemical calculations and phase stability plots.

Keywords: Corrosion, Fluidized Bed Combustion

* Prefunded in FY 1983

381. Hot Corrosivity of Coal Conversion Products on High-Temperature Alloys

	FY 1984	FY 1985
	$ 75,000	$ 80,000

University of Pittsburgh (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-43346C) Contact - G.H. Meier, 412-624-5316

The purpose of this task is to investigate the corrosion reactions of the products of coal conversion (gasification and PFBC) with high-temperature alloys. The kinetics of the complex corrosion processes that occur in high-temperature environments in alloys of interest to fossil energy technologies will be studied. In addition, the factors affecting the degradation of protective oxide layers in atmospheres containing Cl, O, S, and C will be investigated. Both isothermal and thermal-cycling experiments will be performed on alloys that form Cr_2O_3 and those that form Al_2O_3.

Keywords: Corrosion

382. Erosion in Dual-Phase Microstructures

	FY 1984	FY 1985
	$ 100,000	$ 0

University of Notre Dame, Department of Metallurgical Engineering and Materials Science (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-43336C) Contact - T.H. Kosel, 219-239-5642

This research program is designed to provide a systematic investigation of the effects of microstructural variables in dual-phase metallic alloys containing large second-phase particles on erosion by solid particle impact. While considerable research has been done recently to investigate mechanisms of material removal in single-phase metals and ceramics, relatively little work has been done in the area of dual-phase microstructures.

The variables which are studied include microstructural variables such as second-phase particle size and volume fraction. Erosion variables include particle velocity, angle of impact, and erodent particle size and hardness. The materials investigated included a series of high Cr-Mo white cast irons with compositions tailored to provide a systematic variation of carbide volume fraction (CVF) with constant carbide and matrix composition. The effect of matrix hardness on erosion will be investigated by heat treating the as-cast alloys to transform the austenitic matrix to martensite.

Keywords: Erosion and Wear, Alloys

383. Evaluation of Advanced Materials for Slurry Erosion Service

	FY 1984	FY 1985
	$ 225,000	$ 225,000

Battelle Columbus Laboratories (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 85X-69611C) Contact - I.G. Wright, A.H. Clauer, 614-424-4377

The original aim of this project was to obtain erosion data on several candidate valve trim materials under a range of slurry erosion conditions that would be useful to valve and process engineers involved in materials selection and valve design. Reconstituted coal-derived slurries were used to erode candidate materials under a range of slurry velocity and impingement angle conditions. Characterization of the erosive slurries, ranking of the erosive resistance of cemented tungsten carbides and various ceramics, and service trials of an experimental carbide valve stem were completed.

The project continues to obtain erosion data on candidate valve trim materials under varied wear conditions, investigate several approaches to the development of new erosion-resistant materials, and characterize the erosion behavior of new materials. In addition, a suitable substitute erodent and liquid carrier combination is being developed for use in standardized laboratory materials evaluation and screening tests, which preferably will reduce levels of health risks and handling problems. This project will help to develop an understanding of materials behavior in slurry erosion.

Keywords: Erosion, Materials Characterization

384. <u>Mechanisms of Erosion-Corrosion in Coal Combustion Environments</u>

	FY 1984	FY 1985
	\$ 200,000	\$ 215,000

ORNL (Contract No. DE-AC05-84OR21400) Contact - J.R. Keiser, 615-574-4453, FTS 624-4453

This project involves the evaluation of erosion-corrosion of alloys by microscopic techniques. Selected alloys will be subjected to exposure in a flowing gas stream of erodent particles, and the degradation of the alloys will be followed by examination of the alloy surfaces by a scanning electron microscope. This technique should provide direct evidence of the erosion-corrosion modes of materials degradation in these systems.

Keywords: Erosion and Wear, Corrosion, Metals, Alloys

385. <u>Study of Particle Rebound Characteristics and Material Erosion at High Temperature</u>

	FY 1984	FY 1985
	\$ 80,000	\$ 80,000

University of Cincinnati (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-89628C) Contact - W. Tabakoff, 513-475-2849

The purpose of this effort is to investigate the erosion processes and fluid mechanics phenomena that occur in fluidized-bed combustors, coal-fired boilers, cyclones, pumps, turbines, valves, and other coal combustion systems. The overall objective is to develop a quantitative model that will facilitate the prediction of erosion in systems operating in particle-laden environments. This investigation will at first be limited to ductile target materials. The experimental study of the impact and rebound characteristics will be performed with selected solid particles, possibly Al_2O_3 and SiO_2, with sizes from 5 to 200 m. The target materials will be selected according to present and anticipated materials needs of coal combustion systems. Candidate materials will include stainless steel, INCO 718, Ti 6-4, and 2024 Al.

Keywords: Erosion and Wear, Corrosion, Metals, Alloys

386. High Temperature Creep Behavior of Refractory Bricks

	FY 1984	FY 1985
	$ 110,000	$ 100,000

Iowa State University, Engineering Research Institute, Department of Materials Science and Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-07940C) Contact - T.D. McGee, 515-294-9619, FTS 865-9619

This research effort is a continuation of the study of creep of refractories used to line fossil fuel process vessels. The work will concentrate on those refractories intended for use at higher temperatures and under more severe conditions than can be tolerated by refractory concretes. Specifically, the research will focus on the creep behavior of high-chromia refractories suitable for lining the hot section of slagging gasifiers. Uniaxial creep experiments will be conducted in compression in air and mixed gases with very low oxygen partial pressures. The creep behavior of high-chromia refractories in uniaxial compression will be measured as a function of stress, oxygen partial pressure, and temperature. Oxygen partial pressures ranging from 21 kPa to 0.1 pPa will be used. Stress will be varied from 0.7 to 2 MPa. In addition, biaxial creep measurements will be made for selected refractories for which uniaxial creep measurements have been determined.

The creep data will be evaluated in cooperation with related work at the Massachusetts Institute of Technology to correlate the creep behavior of these refractories with a mathematical model.

Keywords: Ceramics, Glasses, Materials Characterization

387. Investigation of the Effect of Slag Penetration on the Mechanical Properties of Refractories

	FY 1984	FY 1985
	$ 165,000	$ 135,000

NBS, Center for Materials Science (Contract No. DE-AI05-83OR21349) Contact - S. Wiederhorn, 301-921-2901

The purpose of this task is to evaluate the effect of slag and microstructure on the fracture and deformation behavior of refractory materials and the development of a base of experimental data that can be used to model refractory degradation caused by slag penetration. The fracture and deformation behavior of model refractories will be determined as a function of applied load and temperature. Changes in density and microstructure will be evaluated for refractories which have been subject to creep deformation. Data will be evaluated in terms of mechanisms that have been developed to explain cavity formation, cavity coalescence and crack growth in ceramic materials and the models will be revised as appropriate.

A model will be developed to predict the lifetimes of refractories in slagging gasifiers. In addition, a portion of the work will focus on a systematic compilation of data relating to slag properties and corrosion of refractories for advanced coal conversion systems.

Keywords: Corrosion, Slag, Refractories

388. Corrosion of Refractories in Slagging Gasifiers

	FY 1984	FY 1985
	$ 160,000	$ 125,000

ANL (Contract No. W-31-109-eng-38) Contact - W.A. Ellingson, S. Greenberg, 312-972-5068, FTS 972-5068

The effects of slag and flux composition on the corrosion of alumina and chromia refractories will be examined in a series of corrosion tests in which the viscosities rather than temperatures are kept constant. The viscosities of coal slags in atmospheres of low oxidizing potential will be determined, and the effects of fluxes will be investigated. An analytical model will be developed for predicting refractory performance as a function of slag composition, refractory composition, temperature, and other slag characteristics.

Keywords: Gasifiers, Corrosion

389. High Temperature Applications of Structural Ceramics

	FY 1984	FY 1985
	$ 265,000	$ 260,000

NBS, Center for Materials Science (Contract No. DE-AI05-80OR20679) Contact - E.R. Fuller, S.J. Schneider, 301-921-2901

The objective of this study is to characterize the high temperature failure mechanisms and factors that influence their operation with an aim toward improving the properties of structural ceramics, especially silicon carbide and silicon nitride based materials, for use in coal conversion applications.

Keywords: Ceramics, Glasses, Materials Characterization

390. Mechanical Behavior of Structural Ceramics

	FY 1984	FY 1985
	$ 225,000	$ 0

ORNL (Contract No. DE-AC05-84OR21400) Contact - P.F. Becher, 615-574-5157, FTS 624-5157

The purpose of this work is to develop improved structural ceramics by correlating the mechanical properties of structural ceramics with their microstructure, crystal structure, microchemistry, and fabrication history. Changes in such key properties as flexural strength, fracture toughness, and subcritical crack growth as a function of exposure time to combustion products of fossil fuels at high temperatures are also determined. This correlation is accomplished by determining changes in mechanical properties of the structural ceramics after long-term exposures and comparing with properties of as-manufactured specimens. Another purpose is to identify the degradation mechanisms for these materials and to determine the fundamental role of intrinsic and extrinsic defects, and second phases in limiting the high-temperature performance of structural ceramics in order to aid in the development of new materials or improvements in existing materials for fossil energy components such as heat exchangers and high-temperature gas turbines.

Keywords: Structural Ceramics

391. "Materials and Components in Fossil Energy Applications" Newsletter

FY 1984	FY 1985
$ 135,000	$ 105,000

Battelle Columbus Laboratories (Contract No. DE-AC05-80ET10609) Contact - E.E. Hoffman (DOE/ORO), 615-576-0735, FTS 626-0735; I.G. Wright (BCL) 614-424-4377

The purpose of this task is to publish a periodic newsletter to address current developments in materials and components in fossil energy applications.

Keywords: Materials, Components

392. Microstructural Control to Improve Properties of Weldments in Chromium-Molybdenum Steels

FY 1984	FY 1985
$ 0*	$ 0

Combustion Engineering, Incorporated, Metallurgical and Materials Laboratory (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 11X-64760V) Contact - E.W. Pickering, Jr., 615-752-7196

This project is concerned with the production and evaluation of shielded metal arc welds to determine the effects of composition of welding consumables and welding parameters on the microstructure and properties of the weldments. Welding parameters studied included heat input, preheat temperature, welding techniques, and postweld heat treatments. The study of welding consumable composition included the effect of important elements as well as deoxidation and basicity of electrodes and fluxes. Materials included microalloyed versions of 3 Cr-1.5 Mo and 9 Cr-1 Mo steels.

Keywords: Steels, Weldments

* Prefunded in FY 1983

393. Electroslag Welding of Pressure Vessel Steels

	FY 1984	FY 1985
	$ 0*	$ 0

Colorado School of Mines, Department of Metallurgical Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-07219C) Contact - R.H. Frost, G.R. Edwards, 303-273-3777

The objective of this program is to characterize the effects of process variables, including potential, electrode composition and velocity, and flux composites, that are important to the optimization of the electroslag welding process. Work has focused on electroslag weldments in 100-mm-thick plates of 2 1/4 Cr-1 Mo steel and 3 Cr-Mo alloys. Emphasis was placed on process control and understanding flux chemistry, rather than microstructural and mechanical properties characterization. Welding of thicker plates is not envisioned since to some extent commercially produced electroslag weldments in 2 1/4 Cr-1 Mo steel are currently available. In contrast, thos project is aimed at a more fundamental understanding of the electroslag welding process.

Keywords: Materials Processing, Joining Methods, Materials Characterization

394. Three-Dimensional Residual Stress Characterization of Thick Plate Weldments with Advanced Instrumentation and Methodologies

	FY 1984	FY 1985
	$ 0*	$ 0

Pennsylvania State University, Materials Research Laboratory (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-89603C) Contact - C.O. Ruud, 814-863-2843

This project is designed: (1) to continue and expand previous work at Pennsylvania State University; (2) to involve the characterization of the three-dimensional residual stress field in an approximately 30-cm-thick (12 in.) V-groove weldment of 2 1/4 Cr-1 Mo steel; and (3) to evaluate various postweld heat treatment techniques and schedules proposed for the fabrication of large pressure vessels. This study is expected to provide the most accurate and detailed experimental residual stress analysis of large weldments to date and the needed information for accurate fracture mechanical calculation and finite-element modeling for these weldments.

Keywords: Materials Processing, Materials Characterization

395. Investigation of the Mechanisms of Molten Salt Corrosion of Candidate Materials for Molten Carbonate Fuel Cells

	FY 1984	FY 1985
	$ 210,000	$ 225,000

ORNL (Contract No. DE-AC05-84OR21400) Contact - H.S. Hsu, 615-576-4810, FTS 626-4810

* Prefunded in FY 1983

This program focuses on the corrosion mechanisms of the anode and cathode current collectors in MCFCs. Thermochemical calculations with the SOLGASMIX-PV computer program will be used to establish equilibrium phase relationships. Differential thermal analysis and thermogravimetric analysis (DTA/TGA) studies of structural metals in Li_2CO_3-K_2CO_3 salts will be conducted to establish the phase stability diagrams of the elements Fe, Ni, and Cr in the salt. The resistance of Ni_3Al to a thin coating of Li_2CO_3-K_2CO_3 will be tested under reducing (anodic) and oxidizing (cathodic) conditions. Finally, salt purification techniques and analytical procedures will be developed to permit determinations of the solubilities of structural metal oxides (Fe_3O_4, Cr_2O_3, and NiO) in molten carbonate salt under anodic and cathodic conditions.

Keywords: Fuel Cells, Current Collectors

396. <u>Oxide Electrodes for High-Temperature Fuel Cells</u>

	FY 1984	FY 1985
	\$ 300,000	\$ 226,000

PNL (Contract No. DE-AC06-76RL01830) Contact - J.L. Bates, D.D. Marchant, 509-375-2579, FTS 444-2579

The objective of this research is to find and develop highly electronically conducting oxides for use as cathodes in SOFCs. Specifically, the work involves determining the effects of rare earth (RE) and indium oxide additions on the electrical transport properties of $HfO_2(ZrO_2)$-RE_xO_y-In_2O_3. In addition, the study will develop an understanding of the crystallographic, microstructural, and phase equilibrium factors that influence the above properties. The compositions of the $HfO_2(ZrO_2)$-RE_xO_y-In_2O_3 are varied, and the electrical properties are measured relative to the phase equilibrium and crystallographic structures to determine the RE and In_2O_3 combinations that provide the highest electronic conductivity. The electronic conductivity, transference numbers, and Seebeck coefficient are measured as functions of temperautre and oxygen partial pressure. An important part of this investigation involves the study of the stability of a particular oxide in the environments and temperature ranges of SOFC fabrication and operation as well as the compatibility of the oxide electrode with the other cell components. This latter criterion includes both chemical compatibility and relative thermal expansion coefficients.

Keywords: Fuel Cells

397. <u>Studies of Materials Erosion in Coal Conversion and Utilization Systems</u>

	FY 1984	FY 1985
	\$ 300,000	\$ 350,000

LBL (Contract No. DE-AC03-76SF00098) Contact - A.V. Levy, 415-486-5822, FTS 451-5822

The objective of this program is to determine the erosion-corrosion behavior of materials used in the flow passages of liquid slurries under conditions representative of those in coal liquefaction systems. From the understanding gained from testing different materials over a range of controlled operating conditions within and beyond those of currently

* Prefunded in FY 1983

acceptable practice, slurry flow operating parameter guidelines and improved performance, materials selection and design criteria will be developed. The information that will be gained from this program will be structured in a manner that will make it directly usable by coal liquefaction system designers.

Keywords: Corrosion, Erosion and Wear

398. Mechanisms of Galling and Abrasive Wear

	FY 1984	FY 1985
	$ 145,000	$ 135,000

NBS, Center for Materials Science (Contract No. DE-AI05-83OR21322) Contact - K.J. Bhansali, 301-921-2982

This project is directed to developing an understanding of the wear mechanisms of materials associated with valves in coal conversion systems. This work addresses the mechanical and chemical effects experienced in closure regions of valves in coal conversion systems. It includes theoretical considerations of chemical reactions and effects of the working media on valve closure materials. Measurements are being performed to determine the static and kinetic coefficients of friction of the various combinations of test materials.

Keywords: Erosion and Wear

399. Thermomechanical Modeling of Refractory Brick Linings for Slagging Gasifiers

	FY 1984	FY 1985
	$ 125,000	$ 125,000

MIT (Contract No. DE-AC05-84OR21400, Margin Marietta Energy Systems, Incorporated Subcontract No. 19X-07862C) Contact - Oral Buyukozturk, 617-253-7186

The objective of this task is to study the failure mechanisms of refractory-brick-lined coal gasification vessels under transient temperature loadings. A thermomechanical model, which will include cyclic multiaxial nonlinear constitutive law, temperature-dependent heat conduction, and temperature-dependent creep laws, is to be developed for refractory brick and mortar. The model will be implemented in a finite-element program for predicting the stresses and strain distributions in brick-mortar linings during the heatup and cooldown cycles. Through simulation and parameter studies, design recommendations will be made for vessel configuration, material property combinations, and optimum heating schedules.

Keywords: Refractory Liners

400. Alkali Attack of Coal Gasifier Refractory Linings

	FY 1984	FY 1985
	$ 90,000	$ 90,000

Virginia Polytechnic Institute and State University, Department of Materials Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-43397C) Contact - J.J. Brown, Jr., 703-961-6777

* Prefunded in FY 1983

This task will investigate the physical and chemical characteristics of alkali attack of coal gasifier linings under nonslagging conditions. Various refractories will be exposed to simulated coal gasification atmospheres containing alkali metals. Phase changes and compound formations that occur in the refractories will be evaluated and compared with theoretical calculations.

Keywords: Corrosion, Ceramics, Glasses

401. Thermodynamic Properties and Phase Relations for Refractory-Slag Reactions in Slagging Coal Gasifiers

	FY 1984	FY 1985
	$ 90,000	$ 90,000

Pennsylvania State University (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Incorporated Subcontract No. 19X-09006C) Contact - Arnulf Muan, 814-865-7659

The purpose of this program is to determine the chemical constraints affecting the performance of refractory materials under experimental conditions corresponding to those prevailing in slagging gasifiers. In particular, this program concentrates on systems containing chronic oxide since refractories containing significant amounts of this component have demonstrated excellent resistance to corrosion. This program interfaces with programs at Argonne National Laboratory to provide information on chemical stability of reaction products.

Keywords: Corrosion, Ceramics

402. Management of the AR&TD Fossil Energy Materials Program

	FY 1984	FY 1985
	$ 353,000	$ 340,000

ORNL (Contract No. DE-AC05-84OR21400) Contact - R.A. Bradley, P.T. Carlson, 615-574-6094, FTS 624-6094

The overall objective of the Advanced Research and Technology Development (AR&TD) Fossil Energy Materials Program is to conduct a fundamental, long-range research and development program that addresses, in a generic way, the materials needs of fossil energy systems and ensures the development of advanced materials and processing techniques. The purpose of this task is to manage the AR&TD Fossil Energy Materials Program in accordance with procedures described in the Program Management Plan approved by DOE.

This task is responsible for preparing the technical program plan for DOE approval; submitting budget proposals for the program; recommending work to be accomplished by subcontractors and by ORNL; placing and managing subcontracts for fossil energy materials development at industrial research centers, universities, and other government laboratories; and for reporting the progress of the program.

Keywords: Management, Materials Program

* Prefunded in FY 1983

403. Development of Nondestructive High-Temperature Erosion Monitoring System

	FY 1984	FY 1985
	$ 85,000	$ 0

ANL (Contract No. W-31-109-eng-38) Contact - W.A. Ellingson, K.J. Reimann, 312-972-5068, FTS 972-5068

The purpose of this continuing program is to develop reliable real-time, on-line, high-temperature systems that will measure erosive wear. An active program involving laboratory and field tests over the past six years has developed a first-generation, field-implementable system for real-time monitoring of erosive wear. The program involves development of nondestructive testing methods and evaluation of the reliability of the test methods for the measurement of erosive wear.

Keywords: Nondestructive Testing, Erosion

404. Development of Nondestructive Evaluation Techniques for Structural Ceramics

	FY 1984	FY 1985
	$ 120,000	$ 205,000

ANL (Contract No. W-31-109-eng-38) Contact - W.A. Ellingson, D.S. Kupperman, 312-972-5068, FTS 972-5068

The purpose of this project is to study and develop acoustic and radiographic techniques and possible novel techniques such as nuclear magnetic resonance, to characterize structural ceramics with regard to presence of porosity, cracking, inclusions, amount of free silicon, and mechanical properties, and to establish the type and character of flaws that can be found by NDE techniques. Both fired and unfired specimens will be studied, and correlations between NDE results and failure of specimens will be established.

Keywords: Nondestructive Evaluation, Ceramics

Office of Surface Coal Gasification

405. Protective Coatings and Claddings: Application Evaluation

	FY 1984	FY 1985
	$ 190,000	$ 180,000

DOE Contact - J.P. Carr, 301-353-5985
METC Contact - J.M. Hobday, 304-291-4347
ANL (Contract No. W-31-109-eng-38) Contact - D.R. Diercks, 312-972-5032

The coating/cladding development activity will provide experimental evaluation and thermodynamic analysis of metallic protective coatings for coal gasifier waste heat steam generators and superheaters as well as the development of coating inspection methods. The evaluation of procedures for the field restoration of protective coatings at welds and damaged areas is included, as is the development of NDE techniques for verifying coating integrity and quality. These protective coatings will enable conventional ferritic steel boiler and superheater alloys to operate in contact with raw product gas at metal temperatures of about 480 to 540 degrees C (900 to 1000 degrees F) required for good plant efficiency.

* Prefunded in FY 1983

Keywords: Coatings and Films, Corrosion, Alternative Fuels

406. Electroslag Component Casting	FY 1984	FY 1985
	$ 300,000	$ 290,000

DOE Contact - J.P. Carr, 301-353-5985
METC Contact - J.M. Hobday, 304-291-4347
ORNL (Contract No. W-7405-eng-26) Contact - V.K. Sikka, 615-574-5112

The Surface Coal Gasification Materials Program electroslag casting (ESC) project is directed toward the development of ESC technology for use in coal conversion components such as valve bodies, pump housings, and pipe fittings (elbows, tees, etc.). The aim is to develop a sufficient data base to permit acceptance of ESC as an ASME Code (Section VIII) material and to transfer the ESC process technology to private industry. The task has four major areas of emphasis: (a) advancement of ESC technology; (b) preparation of castings (by commercial vendors); (c) testing of commercial ES castings for mechanical properties; and (d) participation with industrial component fabricators to demonstrate the ability to produce representative components for coal conversion systems by the ESC process.

Keywords: Metals: Ferrous and Non-Ferrous, Solidification, Conventional Fracture, Structure, Alternative Fuels

407. Plant Materials Surveillance Tests	FY 1984	FY 1985
	$ 100,000	$ 0

DOE Contact - J.P. Carr, 301-353-5985
METC Contact - J.M. Hobday, 304-291-4347
The Metal Properties Council, Inc. (Contract No. W-7405-eng-26), Union Carbide Corporation (Subcontract No. 19X-22241C) Contact - A.O. Schaefer and E.J. Vesely, Jr., 212-705-7693

The purpose of this project is to evaluate construction materials for resistance to coal gasification environments by testing in current gasification pilot plants. This task is being performed for DOE by the Metal Properties Council, Inc. (MPC). This MPC testing program is testing materials in the Bi-Gas, Westinghouse, General Electric (Gegas), and Mountain Fuels Resources plants. To aid the correlation of the different phases of the corrosion program and help identify the effects of the plant variables, detailed metallurgical examinations of test specimens will be performed.

Keywords: Metals, Corrosion, Alternative Fuels

408. Slagging Gasifier Refractories: Application Evaluation

FY 1984	FY 1985
$ 130,000	$ 95,000

DOE Contact - J.P. Carr, 301-353-5985
METC Contact - J.M. Hobday, 304-291-4347
ANL (Contract No. W-31-109-eng-38) Contact - S. Greenberg, 312-972-5084

This effort will establish base technology on refractories which have been systematically selected for slagging gasifiers relative to corrosion resistance. In addition, the total program (for which this effort is

* Prefunded in FY 1983

a part) will develop an analytical predictive model which will be capable of predicting refractory lifetime as a function of the chemical composition of coal, chemical composition of refractory, temperature, and slag viscosity. This effort will emphasize slag corrosion of medium-chromia and high-chromia refractories in acidic and basic slags with the tests to be in a laboratory rotating drum test facility. There will be six to eight refractories included. The data from this effort will contribute to the specification of refractory linings of reasonable lifetimes for slagging gasifiers.

Keywords: Refractory, Ceramics, Erosion, Corrosion, Alternative Fuels

409. Advanced Pressure Vessel Materials Technology

	FY 1984	FY 1985
	$ 175,000	$ 110,000

DOE Contact - J.P. Carr, 301-353-5985
METC Contact - J.M. Hobday, 304-291-4347
ORNL (Contract No. W-7405-eng-26) Contact - R.W. Swindemann, 615-574-5108

The purpose of this project is to advance pressure vessel materials technology to permit more economical design and fabrication of large coal conversion vessels that will operate reliably and safely through their design lifetimes. This project will provide verification to the practicability of utilizing a 3 Cr-1.5 Mo-0.1 V steel heat treated to a strength level greater than that presently permitted in the ASME Boiler Pressure Vessel Code (ASME Code). The approach will include the mechanical testing of commercially supplied base plate and ORNL produced weldments to provide material property data needed for approval of this alloy in appropriate sections of the ASME code.

Keywords: Metals, Fatigue, Fracture, Structure, Alternative Fuels, Hydrogen Attack, Welding

410. Ceramic Fabrication/Application Technology

	FY 1984	FY 1985
	$ 170,000	$ 185,000

DOE Contact - J.P. Carr, 301-353-5985
METC Contact - J.M. Hobday, 304-291-4347
ANL (Contract No. W-31-109-eng-38) Contact - T.E. Easler, 312-972-4250

This structural ceramics program will provide experimental data (corrosion resistance, effect of environment on mechanical properties) for SiC when exposed to coal gasification heat exchanger environments. In addition, this program will evaluate the corrosion resistance of specific SiC joining methods. The first phase of the program consists of running corrosion screening tests on a-SiC, NC-430, and CX-589. These materials will be tested as a function of: (1) fabrication method [slip cast and extruded as well as isostatic pressed (for SC-2 only)]; (2) status of surface (machined or as-received); (3) coal slag (acidic, basic, or no slag); and (4) temperature. Initial corrosion screening tests will be conducted for 200 h at 1250 degrees C in simulated medium-Btu gasification environments. Longer-term (500 h and 1000 h) corrosion tests on those SiC materials that are best able to withstand the corrosive environments as shown by their performance in 200 h tests will be run subsequently.

* Prefunded in FY 1983

Keywords: Structural Ceramics, Corrosion, Alternative Fuels

Office of Oil, Gas, Shale, and Coal Liquids

411. Coating Studies for Coal Conversion

	FY 1984	FY 1985
	$ 125,000	$ 0

DOE Contacts - T.B. Simpson (HQ), 301-353-3913 (FTS 233-3913); S.R. Lee (PETC), 412-675-6137 (FTS 723-6137)
ORNL (Contract No. DE-AC05-84OR21400) Contact - A.J. Caputo, 615-574-4566 (FTS 624-4566)

This task is developing chemically vapor deposited coatings which offer the hope of extending the life of valve trim materials in coal conversion applications. The scope of the task consists of using available equipment to deposit coatings onto cemented tungsten carbide and other substrates. The erosion rates of such coatings are being determined using an established test in order to evaluate whether these coatings appear promising for valve trim and other severe erosion environment fossil applications. A systematic study of the role of coating and substrate variables is being made to determine the optimum conditions for producing coatings that offer the greatest potential for letdown valve trim applications.

Keywords: Ceramics, Erosion and Wear, Chemical Vapor Deposition, Alternative Fuels

412. Assessment of Materials Selection and Performance for Coal Liquefaction Plants

	FY 1984	FY 1985
	$ 0*	$ 0*

DOE Contact - J.A. Reafsnyder (ORO), 615-576-1051 (FTS 626-1051)
ORNL (Contract No. DE-AC05-84OR21400) Contact - A.R. Olsen, 615-574-1753 (FTS 624-1753)

Materials selection and performance data for coal liquefaction pilot plants are being collected, assessed, and compiled. In addition to pilot plant information, data from applicable research and development programs and other sources such as the American Petroleum Institute (API) and the National Association of Corrosion Engineers (NACE) are being assessed for applicability. This work draws on reviews of the SRC demonstration plant design and includes materials selection information for those plants. This compilation provides the identification and assessment of available materials data and identifies limited or missing materials data. This permits reviews of current research and development programs and planning of future efforts.

Keywords: Alloys, Corrosion, Erosion and Wear, Alternative Fuels

* Prefunded in FY 1983

413. Materials Review and Support for the SRC-I Liquefaction Project

	FY 1984	FY 1985
	$ 0*	$ 0*

DOE Contact - J.A. Reafsnyder (ORO), 615-576-1051 (FTS 626-1051)
ORNL (Contract No. DE-AC05-85OR21400) Contact - A.R. Olsen, 615-574-1753 (FTS 624-1753)

The objectives of this work are to provide assistance in the review of contractor documents for materials selection, to review and provide input to materials testing and failure analysis plans, and to compile materials information for specific processing steps to assist designers in making appropriate materials choices. The ORNL Fossil Energy Materials Program staff reviews materials-related items of SRC-I demonstration plant project.

Keywords: Alloys, Corrosion, Erosion and Wear, Alternative Fuels

414. Coal Liquefaction Pilot Plant Materials Testing and Failure Analysis

	FY 1984	FY 1985
	$ 0*	$ 0*

DOE Contact - T.B. Simpson (HQ), 301-353-3913 (FTS 233-2913); S.R. Lee (PETC), 412-675-6137 (FTS 723-6137)

This project provides alloy screening data on the susceptibility to corrosion and stress-corrosion cracking of potential materials of construction for coal liquefaction plants. These data are obtained by performing in-plant coupon exposures, laboratory tests, and metallographic examinations. Alloys are ranked according to their corrosion resistance to the various process stream environments.

Keywords: Alloys, Corrosion, Alternative Fuels

415. Elastomer Test Program

	FY 1984	FY 1985
	$ 18,000	$ 0

DOE Contacts - T.B. Simpson (HQ), 301-353-3913 (FTS 233-3913); S.R. Lee (PETC), 412-675-6137 (FTS 723-6137)
ORNL (Contract No. DE-AC05-84OR21400) Contact - J.R. Keiser, 615-574-4453 (FTS 624-4453)

This project is testing O-ring elastomers for use in coal liquids. Laboratory immersion tests are being performed at ORNL and in-plant testing is being performed at the Wilsonville Advanced Coal Liquefaction Research and Development Facility.

Keywords: Alternative Fuels

* Prefunded in FY 1983

Office of Coal Utilization

416. Electrode Surface Chemistry

	FY 1984	FY 1985
	$ 150,000	$ 200,000

DOE Contact - W.J. Huber, 304-291-4663 (FTS 923-4663)
LBL (Contract No. DE-AC03-76SF00098) Contact - P.N. Ross, 415-486-4000 (FTS 451-4000)

This project involves the synthesis of bimetallic catalysts by thermal annealing of platinum with refractory metals, refractory metal oxides, and refractory metal carbides. These alloys were analyzed and tested for catalytic activity.

Keywords: Catalysts, Performance/Endurance, Sintering/Surface Characterization and Treatment, Fuel Cells

417. Development of Ternary Alloy Cathode Catalysts for Phosphoric Acid Fuel Cells

	FY 1984	FY 1985
	$ 460,000	$ 60,000

DOE Contact - W.J. Huber, 304-291-4663 (FTS 923-4663)
Giner (Contract No. DEN3-294) Contact - V. Jalan, 617-889-7270

This work involves the synthesis of binary and ternary platinum alloy catalysts. A selected few showed increased catalytic activity compared to platinum catalysts alone. Development quantities of catalysts have been supplied to the National Aeronautics and Space Administration (NASA) for evaluation.

Keywords: Catalysts, Performance/Endurance, Sintering/Surface Characterization and Treatment, Fuel Cells

418. Organometallic Catalysts for Primary Phosphoric Acid Fuel Cells

	FY 1984	FY 1985
	$ 150,000	$ 0

DOE Contact - W.J. Huber, 304-291-4663 (FTS 923-4663)
ECO (Contract No. DEN3-206) Contact - F. Walsh, 617-964-7010

This work involves the synthesis of several metal-cobalt-organic ligand type catalysts. These catalysts have shown increased catalytic activity compared to platinum catalysts. Development quantities of these catalysts are being prepared and will be supplied to NASA for further evaluation.

Keywords: Catalysts, Performance/Endurance, Sintering/Surface Characterization and Treatment, Fuel Cells

419. Molten Carbonate Fuel Cell and Stack Technology Development

	FY 1984	FY 1985
	$ 0	$ 0

DOE Contact - F.D. Gmeindl, 304-291-4751 (FTS 923-4751)
United Technologies Corporation (Contract No. DE-AC01-79ET15440) Contact - A. Meyer, 203-727-2214

Materials which maintain springiness under molten carbonate fuel cells (MCFC) operating conditions with temperatures up to about 700 degrees C are being evaluated for use in the construction of flexible flanges which maintain sealing pressures against electrolyte-filled ceramic matrices. Examples of materials studied include 316 SS Fe-Cr alloys, INCO 825, and MA956. No material has been identified that has both satisfactory performance and cost. The typical study evaluates the room temperature spring constant and the extent of load relaxation at operating temperatures. The desired material must permit flange sealing with room temperature pressures of less than about 100 psi and not relax at operating temperature pressures greater than about 10 psi.

UTC has discontinued the search for alternatives to NiO as cathode materials. Work is concentrated on determining stack operating conditions where NiO can last 40,000 hours. The parameters under study include: O_2 and CO_2 partial pressures, total operating pressure, operating temperature as well as electrolyte matrix thickness and electrolyte composition.

The corrosion of 316 SS and other alloys are being studied in a MCFC cathode gas/molten carbonate film environment. These materials have been proposed as the component making up the separator plate in MCFCs. The particular concerns are for the effects of heat and forming operations on the corrosion rate and the nature of the protective layer under normal operation of the fuel cell and under the stress of thermal cycling. The primary technique being used at this time is retort screening under various conditions expected to occur under normal MCFC operation.

ZrO_2 materials in various forms, such as felts and cloths, are being evaluated as gasket materials between gas manifolds and the MCFC stack. The gasket is required to prevent gas leakage and to accommodate differences in expansion coefficients between the manifold and stack. The material selected must also show a minimal capability of wicking the electrolyte. Electromigration of molten carbonate is being used to develop specifications for the gasket material. A 5000 hour subscale stack test completed in March 1985 indicates that the current ZrO_2 gasket material is mechanically sufficient. Its stability in carbonate is a remaining concern. UTC has shown that the stack can be shutdown and the manifold gaskets replaced.

Tape casting studies are being carried out for the purpose of producing thin porous nickel sheets from metal powder. The porous nickel sheets are a required component of MCFCs. The work is being directed to the formation of high strength sheets with controlled porosities. Bending and tensile tests are used to evaluate the strength, and porosities are determined by density and porosimetry measurements.

Keywords: Alloys, Ceramics, Metals, Corrosion, Strength, Fuel Cells

420. Molten Carbonate Fuel Cell Component Technology Development

	FY 1984	FY 1985
	$ 0	$ 0

DOE Contact - F.D. Gmeindl, 304-291-4751 (FTS 923-4751)
Energy Research Corporation (Contract No. DE-AC03-76ET11304) Contact - H. Maru, 203-792-1460

The work at ERC is directed toward improving anode creep resistance by filling the anode with lithium aluminate powders. Ni-Al alloys are formed having 5-2% Al with the Al acting as a stiffening agent. In addition to Al additions, ERC is attempting to improve porosity by controlling particle synthesis and improving the method of pressing and sintering the powders. The anodes are ribbed and the ribs are frequently of different porosity and pore size than the webs.

ERC is also developing catalysts for reforming of methane in the anode compartment of the fuel cell. They have tested commercial MgO-supported Ni catalysts in cells where the catalyst bed is separated from the anode by a porous stainless steel sheet. Catalytic activity may be diminished by electrolyte wetting of the catalyst surface as well as hydrolization of the substrate. Poisoning by small quantities of sulfur in the fuel has also been observed. Methods for scrubbing the poisoned catalyst with steam have been moderately successful. ERC, through a subcontractor, is investigating several materials as non-wetting catalyst substrates.

ERC is developing coatings for separator plate materials. There is some evidence that hydrogen diffusion from the fuel side of the plate may effect the oxide layer on the oxidant side of nickel coated stainless steel plates. In recognition of this, ERC is developing a coating (e.g., copper) for placement between the steel and nickel to serve as a hydrogen diffusion barrier. The objective of this effort is to develop a coating that meets goals of overpotential and resistance to corrosion and spalling after thermal cycling.

Keywords: Composites, Sintering, Strength, Fuel Cells

421. Alternative Molten Carbonate Fuel Cell Cathodes

	FY 1984	FY 1985
	$ 0	$ 0

DOE Contact - F.D. Gmeindl, 304-291-4751 (FTS 923-4751)
ANL (Contract No. W-31-109-eng-38) Contact - R.D. Pierce, 312-972-4450 (FTS 972-4450)

This project is involved in the evaluation of ceramic materials (e.g., Li_2MnO_3, and ZnO) as possible alternatives to NiO for the cathode material for molten carbonate fuel cells because in-cell migration of NiO has been found to be excessive for long-term operation. The thermodynamically stable oxide phases under a range of cathode conditions for many metals (principally transition elements) have been determined. Experiments are underway to promote conductivity in these stable phases by doping and to assess the suitability of these materials as MCFC cathodes. This assessment involves conductivity measurements, dopants and morphological stability testing, solubility determinations, fabrication studies, in-cell migration testing, and cell-performance determinations.

Keywords: Ceramics, Semiconductors, Microstructure, Fuel Cells

422. High Temperature Solid Oxide Electrolyte Fuel Cell Power Generation System

	FY 1984	FY 1985
	$ 0	$ 0

DOE Contact - C.M. Zeh, 304-291-4265 (FTS 923-4265)
Westinghouse Electric Corporation R&D Center (Contract No. DE-AC02-80ET17089)
Contact - W. Feduska, 412-256-1951

The goal for this project for FY 1985 is to qualify submodule performance prior to initiating development of a 5kW generator. The 24-cell submodule test goal is to operate continuously for 750 hours with no more than 4% per 1,000 hours voltage degradation. Initial cell performance must meet or exceed 600 mV at 160 mA/cm^2 with 85% utilization of fuel (67% H_2, 22% CO, and 11% H_2O). Essential design features (sealless generator concept, temperature profiles, fuel and oxidant distribution) will be demonstrated in the submodule prior to design and fabrication of the 5kW generator. The principal problem has been the development of a large scale (12-cell) electrochemical vapor deposition (EVD) process to fabricate cells with greater than 30 cm-long active area. Deposition conditions optimized in the single-cell EVD reactor have not yet been attained in the large reactor. Diffusion studies to determine potential life limiting factors are underway. Various techniques to reduce diffusion losses in the support tube, improve support tube strength, and increase air electrode conductivity are being investigated.

Keywords: Ceramics, Metals, Semiconductors, Chemical Vapor Deposition, Sintering, Fuel Cells

423. Advanced Fuel Cell Research

	FY 1984	FY 1985
	$ 0	$ 0

DOE Contact - C.M. Zeh, 304-291-4265 (FTS 923-4265)
ANL (Contract No. W-31-109-eng-38) Contact - D.C. Fee, 312-972-8931 (FTS 972-8931)

This work involves the development of a fabrication process for a monolithic fuel cell design composed of a "honeycomb" of small 1- to 2-mm diameter cells. The effort is centered on fabricating 1- to 5-mil layers of cell components chiefly by tape casting. The results show that close attention must be given to preparation of starting materials and ceramic processing procedures to obtain derived porosity and microstructure in the sintered ceramic. The materials under investigation are similar chemical compounds to those in the fuel cell being developed by Westinghouse Electric Corporation.

Keywords: Ceramic, Sintering, Fuel Cells

Magnetohydrodynamics Program

Successful economic operation of commercial MHD power systems will depend to a large measure on the availability of reliable materials of construction, capable of extended service at MHD operating conditions. The primary objective of the Materials Program of the Office of MHD is the development of materials applicable to the unique operating environment of coal-fired MHD systems. Program effort is divided into two general categories: (1) research effort to provide a fundamental understanding of materials behavior and a basis for the development of particular materials properties for MHD systems; and (2) applied engineering development of MHD component materials.

The materials development effort within the Office of MHD is coordinated by the Program Manager for Materials Development through the Office of the Director. Development effort in the first category is managed by the Division of Research and Advanced System Development, and effort in the second category by the Division of Engineering Development.

Development of MHD Generator Electrode and Insulator Materials

The objectives of this area are to define the thermal, electrical, chemical, and fluidynamic environment of electrode materials and to develop electrode and insulator materials applicable to this environment. Service conditions include: temperatures up to 2000 degrees C, heat fluxes up to 300 w/cm^2, exposure to magnetic fields of 50,000-60,000 Gauss, exposure to strongly alkali chemical species and reducing gases, current densities up to 1 amp/cm^2, and sonic velocities.

Program effort is currently directed toward the development of alternative electrode concepts; the development of cold (externally cooled) metallic electrodes, hot (1200-1900 degrees K) refractory electrodes, and superhot (> 1900 degrees K) ceramic electrodes. Among the metals, Ni, Co, Cr, Fe, W, Ti, Ta, Nb, and their alloys have been evaluated. Among the refractories a number of spinels based on Al, Fe, La, Cr, and Mn have been evaluated. Key materials development contractors for this area are: Avco-Everett Research Laboratory, Westinghouse Electric Corporation, Battelle Northwest Laboratory, Massachusetts Institute of Technology, and Stanford University.

424. MHD Materials Development Testing, and Evaluation

FY 1984	FY 1985
$ 100,000	$ 30,000

DOE Contact - T.W. Arrigoni, 412-675-5981 (FTS 723-5981)
PNL (Contract No. DE-AC06-76RL01830) Contact - P.E. Hart, 504-375-2905

PNL has been involved in the development and testing of hot composite ceramic electrodes and MHD channel insulator materials. The current effort has placed emphasis on the development of composite, multi-layered, high temperature electrodes of hafnium oxide/rare earth oxides/indium oxides with improved thermal shock resistance. These electrode materials are tested by direct exposure to hot molten coal slag.

Keywords: Ceramics, Composites, Electrodes, Insulators

	FY 1984	FY 1985
425. UTSI MHD Development Testing	$ 594,000	$ 680,000

DOE Contact - C.A. Thomas, 412-675-5731 (FTS 723-5731)
University of Tennessee Space Institute (Contract No. DE-AC02-79ET10815)
Contact - N.R. Johanson, 615-455-0631

A major task in the MHD development testing, being conducted at the Coal-Fired Flow Facility (CFFF) at the University of Tennessee Space Institute, includes the evaluation of materials for use in MHD system superheaters and air heaters. Materials being evaluated include Croloy; Inconel; and 304, 316, 321. 446, and 26-1 stainless steels. Measurements of corrosion, fouling, and ash deposition are made for these materials under various conditions of a coal-fired MHD gas flow environment.

Keywords: Corrosion, Fouling, Superheaters

	FY 1984	FY 1985
426. MHD Heat and Seed Recovery Technology	$ 100,000	$ 100,000

DOE Contact - R.F. Sperlein, 412-675-5985 (FTS 723-5985)
ANL (Contract No. W-31-109-eng-38) Contact - T. Johnson, 312-972-5964

A series of tests were conducted at Argonne National Laboratory to investigate critical factors affecting the formation and growth of seed/slag deposites in a coal-fired MHD steam plant. These deposites consist of eighty to ninety-five percent potassium sulfate, with the balance consisting of sulfates and carbonates of seed impurities. Simulated MHD channel exhaust gas was produced by burning a slurry of heating oil, potassium sulfate, and fly ash with preheated air. The deposits were formed on type 304 stainless steel tubes.

Keywords: Scale Growth, Deposites, Corrosion

EMaCC Structural Ceramics Subcommittee Report

Research on Structural Ceramics is sponsored by several portions of the Department; namely, the Office of Energy Research, Basic Energy Sciences Program; Fossil Energy, Surface Gasification ad Advanced Research and Technology Development Programs; and the Office of Conservation and Renewable Energy, Advanced Heat Exchange, Advanced Materials Development, Energy Conservation and Utilization, and Vehicle Propulsion Programs. The structural ceramics subcommittee was formed in 1983 and consists of the following members: R. Gottschall, ER-131; R. Schulz, CE-131; J. Eberhardt, CE-142; A. Hayes, CE-121; S. Richlen, CE-121; C. Craig, CE-131; J. Fairbanks, FE-22; J. Carr, FE-24; and S. J. Dapkunas (chairman), FE-14.

In 1984 and 1985, the subcommittee chairman, S. J. Dapkunas, compiled a summary of on-going research sponsored by the Department. This summary has been programmed into an IBM personal computer and may be analyzed in several ways. The following tables, generated for this program, identify specific projects by (1) funding program and (2) research topics. Analysis of the data indicates the following points:

1. Departmental total funding changed from $27M in FY84 to $22M in FY85.

2. Conservation and Renewable Energy is the largest sponsor of structural ceramics research, with Vehicle Propulsion R&D the largest program.

3. Most funds are directed toward processing and fabrication studies, the least toward design.

4. Of the 18 research categories by which the Department's research is described, the greatest funding level was found to be for monolithic fabrication.

Specific funding levels of the sponsoring offices follows:

Office of Energy Research	FY84	FY85
Basic Energy Sciences Program	4444	4639
Office of Fossil Energy		
AR&TD Program	1106	1450
Surface Gasification Program	170	185
Office of Conservation & Renewable Energy		
ECUT Program	1461	2555
Advanced Materials Development Program	3864	4726
Vehicle Propulsion R&D	13409	7323
Advanced Heat Exchanger Program	2182	1630
Department Total	26638	22508

The distribution of funding by research topic is as follows:

	FY84	FY85
I. Processing & Fabrication		
A. Powder Synthesis	1158	1120
B. Monolithic Fabrication	13284	8106
C. Composite Fabrication	2248	2304
D. Coating Fabrication	878	1655
E. Joining/Attachment	768	1706
F. Chemistry		
G. Machining	276	208
	18612	15098
II. Design		
A. Modeling	377	270
B. Contact Interfaces	262	260
C. Component Design & Testing	1368	1000
	2007	1530
III. Properties/Characteristics		
A. Mech. Properties & Fracture Mechanics	2074	1920
B. Time Dependent Behavior	590	595
C. Non-Destructive Evaluation	750	461
D. Environmental Effects	996	1435
E. Microstructure/Microchemistry	744	792
F. Phase Equilibria & Reactivity	30	30
G. Component Testing	0	50
H. Tribology	833	595
	6017	5878
Department Totals	26638	22508

This data base is now being expanded to include summaries of all research sponsored by the Government. When complete, DOE, DOD, NASA, BOM, DOC and NSF program will be included.

ABBREVIATIONS

FE - Fossil Energy
AR&TD - Advanced Research and Technology Development
CRE - Conservation and Renewable Energy
ECUT - Energy Conservation and Utilization Program
ER - Energy Research
AMMRC - Army Mechanics and Materials Research Center
PSZ - Partially Stabilized Zirconia
LeRC - NASA Lewis Research Center

TBD - Performer, to be determined
-1 - Funds, to be determined

STRUCTURAL CERAMICS PROJECTS BY TECHNICAL AREA

U. S. DEPARTMENT OF ENERGY

OFFICE	PROGRAM	PROJECT TITLE	$FY84	$FY85	PERFORMER 1	PERFORMER 2
** AREA 1. PROCESSING AND FABRICATION						
* TYPE A. Powder Synthesis						
C&RE	ADVANCED HEAT EXCHANGER	Improved Low-Cost Silicon Carbide Powder	0	100	Oak Ridge Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	High Temperature Tensile Testing	388	100	North Carolina A&T U.	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Powder Characterization	34	31	Massachusetts Inst. Tech	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Silicon Carbide Powder Plasma Synthesis	112	110	Carborundum	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Silicon Carbide Powder Carbothermic Synthesis	130	0	Oak Ridge Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Silicon Nitride Powder Synthesis	112	110	Ford Motor	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Sol Gel Oxide Powder	105	110	Oak Ridge Nat'l Lab	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Novel Gas Phase Routes for Producing Ceramic Powders	0	0	TBD	
ER	BASIC ENERGY SCIENCES MATERIALS	Carbothermal Processing of Non-Oxide Ceramics	185	190	Ames	
ER	BASIC ENERGY SCIENCES MATERIALS	High-Temperature Chemistry and Thermodynamics of Structural Materials	150	150	Oak Ridge Nat'l Lab	
ER	BASIC ENERGY SCIENCES MATERIALS	Particulate Processing	305	320	Ames	
ER	BASIC ENERGY SCIENCES MATERIALS	Rapidly Solidified, Spherical, Fine Ceramic Powders	25	-1	Micromaterials Technology	
* TYPE B. Monolithic Fabrication						
C&RE	ADVANCED HEAT EXCHANGER	Low-Cost Extrusion of Silicon Carbide Tubes	0	100	Oak Ridge Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Sintering of Silicon Nitride	150	150	AMMRC	GeoSciences
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Novel Chemical Routes to Near Net Shape Processing	0	85	U. of Washington	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Plasma Sintering of Ceramics	2	100	Northwestern U.	
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Advanced Gas Turbine (AGT-100) Ceramic Parts Design, Processing, Fabrication & Acceptance Testing(Funding estimate)	5879	4860	Allison Turbine	Pontiac
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Advanced Gas Turbine (AGT-101) Ceramic Parts Design, Processing, Fabrication & Acceptance Testing(Funding estimate)	6070	4900	Garrett Turbine Engine	Ford Motor
ER	BASIC ENERGY SCIENCES MATERIALS	Center for Advanced Materials	300	350	Lawrence Berkeley Lab	
ER	BASIC ENERGY SCIENCES MATERIALS	High-Temperature Mechanical Behavior of Silicon Nitride	99	108	Cornell U.	
ER	BASIC ENERGY SCIENCES MATERIALS	Physics and Chemistry of Packing Fine Ceramic Powders	45	45	Massachusetts Inst. Tech	
ER	BASIC ENERGY SCIENCES MATERIALS	Processing and Characterization of Silicon Carbide-Aluminum Oxycarbide Ceramics	50	-1	Ceramatec	

STRUCTURAL CERAMICS PROJECTS BY TECHNICAL AREA

U. S. DEPARTMENT OF ENERGY

OFFICE	PROGRAM	PROJECT TITLE	$FY84	$FY85	PERFORMER 1	PERFORMER 2
ER	BASIC ENERGY SCIENCES MATERIALS	Research in Ceramic Processing	399	410	Oak Ridge Nat'l Lab	
ER	BASIC ENERGY SCIENCES MATERIALS	Structural Ceramics	290	320	Los Alamos Nat'l Lab	
ER	BASIC ENERGY SCIENCES MATERIALS	Wetting and Dispersion in Ceramic/Polymer Melt Injection Molding Systems	0	120	U. of Florida	
# TYPE C. Composite Fabrication						
C&RE	ADVANCED HEAT EXCHANGER	Toughened Oxide Ceramics	0	100	Oak Ridge Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Advanced Transformation Toughened Ceramics	90	90	U. of Michigan	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Dispersion Toughened Silicon Carbide	100	77	Oak Ridge Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Improved Transformation Toughened Ceramics	83	100	Norton	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Injection Molded Composites	0	200	TBD	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Mullite-Silicon Carbide Whisker Composite	0	130	General Electric	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Silicon Carbide Reinforced Oxide Composite	200	345	Oak Ridge Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Silicon Carbide Whiskers	35	0	Los Alamos Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Silicon Nitride-Metal Carbide Composite	336	37	GTE Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Silicon Nitride-Silicon Carbide Whisker Composite	133	35	AiResearch Casting	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Transformation Toughened Silicon Nitride	155	35	Rockwell International	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Dispersoid Toughened Ceramics Via CVD	0	75	Oak Ridge Nat'l Lab	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Synthetic Nephrite	0	0	Oak Ridge Nat'l Lab	
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Mullite Ceramics for Stirling Engines	170	23	LeRC	
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Toughened Mullite for Diesel	175	200	General Electric:V. Forge	
ER	BASIC ENERGY SCIENCES MATERIALS	Superplastic Forging of Structural Ceramics	50	0	Jupiter International	
FE	ADVANCED RESEARCH & TECHNOLOGY DEVELPMNT	Fabrication of Fiber-Reinforced Composites by CVD Infiltration	235	340	Oak Ridge Nat'l Lab	
FE	ADVANCED RESEARCH & TECHNOLOGY DEVELPMNT	Silicon Carbide Fiber Synthesis & Characteristics	250	260	Los Alamos Nat'l Lab	
FE	ADVANCED RESEARCH & TECHNOLOGY DEVELPMNT	Study Approaches for Fabricating Fiber Reinforced Ceramic Composites with Fused Silica & Silicon-Nitride Matrices	180	180	Georgia Tech	
FE	ADVANCED RESEARCH & TECHNOLOGY DEVELPMNT	Transfer of CVD Infiltration Technology to Industry	56	100	Oak Ridge Nat'l Lab	

STRUCTURAL CERAMICS PROJECTS BY TECHNICAL AREA

U. S. DEPARTMENT OF ENERGY

OFFICE	PROGRAM	PROJECT TITLE	$FY84	$FY85	PERFORMER 1	PERFORMER 2
* TYPE D. Coating Fabrication						
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	CVD and Sol Gel Zirconia Coatings	200	0	Oak Ridge Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Evaluation of Chromia Coatings	113	0	Cummins Engine	Kuman
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Insulating Coatings for Metal	0	200	TBD	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Zirconia Coatings for Silicon Ceramics	0	250	TBD	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Cubic Boron Nitride & Diamond-Like Carbide Coatings	40	0	Oak Ridge Nat'l Lab	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Ion Implantation of Ceramics	165	300	Oak Ridge Nat'l Lab	Georgia Tech
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Laser Modifications of Ceramics	60	150	North Carolina State U.	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Tribological Surface Modifications and Coatings (A)	150	250	Massachusetts Inst. Tech	Borg-Warner
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Tribological Surface Modifications and Coatings (B)	150	250	U. of California:LA	Argonne Nat'l Lab
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Plasma Sprayed Zirconia for Diesels	0	255	Allison Turbine	
* TYPE E. Joining/Attachment						
C&RE	ADVANCED HEAT EXCHANGER	COMPGLAS Seal and Joint	50	0	United Technologies Res.C	
C&RE	ADVANCED HEAT EXCHANGER	High-Temperature Seals	100	90	AiResearch Casting	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Ceramic-Ceramic Joints AGT	0	200	TBD	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Ceramic-Metal Joining AGT	0	211	TBD	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Diesel Ceramic-Metal Joint	0	150	TBD	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	PSZ Iron Brazing	180	250	Oak Ridge Nat'l Lab	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Ceramic Attachments Modeling	225	150	Norton	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Development and Use of Tests for Ceramic-Ceramic and Ceramic-Metal Joints	140	125	Oak Ridge Nat'l Lab	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Electomagnetic Joining of Ceramics	73	80	DHR	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Experimental Verification of Ceramic Attachment Models	0	225	TBD	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Mechanisms of Adherence of Ceramic-Ceramic and Ceramic-Metal Interfaces	0	150	Oak Ridge Nat'l Lab	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Non-Destructive Evaluation of Ceramic-Ceramic and Ceramic-Metal Joints	0	75	Oak Ridge Nat'l Lab	

STRUCTURAL CERAMICS PROJECTS BY TECHNICAL AREA

U. S. DEPARTMENT OF ENERGY

OFFICE	PROGRAM	PROJECT TITLE	$FY84	$FY85	PERFORMER 1	PERFORMER 2
* TYPE G. Machining						
C&RE	ADVANCED HEAT EXCHANGER	Laser Drilling of Ceramics	74	0	United Technologies Res.C	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Effects of Machining and Surface Preparation Methods on the Properties of Structual Ceramics	0	0	TBD	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Novel Machining and Surface Preparation Methods for Ceramics	0	0	TBD	
ER	BASIC ENERGY SCIENCES MATERIALS	Evaluation of Machining Damage in Brittle Materials	94	100	Stanford U.	
ER	BASIC ENERGY SCIENCES MATERIALS	Fracture Mechanics Investigation of Grinding of Ceramics	108	108	Ceramic Finishing	
** AREA 2. DESIGN						
* TYPE A. Modeling						
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Advanced Statistics Calculations	247	140	Oak Ridge Nat'l Lab	General Electric
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Design Allowable Code	130	130	AMMRC	
* TYPE B. Contact Interface						
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Ceramic Coatings to Reduce Contact Stress	123	150	Garrett Turbine Engine	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Dynamic Interfaces for Diesels	139	110	Battelle:Columbus	
* TYPE C. Component Design & Testing						
C&RE	ADVANCED HEAT EXCHANGER	CVD Ceramic Composite Heat Exchanger	100	-1	Thermo Electron	
C&RE	ADVANCED HEAT EXCHANGER	Ceramic Composite Heat Exchanger	175	-1	Babcock & Wilcox	
C&RE	ADVANCED HEAT EXCHANGER	Ceramic Tubular Distributor Plate	123	-1	Aerojet	
C&RE	ADVANCED HEAT EXCHANGER	High-Temperature Burner Duct Recuperator System	450	0	Babcock & Wilcox	
C&RE	ADVANCED HEAT EXCHANGER	High-Temperature Burner Duct Recuperator System	290	0	AiResearch Casting	
C&RE	ADVANCED HEAT EXCHANGER	High-Temperature Heat Pipe	130	-1	AiResearch Casting	
C&RE	ADVANCED HEAT EXCHANGER	High-Temperature Heat Pipe	100	-1	Thermo Electron	
** AREA 3. PROPERTIES AND CHARACTERIZATION						
* TYPE A. Mechanical Properties & Fracture Mechanics						
C&RE	ADVANCED HEAT EXCHANGER	Cyclic Fatigue of Toughened Ceramics	0	90	Oak Ridge Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	High Temperature Fracture Toughness	66	150	U. of Washington	

STRUCTURAL CERAMICS PROJECTS BY TECHNICAL AREA

U. S. DEPARTMENT OF ENERGY

OFFICE	PROGRAM	PROJECT TITLE	$FY84	$FY85	PERFORMER 1	PERFORMER 2
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Standard Tensile Test Development	0	90	Nat'l Bureau of Standards	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Static Fatigue Behavior of Toughened Ceramics	175	0	Oak Ridge Nat'l Lab	
ER	BASIC ENERGY SCIENCES MATERIALS	Mechanical Properties	300	310	Los Alamos Nat'l Lab	
ER	BASIC ENERGY SCIENCES MATERIALS	Mechanical Properties of Ceramics	305	330	Lawrence Berkeley Lab	
ER	BASIC ENERGY SCIENCES MATERIALS	Mechanical Properties of Ceramics	400	410	Oak Ridge Nat'l Lab	
ER	BASIC ENERGY SCIENCES MATERIALS	Micromechanics and Micromechanisms of Fracture	15	15	U. of Illinois	
ER	BASIC ENERGY SCIENCES MATERIALS	Multiaxial Stress Response of Ceramics	160	165	Battelle:Columbus	
FE	ADVANCED RESEARCH & TECHNOLOGY DEVELPMNT	Mechanical Properties of Structural Ceramics	265	260	Nat'l Bureau of Standards	
* TYPE B. Time Dependent Behavior						
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Characterization of Transformation Toughened Ceramics	70	80	AMMRC	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Experimental Life Testing	230	0	Ford Motor	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Fracture Behavior and Cyclic Fatigue of Toughened Ceramics	0	280	Oak Ridge Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Stress Rupture Testing	100	85	AMMRC	
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Ceramic 3500 Hour Durability for Turbines	190	100	Garrett Turbine Engine	
* TYPE C. Non-Destructive Evaluation						
C&RE	ADVANCED HEAT EXCHANGER	Assessment of Strength-Limiting Flaws	350	0	Babcock & Wilcox	
C&RE	ADVANCED HEAT EXCHANGER	Microfocus X-Ray and Pulsed Echo Acoustic Microscopy	120	0	Idaho Nat'l Engr. Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Needs Assessment for Ceramics Characterization	0	80	Oak Ridge Nat'l Lab	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Non-Destructive Evaluation Development	0	70	Oak Ridge Nat'l Lab	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	X-Ray Methods for Investigation of Ceramic Wear Surfaces	70	95	Virginia Polytechnic In.	
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Non-Destructive Evaluation for Heat Engines	90	90	LeRC	
FE	ADVANCED RESEARCH & TECHNOLOGY DEVELPMNT	Development of Non-Destructive Evaluation Techniques for Structural Ceramics	120	216	Argonne Nat'l Lab	
* TYPE D. Environmental Effects						
C&RE	ADVANCED HEAT EXCHANGER	High-Temperature Corrosion	0	100	Oak Ridge Nat'l Lab	
C&RE	ADVANCED HEAT EXCHANGER	In-Situ Stress Rupture Test Development	120	0	Idaho Nat'l Engr. Lab	

STRUCTURAL CERAMICS PROJECTS BY TECHNICAL AREA

U. S. DEPARTMENT OF ENERGY

OFFICE	PROGRAM	PROJECT TITLE	$FY84	$FY85	PERFORMER 1	PERFORMER 2
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Corrosion/Erosion Effects	0	285	Nat'l Bureau of Standards	LeRC
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Environmental Effects in Toughened Ceramics	139	125	U. of Dayton	
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Static Behavior of Toughened Ceramics	112	120	U.of Illinois	0
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Corrosion/Erosion for Turbines	0	150	LeRC	
ER	BASIC ENERGY SCIENCES MATERIALS	High-Temperature Corrosion of Ceramics	65	70	U. of Pittsburgh	
ER	BASIC ENERGY SCIENCES MATERIALS	Protective Barriers and Coatings for Combustion-Related Materials	390	400	Sandia Nat'l Lab	
FE	SURFACE GASIFICATION	Corrosion of Silicon Carbide in Coal Gasification Environments	170	185	Argonne Nat'l Lab	
* TYPE E. Microstructure/Microchemistry						
C&RE	ADVANCED MATERIALS DEVELOPMENT (ORNL)	Failure Analysis of Ceramics	65	10	Nat'l Bureau of Standards	
ER	BASIC ENERGY SCIENCES MATERIALS	Analytical Electron Microscope Studies of Precipitation in Ceramic Systems	40	40	Lehigh U.	
ER	BASIC ENERGY SCIENCES MATERIALS	Characterization of Pore Evolution in Ceramics during Creep Failure and Densification	160	148	Southwest Research Inst.	
ER	BASIC ENERGY SCIENCES MATERIALS	Effect of Microstructure on the Mechanical Properties of Silicon Nitride Ceramics	92	95	U. of Michigan	
ER	BASIC ENERGY SCIENCES MATERIALS	Ion-Beam Processing of Materials	80	80	Oak Ridge Nat'l Lab	
ER	BASIC ENERGY SCIENCES MATERIALS	Mechanisms of Transformation Toughening	80	85	Massachusetts Inst. Tech	
ER	BASIC ENERGY SCIENCES MATERIALS	Microstructure-Mechanical Property Relationships in Transformation of Toughened Ceramics	142	150	Case Western Reserve U.	
ER	BASIC ENERGY SCIENCES MATERIALS	Processing and Microstructure of Complex Ceramic Systems	85	90	U. of Illinois	
FE	ADVANCED RESEARCH & TECHNOLOGY DEVELPMNT	Effects of Flaws on the Fracture Toughness of Structural Ceramics	0	94	Argonne Nat'l Lab	
* TYPE F. Phase Equilibria & Reactivity						
ER	BASIC ENERGY SCIENCES MATERIALS	Fracture Toughness of Materials	30	30	U. of Rochester	
* TYPE G. Component Testing						
C&RE	ADVANCED HEAT EXCHANGER	Assessment of Acceptance Testing	0	50	TBD	
* TYPE H. Tribology						
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Assessment of Ceramic Friction and Wear Data and Theory	0	-1	TBD	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Development of Theory of Wear of Ceramics	65	75	Georgia Tech	

STRUCTURAL CERAMICS PROJECTS BY TECHNICAL AREA

U. S. DEPARTMENT OF ENERGY

OFFICE	PROGRAM	PROJECT TITLE	$FY84	$FY85	PERFORMER 1	PERFORMER 2
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Friction and Wear of Ceramics at Elevated Temperatures	261	300	Oak Ridge Nat'l Lab	AMT
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Friction and Wear of Ceramics under Oscillatory Sliding Carborundum	5	0	Pennsylvania State U.	DHR
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Solid Lubricants Deposited from the Gas Phase	55	70	Pennsylvania State U.	
C&RE	ENERGY CONSERVATION & UTILIZATN TECHNLGY	Standardized Tests & Characterization Methods for Friction and Wear of Ceramics	0	-1	TBD	
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Friction and Wear of Ceramics	159	0	Westinghouse	
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	High-Temperature Tribometer	100	50	LeRC	
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Sliding Seal Materials for Diesels	0	100	Southwest Research Inst.	
C&RE	VEHICLE PROPULSION R&D (NASA LeRC)	Solid Lubricant Design Methodology and High-Temperature Testing	188	0	SKF	

DEPARTMENT OF ENERGY STRUCTURAL CERAMICS PROJECTS

PROJECT TITLE	TYPE	PERFORMER 1	PERFORMER 2	$FY84	$FY85
** PROGRAM: ADVANCED HEAT EXCHANGER					
* OFFICE: C&RE					
Assessment of Acceptance Testing	3G	TBD		0	50
Assessment of Strength-Limiting Flaws	3C	Babcock & Wilcox		350	0
COMPGLAS Seal and Joint	1E	United Technologies Res.C		50	0
CVD Ceramic Composite Heat Exchanger	2C	Thermo Electron		100	-1
Ceramic Composite Heat Exchanger	2C	Babcock & Wilcox		175	-1
Ceramic Tubular Distributor Plate	2C	Aerojet		123	-1
Cyclic Fatigue of Toughened Ceramics	3A	Oak Ridge Nat'l Lab		0	90
High-Temperature Burner Duct Recuperator System	2C	Babcock & Wilcox		450	0
High-Temperature Burner Duct Recuperator System	2C	AiResearch Casting		290	0
High-Temperature Corrosion	3D	Oak Ridge Nat'l Lab		0	100
High-Temperature Heat Pipe	2C	AiResearch Casting		130	-1
High-Temperature Heat Pipe	2C	Thermo Electron		100	-1
High-Temperature Seals	1E	AiResearch Casting		100	90
Improved Low-Cost Silicon Carbide Powder	1A	Oak Ridge Nat'l Lab		0	100
In-Situ Stress Rupture Test Development	3D	Idaho Nat'l Engr. Lab		120	0
Laser Drilling of Ceramics	1G	United Technologies Res.C		74	0
Low-Cost Extrusion of Silicon Carbide Tubes	1B	Oak Ridge Nat'l Lab		0	100
Microfocus X-Ray and Pulsed Echo Acoustic Microscopy	3C	Idaho Nat'l Engr. Lab		120	0
Toughened Oxide Ceramics	1C	Oak Ridge Nat'l Lab		0	100
** PROGRAM: ADVANCED MATERIALS DEVELOPMENT (ORNL)					
* OFFICE: C&RE					
Advanced Statistics Calculations	2A	Oak Ridge Nat'l Lab	General Electric	247	140
Advanced Transformation Toughened Ceramics	1C	U. of Michigan		90	90
CVD and Sol Gel Zirconia Coatings	1D	Oak Ridge Nat'l Lab		200	0
Ceramic Coatings to Reduce Contact Stress	2B	Garrett Turbine Engine		123	150
Ceramic-Ceramic Joints AGT	1E	TBD		0	200
Ceramic-Metal Joining AGT	1E	TBD		0	211
Characterization of Transformation Toughened Ceramics	3B	AMMRC		70	80
Corrosion/Erosion Effects	3D	Nat'l Bureau of Standards	LeRC	0	285
Design Allowable Code	2A	AMMRC		130	130
Diesel Ceramic-Metal Joint	1E	TBD		0	150
Dispersion Toughened Silicon Carbide	1C	Oak Ridge Nat'l Lab		100	77
Dynamic Interfaces for Diesels	2B	Battelle:Columbus		139	110
Environmental Effects in Toughened Ceramics	3D	U. of Dayton		139	125
Evaluation of Chromia Coatings	1D	Cummins Engine	Kuman	113	0
Experimental Life Testing	3B	Ford Motor		230	0
Failure Analysis of Ceramics	3E	Nat'l Bureau of Standards		65	10
Fracture Behavior and Cyclic Fatigue of Toughened Ceramics	3B	Oak Ridge Nat'l Lab		0	280
High Temperature Fracture Toughness	3A	U. of Washington		66	150
High Temperature Tensile Testing	1A	North Carolina A&T U.		388	100
Improved Transformation Toughened Ceramics	1C	Norton		83	100
Injection Molded Composites	1C	TBD		0	200
Insulating Coatings for Metal	1D	TBD		0	200
Mullite-Silicon Carbide Whisker Composite	1C	General Electric		0	130
Needs Assessment for Ceramics Characterization	3C	Oak Ridge Nat'l Lab		0	80
Non-Destructive Evaluation Development	3C	Oak Ridge Nat'l Lab		0	70
PSZ Iron Brazing	1E	Oak Ridge Nat'l Lab		180	250
Powder Characterization	1A	Massachusetts Inst. Tech		34	31

DEPARTMENT OF ENERGY STRUCTURAL CERAMICS PROJECTS

PROJECT TITLE	TYPE	PERFORMER 1	PERFORMER 2	$FY84	$FY85
Silicon Carbide Powder Carbothermic Synthesis	1A	Oak Ridge Nat'l Lab		130	0
Silicon Carbide Powder Plasma Synthesis	1A	Carborundum		112	110
Silicon Carbide Reinforced Oxide Composite	1C	Oak Ridge Nat'l Lab		200	345
Silicon Carbide Whiskers	1C	Los Alamos Nat'l Lab		35	0
Silicon Nitride Powder Synthesis	1A	Ford Motor		112	110
Silicon Nitride-Metal Carbide Composite	1C	GTE Lab		336	37
Silicon Nitride-Silicon Carbide Whisker Composite	1C	AiResearch Casting		133	35
Sintering of Silicon Nitride	1B	AMMRC	GeoSciences	150	150
Sol Gel Oxide Powder	1A	Oak Ridge Nat'l Lab		105	110
Standard Tensile Test Development	3A	Nat'l Bureau of Standards		0	90
Static Behavior of Toughened Ceramics	3D	U. of Illinois	0	112	120
Static Fatigue Behavior of Toughened Ceramics	3A	Oak Ridge Nat'l Lab		175	0
Stress Rupture Testing	3B	AMMRC		100	85
Transformation Toughened Silicon Nitride	1C	Rockwell International		155	35
Zirconia Coatings for Silicon Ceramics	1D	TBD		0	250

** PROGRAM: ENERGY CONSERVATION & UTILIZATN TECHNLGY

* OFFICE: C&RE

PROJECT TITLE	TYPE	PERFORMER 1	PERFORMER 2	$FY84	$FY85
Assessment of Ceramic Friction and Wear Data and Theory	3H	TBD		0	-1
Ceramic Attachments Modeling	1E	Norton		225	150
Cubic Boron Nitride & Diamond-Like Carbide Coatings	1D	Oak Ridge Nat'l Lab		40	0
Development and Use of Tests for Ceramic-Ceramic and Ceramic-Metal Joints	1E	Oak Ridge Nat'l Lab		140	125
Development of Theory of Wear of Ceramics	3H	Georgia Tech		65	75
Dispersoid Toughened Ceramics Via CVD	1C	Oak Ridge Nat'l Lab		0	75
Effects of Machining and Surface Preparation Methods on the Properties of Structual Ceramics	1G	TBD		0	0
Electomagnetic Joining of Ceramics	1E	DHR		73	80
Experimental Verification of Ceramic Attachment Models	1E	TBD		0	225
Friction and Wear of Ceramics at Elevated Temperatures	3H	Oak Ridge Nat'l Lab	AMT	261	300
Friction and Wear of Ceramics under Oscillatory Sliding Carborundum	3H	Pennsylvania State U.	DHR	5	0
Ion Implantation of Ceramics	1D	Oak Ridge Nat'l Lab	Georgia Tech	165	300
Laser Modifications of Ceramics	1D	North Carolina State U.		60	150
Mechanisms of Adherence of Ceramic-Ceramic and Ceramic-Metal Interfaces	1E	Oak Ridge Nat'l Lab		0	150
Non-Destructive Evaluation of Ceramic-Ceramic and Ceramic-Metal Joints	1E	Oak Ridge Nat'l Lab		0	75
Novel Chemical Routes to Near Net Shape Processing	1B	TBD		0	85
Novel Gas Phase Routes for Producing Ceramic Powders	1A	TBD		0	0
Novel Machining and Surface Preparation Methods for Ceramics	1G	TBD		0	0
Plasma Sintering of Ceramics	1B	Northwestern U.		2	100
Solid Lubricants Deposited from the Gas Phase	3H	Pennsylvania State U.		55	70
Standardized Tests & Characterization Methods for Friction and Wear of Ceramics	3H	TBD		0	-1
Synthetic Nephrite	1C	Oak Ridge Nat'l Lab		0	0
Tribological Surface Modifications and Coatings (A)	1D	Massachusetts Inst. Tech	Borg-Warner	150	250
Tribological Surface Modifications and Coatings (B)	1D	U. of California:LA	Argonne Nat'l Lab	150	250
X-Ray Methods for Investigation of Ceramic Wear Surfaces	3C	Virginia Polytechnic In.		70	95

U. S. DEPARTMENT OF ENERGY STRUCTURAL CERAMICS PROGRAMS

PROJECT TITLE	TYPE	PERFORMER 1	PERFORMER 2	$FY84	$FY85
** PROGRAM: VEHICLE PROPULSION R&D (NASA LeRC)					
* ORGANIZATION: Office of Conservation & Renewable Energy					
Advanced Gas Turbine (AGT-100) Ceramic Parts Design, Processing, Fabrication & Acceptance Testing(Funding estimate)	1B	Allison Turbine	Pontiac	5879	4860
Advanced Gas Turbine (AGT-101) Ceramic Parts Design, Processing, Fabrication & Acceptance Testing(Funding estimate)	1B	Garrett Turbine Engine	Ford Motor	6070	4900
Ceramic 3500 Hour Durability for Turbines	3B	Garrett Turbine Engine		190	100
Corrosion/Erosion for Turbines	3D	LeRC		0	150
Friction and Wear of Ceramics	3H	Westinghouse		159	0
High-Temperature Tribometer	3H	LeRC		100	50
Mullite Ceramics for Stirling Engines	1C	LeRC		170	23
Non-Destructive Evaluation for Heat Engines	3C	LeRC		90	90
Plasma Sprayed Zirconia for Diesels	1D	Allison Turbine		0	255
Sliding Seal Materials for Diesels	3H	Southwest Research Inst.		0	100
Solid Lubricant Design Methodology and High-Temperature Testing	3H	SKF		188	0
Toughened Mullite for Diesel	1C	General Electric:V. Forge		175	200
** PROGRAM: BASIC ENERGY SCIENCES MATERIALS					
* OFFICE: ER					
Analytical Electron Microscope Studies of Precipitation in Ceramic Systems	3E	Lehigh U.		40	40
Carbothermal Processing of Non-Oxide Ceramics	1A	Ames		185	190
Center for Advanced Materials	1B	Lawrence Berkeley Lab		300	350
Characterization of Pore Evolution in Ceramics during Creep Failure and Densification	3E	Southwest Research Inst.		160	148
Effect of Microstructure on the Mechanical Properties of Silicon Nitride Ceramics	3E	U. of Michigan		92	95
Evaluation of Machining Damage in Brittle Materials	1G	Stanford U.		94	100
Fracture Mechanics Investigation of Grinding of Ceramics	1G	Ceramic Finishing		108	108
Fracture Toughness of Materials	3F	U. of Rochester		30	30
High-Temperature Chemistry and Thermodynamics of Structural Materials	1A	Oak Ridge Nat'l Lab		150	150
High-Temperature Corrosion of Ceramics	3D	U. of Pittsburgh		65	70
High-Temperature Mechanical Behavior of Silicon Nitride	1B	Cornell U.		99	108
Ion-Beam Processing of Materials	3E	Oak Ridge Nat'l Lab		80	80
Mechanical Properties	3A	Los Alamos Nat'l Lab		300	310
Mechanical Properties of Ceramics	3A	Lawrence Berkeley Lab		305	330
Mechanical Properties of Ceramics	3A	Oak Ridge Nat'l Lab		400	410
Mechanisms of Transformation Toughening	3E	Massachusetts Inst. Tech		80	85
Micromechanics and Micromechanisms of Fracture	3A	U. of Illinois		15	15
Microstructure-Mechanical Property Relationships in Transformation of Toughened Ceramics	3E	Case Western Reserve U.		142	150
Multiaxial Stress Response of Ceramics	3A	Battelle:Columbus		160	165
Particulate Processing	1A	Ames		305	320
Physics and Chemistry of Packing Fine Ceramic Powders	1B	Massachusetts Inst. Tech		45	45
Processing and Characterization of Silicon Carbide-Aluminum Oxycarbide Ceramics	1B	Ceramatec		50	-1

DEPARTMENT OF ENERGY STRUCTURAL CERAMICS PROJECTS

PROJECT TITLE	TYPE	PERFORMER 1	PERFORMER 2	$FY84	$FY85
Processing and Microstructure of Complex Ceramic Systems	3E	U. of Illinois		85	90
Protective Barriers and Coatings for Combustion-Related Materials	3D	Sandia Nat'l Lab		390	400
Rapidly Solidified, Spherical, Fine Ceramic Powders	1A	Micromaterials Technology		25	-1
Research in Ceramic Processing	1B	Oak Ridge Nat'l Lab		399	410
Structural Ceramics	1B	Los Alamos Nat'l Lab		290	320
Superplastic Forging of Structural Ceramics	1C	Jupiter International		50	0
Wetting and Dispersion in Ceramic/Polymer Melt Injection Molding Systems	1B	U. of Florida		0	120
** PROGRAM: ADVANCED RESEARCH & TECHNOLOGY DEVELPMNT					
* OFFICE: FE					
Development of Non-Destructive Evaluation Techniques for Structural Ceramics	3C	Argonne Nat'l Lab		120	216
Effects of Flaws on the Fracture Toughness of Structural Ceramics	3E	Argonne Nat'l Lab		0	94
Fabrication of Fiber-Reinforced Composites by CVD Infiltration	1C	Oak Ridge Nat'l Lab		235	340
Mechanical Properties of Structural Ceramics	3A	Nat'l Bureau of Standards		265	260
Silicon Carbide Fiber Synthesis & Characteristics	1C	Los Alamos Nat'l Lab		250	260
Study Approaches for Fabricating Fiber Reinforced Ceramic Composites with Fused Silica & Silicon-Nitride Matrices	1C	Georgia Tech		180	180
Transfer of CVD Infiltration Technology to Industry	1C	Oak Ridge Nat'l Lab		56	100
** PROGRAM: SURFACE GASIFICATION					
* OFFICE: FE					
Corrosion of Silicon Carbide in Coal Gasification Environments	3D	Argonne Nat'l Lab		170	185

EMaCC BATTERIES AND FUEL CELLS SUBCOMMITTEE REPORT

Research and development in the Department of Energy on batteries and fuel cells is funded principally through Conservation and Renewable Energy, Office of Systems Research, Division of Energy Storage technologies; Fossil Energy, Office of Coal Utilization and Advanced Conversion and Gasification; and Office of Energy Research, Office of Basic Energy Sciences. This year EMaCC formed a subcommittee on Batteries and Fuel Cells to help coordinate the work in this area. The members of this subcommittee are Graham Hagey, FE-22, Albert Landgrebe, CE-141, and Iran Thomas (Chair), ER-132.

The subcommittee on Batteries and Fuel Cells held a joint meeting with EMaCC January 25, 1985. At this meeting, summaries of the research and development in Basic Energy Sciences, Fossil Energy, and Conservation and Renewable Energy were presented.

In Basic Energy Sciences, about $4.6 million was spent on research related to batteries and fuel cells in FY 1984. This amount of funding is not expected to change substantially in the future. Of this amount, $1.1 million came from the Chemical Sciences Division, $2.9 million from the Materials Sciences Division, and $0.6 million from Advanced Energy Projects. Programs supported at the National Laboratories amounted to $2.6 million. The balance, $2.0 million, funded unsolicited proposals primarily from universities.

In Fossil Energy, the Office of Coal Utilization, Advanced Conversion, and Gasification supports research and development in fuel cell power plant technologies. In the near-term, the objective of this program is to develop systems using natural gas and distillate fuels as an interim step toward the long-term objective of coal-based fuel cell power plants. Three types of fuel cells are under development. These are the phosphoric acid, molten carbonate, and solid oxide fuel cell systems. The program is coordinated and cost-shared with private sector organizations. The funding for the program is given in the table below.

FUEL CELL BUDGETS
($ millions)

	FY 84	FY 85
Phosphoric Acid	28.8	28.9
Molten Carbonate	9.2	8.9
Solid Oxide	2.0	3.0
Advanced Research & Technology	4.0	2.9
Total	44.0	43.7

In Conservation and Renewable Energy, Office of Energy Systems, Division of Energy Storage Technologies, the objective is to develop efficient, cost effective technologies to store energy. The principal applications are for electric vehicles, stationary storage of electricity, and storage from intermittent sources. Work is supported on rechargeable, high-energy-density batteries, new electrochemical couples, improved battery components and materials, electrochemical processes, and fuel cells for electric vehicles. The funding in FY 1984 was $18 million and in FY 1985 $16.8 million.

All of these programs are described more fully in the following sections.

ENERGY STORAGE TECHNOLOGIES

The purpose of the Electrochemical Energy Storage R&D program is to conduct research leading to the development and improvement of electrochemical storage systems with primary focus on the development of high-performance, low-cost rechargeable batteries. The program also addresses areas where electrochemical technology can improve energy productivity, conversion efficiency, and corrosion resistance. Research activities are designed to ensure the availability of advanced technologies that will permit development of electrochemical power systems for use in the transportation sector, electric network systems, solar applications and industrial applications. Specific technology needs include:

Development of low-cost materials for use in batteries which have both long life and high energy conversion efficiency; and

Research designed to facilitate incorporation of energy storage technologies into the existing electric energy network and transportation markets.

The program currently conducts research in two areas:

Technology Base Research and Advanced Development and Testing.

The goal of Technology Base Research is to expand and refine the existing technology base and provide fundamental research that supports all end-use applications for batteries. The areas of major promise include use in electric vehicles and for electric utility load-leveling.

The goal of Advanced Technology and Testing is to provide technology development and testing for electrochemical systems judged to be scientifically viable. Technologies are advanced from the applied research phase through exploratory development and testing. Technical problems are first identified and then solved. The funding in FY 1984 was $18 million and in FY 1985, $16.8 million.

Lawrence Berkeley Laboratory
Berkeley, CA

Battery Electrode Studies

E. Cairns and F. McLarnon

The objective of this research is to study the behavior of electrodes used in secondary batteries and to investigate practical means for improving their performance and lifetime. Systems of current interest include ambient-temperature rechargeable cells with zinc electrodes, rechargeable high-temperature cells, fuel cells, and photoelectrochemical cells. The approach used in this investigation is to study life- and performance-limiting phenomena under realistic cell operating conditions.

Continuing research efforts on secondary alkaline zinc electrodes will focus on the development of a two-dimensional, time-dependent mathematical model; the analysis of zinc-electrode current collection; electrolyte and electrode formulations that exhibit reduced zinc-species solubility; and the microscopic study of model zinc electrodes. High-temperature alkali metal/sulfur cell studies will continue on the corrosion of candidate materials for use as positive/electrode current collectors and the examination of Li/glass electrolyte/S cell configurations. Efforts to model the sulfur/polysulfide electrode will begin. Additional research on electrolytes for fuel cells and analysis of photoelectrochemical cells will continue.

Lawrence Berkeley Laboratory
Berkeley, CA

Electrochemical Properties of Solid Electrolytes

Lutgard C. De Jonghe

The objective of this research is to study the electrochemical behavior of solid electrolytes used in the sodium/sulfur cell. The work focuses on the behavior of sodium Beta"-aluminas and the effects of cell operating conditions and impurities. The problem of electrolyte degradation is addressed both from an experimental and a theoretical point of view. Based on the results, recommendations are made for the implementation of electrolyte compositions and cell operating parameters that can extend the lifetime of the electrolytes.

Research efforts will continue toward further understanding the factors that contribute to the failure of the ceramic electrolytes for sodium/ sulfur cells. Attention will be focused on the origin of slow degradation and on the possible further improvements that toughened electrolytes may show. Effects of impurities on the electrochemical performance of the Na/electrolyte interface will be examined.

Materials and Components

As research continues to identify properties of materials suited to the development of new batteries, new materials that exhibit these properties must be identified or developed. For example, positive electrode reagents must be, by their very nature, highly corrosive, yet they must not corrode current collectors, separators or other construction materials, nor may they react with the electrolyte. Also, materials selected must allow the battery to be mass producible in order for it to be manufactured at a reasonable cost.

Argonne National Laboratory
Argonne, IL

Polysulfide Containment Materials

J E Battles

The objective of this research is the development of new alloys for positive side current collection and containment in Na/S and FeS_2 cells, or other cells with high sulfur activity and high electrical potential at the positive electrode. The alloy development is to be accomplished through a basic understanding of the corrosion phenomena in the respective environments. The plan is to obtain a scientific understanding of the corrosion of potential alloy base metals and principal alloying elements in sodium polysulfides and sulfur. New alloys are to be made that contain additional alloying elements that will work synergistically with the principal alloying element to reduce corrosion rates to an acceptably low level. Corrosion testing of the developed, low-corrosion rate alloys will be extended to electrochemically dynamic conditions that simulate the in-cell environment. Metallographic characterization of modified E-brite alloys has been completed and corrosion tests initiated.

Department of Materials Science and Engineering
Massachusetts Institute of Technology
Cambridge, MA

Electrical Conduction and Corrosion Processes in Fast Ion Conducting Glass

H. L. Tuller

The objective of this program has been the identification and characterization of highly conducting glasses for use as solid electrolytes. To this end families of glasses which exhibit fast ion conducting (FIC) properties for temperatures lower than 350°C and which possess physical attributes that eliminate many of the shortcomings of ceramic components are being investigated. Aside from the transport properties, a major focus of this program continues to be on the stability and electrochemical characteristics of these glasses.

Stanford University
Stanford, CA

New Battery Materials

R. Huggins

The purpose of this research is to identify, characterize and improve materials and components for use in batteries and electrochemical systems. Particular focus is given to the structural, thermodynamic and kinetic parameters of materials used as electrodes and electrolytes in advanced lithium-based battery systems. Other work involves development of novel electrode structures and selection of new materials based on these evaluations. Research is also being done to evaluate the effectiveness of ceramic, glass, and polymeric electrolytes.

Current research has shifted the emphasis from high-temperature molten salts to inorganic polymer materials and ambient temperature organic electrolyte cells.

Electrocatalysis

Systems using air for the positive electrode show great promise for use in electric vehicles. Unfortunately, the rate of chemical reduction of oxygen is very slow, limiting power and efficiency. Reaction rates can be increased by elevating temperatures or using catalysis. With aqueous electrolytes, large temperature increases are impossible, so platinum is used as the standard catalyst. Research is being conducted on transition metal-organic compounds that appear to have equal or greater catalytic activity than platinum.

Case Western Reserve University
Cleveland, OH

Electrocatalysts for Oxygen Electrodes

E. Yeager

The objective of this project is to develop more effective catalysts for O_2 reduction and generation in alkaline and acid electrolytes. The combination of high catalytic activity and long-term stability provides the long life and low cost necessary for use in fuel cell and metal air battery systems. Particular emphasis is placed on understanding the relation of the catalytic activity and mechanistic aspects of the structural and electronic properties of the catalyst surfaces.

Lawrence Berkeley Laboratory
Berkeley, CA

Electrode Kinetics and Electrocatalysis

P. Ross

The objective of this project is to develop an atomic level understanding of the processes taking place in complex electrochemical reactions at electrode surfaces. Processes under study include metal electrodeposition/dissolution, passive film formation on metals, oxygen electrocatalysis by organometallic complexes, and the corrosion of non-metallic electrode materials. Atomic level structure determination is made using a variety of techniques, depending on the material under study: low energy electron diffraction (LEED) in the case of single crystals; high resolution electron microscopy in the case of non-metallic electrode materials; extended x-ray adsorption fine spectroscopy (EXAFS) in the case of organometallic catalysts.

Plans include: using LEED to determine the effect of cycling through the anodic film formation potential region on the atomic structure of Au(111); using LEED to determine the atomic structure of Cu deposition on Au(111), and on Cu(111) substrates and the relation of structure to the substrate, rate of deposition, and foreign adsorption; examine the role of the oxygen evolution catalyst on the corrosion of carbon black materials; compare different catalysts (e.g., oxides of Co, Fe, Ni and Ru); and extend corrosion studies to non- metallic materials other than carbon (e.g., TiC, TiO_x).

Corrosion Research

As advanced battery development moves in the direction of higher temperatures and more active electrodes and electrolytes, corrosion control research will become increasingly more important in advancing the state-of-the-art. Research is being conducted to study means of controlling corrosion by two methods: the use local galvanic cells; and the development of corrosion-resistant coatings for use in high-temperature batteries.

Illinois Institute of Technology
Chicago, IL

Corrosion-Resistant Coatings

J Selman

The objective of this project is to perform research on corrosion problems encountered in battery development. Corrosion phenomena on various metals and alloys in lithium and sodium-sulfur-polysulfide melts are being studied over the composition, temperature and potential ranges expected during the operation of the corresponding high-temperature cells. Both static and electrochemical corrosion studies are underway. Major emphasis will be on studies of the electrode reactions that lie behind the processes of corrosion, development of resistive layers to stop corrosion, and methods of stabilizing resistive layers.

Electrochemical Conversion Systems

The use of electrochemical conversion systems for transportation applications presents many problems. Varying load requirements and long periods of inactivity produce severe conditions for catalytic electrodes and reformers. Research is being conducted to develop both alkaline and methanol fuel cells. Development of these cells could provide a power source for electric vehicles that would rival internal combustion engines in range and ease of refueling, while reducing dependence on petroleum and eliminating the pollution of combustion.

Los Alamos National Laboratory
Los Alamos, NM

Fuel Cells for Vehicles

J Huff

The objectives of this program are to conduct basic research in electrochemistry to explore and improve the potential of fuel cells for use in electric vehicles, and to conduct applied research necessary to establish fuel cell performance to a proof-of-concept level. Two major systems, the phosphoric-acid fuel cell and the solid-polymer-electrolyte (SPE) fuel cell, are being evaluated. Additional research on alternative electrolytes, electrocatalysis, membranes, and fuel processing is being conducted in support of the fuel cell systems development. Development of these fuel cells could provide vehicles which have long-range (300 - 400 miles), are fast and easy to refuel, and are quieter, less polluting and more efficient than internal combustion engine powered vehicles.

Aluminum/Air

Aluminum/air batteries appear to hold promise for use in electric vehicles, rivaling the performance of internal combustion engines. A DOE project has succeeded in producing a cell design which allows addition of new aluminum anodes in very simple fashion, elimination of platinum from the air electrodes, and use of a small hydrocyclone for separating the product of the electrode reaction from the electrolyte. Additional research is required to identify an aluminum alloy that will yield a higher voltage and lower parasitic corrosion (which will increase efficiency and lower cost), a cheaper air electrode, optimum temperature and electrolyte composition.

Eltech Systems Corporation
Fairport Harbor, OH

Aluminum/Air Research

L. Gestaut

The objective of this research is to develop an aluminum-air battery for use in an electric general purpose vehicle. The major subsystems being developed are the air cathode, the aluminum anode, the crystallizer/separator, the cell, and the fuel distribution system. As presently conceived, the battery will provide a vehicle with a range of about 250 miles between addition of aluminum plates.

The battery achieves high energy to unit weight and volume ratios by not requiring the storing of the oxidant.

Advanced Battery Research

In this research area of the program, new concepts of galvanic couples are made into cells on a laboratory scale and tested for technical feasibility and to determine what research is required for full development. One cell, zinc/ferricyanide, has been transferred to exploratory development. An area that has recently gained a broader-based interest is electronically conducting and ionically conducting polymers, the former for electrodes and the latter for electrolytes. Although no system that has been reported thus far appears to have the potential for large, inexpensive, long-lived batteries, the existence of such materials opens up possibilities for all solid, high-energy density, ambient temperature batteries.

Argonne National Laboratory
Argonne, IL

Molten-Salt Cell Research

J. Barnes

The purpose of this project is to generate scientific and technical bases for developing cell concepts that will result in new high-performance batteries for energy conservation applications. In addition, a research base is being generated from which major increases in performance and cycle life of molten-salt batteries can be derived. A complex new method was developed for electrode characterization by area specific properties. Further materials characterization will lead to selection of current collector, separator and cell housing materials.

Advanced Development and Testing

A. Landgrebe, J. Quinn, Doe

The following research activities comprise the Advanced Development and Testing Area:

- Sodium Sulfur Battery
- Zinc-Bromine Batteries
- Battery Testing and Post-Test Analysis

Sodium Sulfur Battery

The sodium-sulfur system is the closest to being a commercial product of all systems presently under development. Research is still necessary to identify an inexpensive container/cathode resistant to sulfur corrosion and to increase the life of the ceramic electrolyte.

Ford Aerospace & Communications Corporation
Newport Beach, CA

Ford Motor Company
Dearborn, MI

Sodium Sulfur Core Technology Development

R. Harlow (FA&C) and E. Sickafus (FM)

The objectives of this project are the development of safe, high-performance, reliable, efficient and cost-effective sodium/sulfur cells and modules for electric vehicle and stationary energy storage applications. Sodium/sulfur cells indicate potential for possibly being the best performing battery system now under exploratory development, while using abundant and low-cost fuels. Results to date indicate continued need for materials development, including improvements in Beta"-alumina electrolyte strength, reliability and cost; better corrosion-resistant containers; improved freeze-thaw resistance; improved cell performance; and more reliable intercell connection strategies.

Ceramatec, Inc.
Salt Lake City, UT

Beta"—Alumina Process Improvement

R.S. Gordon, E.E. Conabee and G.R. Miller

DOE-sponsored efforts have had as their objective the fabrication and delivery of Beta"-alumina electrolytes in support of the Ford Aerospace Na/S Battery Program. Internally funded research was aimed at the development of high conductivity, tough electrolytes for use in devices requiring the passage of high sodium ion currents.

A reconstructed pilot plant was completed in Salt Lake City in September 1983. Sodium Beta"-alumina electrolyte tubes as well as electrolytes for stationary energy storage cells and other experimental test cells have been provided to Ford Aerospace and Communications Corporation in support of the

Na/S Battery Program. Internally funded research and development has provided for optimizing transformation toughened, highly conductive electrolyte materials along with the scale-up of a laboratory process to allow for fabrication of cell size tubing.

Research and development on solid electrolytes will focus on cost reduction, early failure prevention and nondestructive evaluation techniques. Specifically, work will continue on: the nondestructive evaluation of electrolyte tubing; cost reduction activities so that an economically viable process can be projected for large-scale electrolyte manufacture.

Sandia National Laboratories
Albuquerque, NM

Beta"—Alumina Characterization Studies

K.R. Grothaus

The objective of this study is twofold: 1) to define the mechanical, chemical, and electrical properties of the Beta"-alumina electrolytes produced by Ceramatec for the Ford Aerospace Sodium/Sulfur Battery Development Program and 2) identify Beta"-alumina electrolyte failure modes in sodium/sulfur cells that fail during initial heat-up or very early in life.

This study was initiated in January 1984 with the delivery of electrolytes and in-process samples from Ceramatec's first production run of their relocated pilot facility. These electrolytes have been dimensionally verified and sectioned in preparation for characterization. Data from the first production run included chemical and phase analysis, fracture strength and toughness, microstructure, Young's Modulus, thermal expansion, density, and ionic resistivity. Samples of electrolytes from failed cells were analyzed, and the results suggest that different mechanisms are involved in different cells. One finding is that some cells apparently fail from a stress loading at one location during normal cycling.

Zinc Bromine Battery

The zinc-bromine system is the second closest to full development. Its advantages include long life and low-cost materials. Ultimate applications appear to be in the utility load-leveling area.

Exxon Research & Engineering Company
Linden, NJ

Zinc-Bromine Core Technology Development

R. Bellows

The objective of this program is to develop zinc/bromine batteries for both electric vehicle and stationary load-leveling applications. Bipolar zinc/bromine flowing electrolyte batteries have potentially twice the storage capacity of present lead-acid batteries at a lower cost. A 20 kWh battery, designed for stationary domestic photovoltaic applications is now on test. The program expects to refocus attention on critical scientific fundamentals that will extend life and improve performance.

Battery Testing and Post-Test Analysis

The National Battery Test Laboratory (NBTL) was established to perform uniform and standardized battery testing and provide a common basis for assessing the status of battery technology for applications such as electric vehicles and utility load leveling. NBTL can extrapolate data from tests on single battery modules to predict acceleration and range capabilities of electric vehicles containing complete battery cells, reducing tests costs. Battery testing and evaluation also provide a sound scientific insight into the behavior of batteries, contributing significantly to understanding problems and identifying battery research and development needs. All batteries under development in the DOE program are scheduled for testing at NBTL.

Argonne National Laboratory
Argonne, IL

National Battery Test Laboratory

N. Yao, F. Hornstra

The National Battery Test Laboratory was established to acquire and provide information on battery performance and lifetime under uniform test conditions. Batteries are also tested under conditions that simulate load profiles in the intended application. Batteries developed within DOE-sponsored programs and with private funds are tested. The results of these tests are compiled in a standard format for periodic publication as additions to a Battery Information Notebook.

Sandia National Laboratories
Albuquerque, NM

Engineering Evaluation

P.C Butler

The objective of this project is to evaluate the operation of battery systems under a variety of conditions, and to determine electrochemical performance, efficiency, and life. Failure modes have been determined for sealed lead-acid batteries that survived for periods that varied between 500 and 1000 cycles. Nickel/hydrogen cells have recently been placed on test. Flowing electrolyte batteries have been tested under a parametric plan, and results indicate that battery performance was relatively insensitive to the levels of the parametric factors chosen. Finally, operating and performance data have been obtained from batteries in three field test environments.

More than two years of data have been collected on the use of advanced lead-acid batteries in field test experiments. Sodium/sulfur tests and evaluations will be expanded to encompass electric vehicle prototype cells. Testing of nickel/hydrogen cells will continue with the testing of a 6-cell nickel/hydrogen battery. The utility-grid test is currently being readied for installation of a zinc-bromine battery.

OFFICE OF COAL UTILIZATION, ADVANCED CONVERSION, AND GASIFICATION

The Office of Coal Utilization, Advanced Conversion, and Gasification has established a fuel cell system program with the following goals:

- In the near-term, to develop systems utilizing natural gas and distillate fuels as an interim step toward the development of coal-based fuel cell power plants.
- In the long-term, to develop advanced systems for the improved utilization of coal.

As part of its program strategy, and in support of the above strategic objectives, the DOE is participating with the private sector in the development of fuel cell power plant technologies which are forecast to exceed the economic, environmental, and technical performance of conventional technology for electric utility, industrial and so-called "on-site" applications, which produce electric and thermal energy at the user's location. The objective of this effort is to develop the technology base to enable subsequent commercialization by the private sector.

Fuel cells have been operated in laboratories and special applications for over two decades and their efficiences, modularity, fuel flexibility and environmental advantages have been verified. While there are several types of fuel cells being developed and their state of development varies, all lack adequate verification of projected capital costs and lifetime.

The DOE is, at present, supporting the development of three types of fuel cells, (characterized by the cell electrolyte used) - phosphoric acid systems, molten carbonate systems, and solid oxide systems. In the development of these fuel cell sytems, DOE is supporting the technology development of long-term high-risk components and subsystems; the private sector is developing the balance of plant subsystems, and will undertake future market-related activities.

The DOE fuel cell program is coordinated and cost-shared with private sector organizations supporting the development of the above technologies, including the Gas Research Institute (GRI), Electric Power Research Institute (EPRI) and industrial contractors. In addition, DOE assists in the coordination of all U.S. fuel cell activities through the National Fuel Cell Coordinating Group (NFCCG). The participants in this national program are DOE, EPRI, GRI, the National Aeronautics and Space Administration (NASA), and the Department of Defense (DOD). Since there is no established fuel cell industry, it has been necessary to provide the government funding for much of the early development cycle. A strategy of the program is to aid in establishing an early commercial entry so that the newly-formed industry can assume responsibility for developing improved fuel cell types in the course of typical product improvement.

The technology application focus is multi-megawatt-size electric utility power plants and multi-kilowatt-size on-site power plants for commercial and industrial applications. First generation phosphoric acid systems offer attractive benefits relative to competing technologies, and future, more advanced fuel cell technologies potentially offer additional benefits in terms of economics, technical performance and fuel flexibility. The rationale for development of multiple advanced technologies is, that at the present embryonic state of development, it is uncertain which advanced technology will be able to progress satisfactorily to the point of a prototype power plant. The funding in FY 1984 was $44 million and in FY 1985, $43.7 million.

Phosphoric Acid Fuel Cells

Phosphoric acid systems are the most mature of the fuel cell systems under development by DOE and have the greatest private sector cost-sharing. Phosphoric acid systems have been under development since the 1950s by the private sector, and since 1976 by DOE (formerly ERDA). There has been a strong and continuing interest in phosphoric acid (and advanced systems) by the electric and gas utilities. DOE is contributing to this effort by funding, on a cost-shared basis, the high-risk cell and stack and other critical technology development with the objective of improving performance and reducing cost. The private sector has taken the responsibility for the balance of plant R&D. Within the phosphoric acid program, two fuel cell applications are being pursued viz., electric utility systems and on-site integrated energy systems. The primary difference between the two applications is fuel cell unit size, with the electric utility systems being in the multimegawatt range and the on-site systems in the 40 kw to 400 kw range. Parallel design approaches are being pursued in each of these areas. The phosphoric acid fuel cells being developed in one effort utilize a water cooling loop for cooling of the fuel cell section. This is the basis for a 4.8 MW preprototype electric utility powerplant and an initial field test of 40 kw On-Site/Integrated Energy Systems. Further advancement of cell and stack technology (operation at higher temperatures and pressures) is expected to lower plant costs and improve the performance of plant subsystems. Such efforts are presently being developed and evaluated for incorporation into an 11 MW electric utility powerplant design.

An alternative phosphoric acid systems approach for electric utility powerplants utilizes gas-loop cooling of the fuel cell section. This technology is not as far developed as the primary effort and requires further technology development prior to scale-up to demonstrate technology readiness in a 7.5 MW powerplant. An alternative phosphoric acid system is also under development for on-site cogeneration applications.

A project is being implemented in FY 1985 which will lead to development of an integrated coal gasifier phosphoric acid fuel cell system. This technology is intended primarily for base load electric utility applications.

The development of phosphoric acid fuel cell systems is crucial to the development, commercial acceptance and deployment of advanced fuel cell systems. Private sector commercialization of first generation technology (i.e., phosphoric acid system) is expected to aid in establishing a viable fuel cell industry which can assume responsibility for developing improved fuel cell types in the course of typical product improvement.

Molten Carbonate Fuel Cells

Molten carbonate fuel cell technology is at a relatively early development stage. The molten carbonate fuel cell program was initiated in 1976 in a series of exploratory development projects focused on verifying feasibility and identifying technology development needs. This effort resulted in a major effort beginning in 1979 to develop the technology to permit large scale molten carbonate systems compatible with operation on coal.

Current efforts are focused on improving the stability of the electrodes and providing electrolyte control to achieve long life. Concepts to improve performance through internal fuel reforming are also being explored.

Solid Oxide Fuel Cells

Solid oxide fuel cell technology is in the earliest stages of development. These fuel cells operate at high temperature (approximately 1800°F), thereby offering high-quality co-product heat for cogeneration or for use in a bottoming cycle for increased efficiency. In addition, they offer simple systems since carbon monoxide in the fuel gas does not have to be converted with steam to hydrogen and carbon dioxide as in phosphoric acid systems; CO_2 recycle is not required, as in the molten carbonate systems. Internal reforming is readily achieved as a result of the high operating temperature, and solid oxide cells have a low sensitivity to sulfur impurities in the output fuel.

In December 1962, the Department of Interior's, Office of Coal Research initiated an effort to develop a commercial, coal-based, fuel cell power generating system. The initial contractual effort was completed in August 1970. This effort demonstrated the technical feasibility of using solid electrolyte fuel cells to generate electric power from coal. In addition, it identified the materials and processes for component fabrication.

The current DOE effort, initiated in 1980, is aimed at producing a practical cell design and fabricating and testing a 5 kw generator. The results of this work are to be used by the private sector to decide whether to proceed with commercialization.

Key Projects

Key projects within the program include the following:

Phosphoric Acid:

- United Technologies Corporation 11 MW Powerplant Technology Development
- Westinghouse 7.5 MW Powerplant Technology Development
- Field Test of 40 kw On-Site Integrated Energy Systems
- Englehard On-Site Integrated Energy System Technology Development
- United Technology Corporation On-Site Technology Development
- Integrated Coal Gasifier Phosphoric Acid Fuel Cell Project
- Supporting Research

Molten Carbonate:

- Limited Fuel Cell and Stack Technology Development
- Energy Research Corporation Internal Reforming Fuel Cell Component Technology Development
- Evaluation of Effects of Contaminants on Molten Carbonate Fuel Cells
- Supporting Research

Solid Oxide:

- Westinghouse Solid Oxide Technology Development in 5 kw Module
- Supporting Research

AR&TD

- Tunary Alloy Cathode Catalysts for Phosphoric Acid Fuel Cells
- Organometallic Catalyst for Phosphoric Acid Fuel Cells
- Electric Surface Chemistry
- Fuel Cell Electrocatalysts Studies
- Materials Chemistry of Fuel Cells
- Investigation of Electrode Structures and Electrocatalyst Surface Areas
- Development of Thin Section Porous Graphite Materials for Fuel Cell Electrode Applications
- Development of Corrosion Resistant Materials in Molten Carbonate Fuel Cell Environments

Interfaces and Private Sector Programs

In addition to many effective informal contacts, the fuel cell program interfaces with co-funding members in the National Fuel Cell Coordinating Group (NFCCG), with potential users represented in three fuel cell user's organizations and the technical community through technical meetings and publications.

Private Sector programs are being managed by EPRI and GRI as summarized below:

Electric Power Research Institute

The major thrust of the EPRI fuel cell program is to expedite the commerical introduction of a modular fuel cell powerplant that is efficient, environmentally acceptable and can use a variety of petroleum and coal-derived fuels. To this end, EPRI's fuel cell projects address both near-term and advanced technologies. The near-term projects concentrate on the early demonstration and commercialization of the 11 MW phosphoric acid FCG-1 (Fuel Cell Generator-1) powerplant by United

Technologies Corporation, and the 7.5 MW powerplant by Westinghouse. The advanced technology efforts concentrate on increasing the fuel cell's efficiency and operating flexibility for dispersed applications in the nearer term, and on developing a central station fuel cell powerplant with an integrated coal gasifier in the longer term. The EPRI fuel cell program is closely coordinated with the DOE program through the NFCCG and through frequent direct contact. The Fuel Cell Users Group of the Electric Utility Industry plays a key role in defining fuel cell requirements, specifications and markets, and in assuring that EPRI's program is directed toward the most important and beneficial utility applications.

The major objectives of the EPRI fuel cell program over the next five-year planning period are to:

- Define and verify commercial prototype configurations that take into account lessons learned in the 4.8 MW test program, and assist in the development of early units on utility systems (1986-1988).

- Define approaches and risks to development of yet more efficient (6000-7000 Btu/kwhr) fuel cell powerplants (1986 and beyond).

In addition to these program objectives, EPRI is supporting materials-related research and is investigating the contaminant level tolerance of phosphoric acid fuel cells which could operate on coal gasification fuels.

<u>Gas Research Institute</u>

The focus of the GRI fuel cell program is on-site energy service — to provide enhanced profits for the gas industry while providing cost savings to the gas consumer. The GRI program has two major subprograms: (1) field testing of approximately 43 preprototype 40 kw on-site/integrated energy system units to verify performance and maintenance characteristics and assess business issues, and (2) support of phosphoric acid fuel cell technology development aimed at reducing costs for initial commercialization.

The GRI fuel cell program is also coordinated with the DOE program through the NFCCG and direct contact. Input on user needs is provided by the Gas Industries Fuel Cell Users Group.

BASIC ENERGY SCIENCES

The research in Basic Energy Sciences is fundamental and generic. Currently there are programs related to batteries and fuel cells in the Chemical Sciences Division, the Materials Sciences Division, and in Advanced Energy Projects. With the exception of projects in Advanced Energy Projects, the research does not address specific battery or fuel cell systems. Research is supported at national laboratories, universities, and industries. At the national laboratories, the research is done by multidisciplinary groups which typically have 6 to 10 professional scientists or engineers in the project. University projects arise from unsolicited proposals and usually involve a single professor, one or two graduates students, and a postdoctoral appointee. The average university grant lasts about seven years. The research results are published in the open literature and reported at appropriate scientific meetings, and summaries of all of the programs are published annually by each Division. These summary books are listed in the bibliography.

CHEMICAL SCIENCES

The Chemical Sciences Division supports 8 projects related to batteries and fuel cells. The total funding in FY 84 was about $1.1 million. This number is not expected to change much in the future. Summaries of these programs are given below.

Brookhaven National Laboratory
Upton, New York 11973

Dept. of Applied Sciences

Electrochemistry and Photoelectrochemistry
S. Feldberg, T. Skotheim ~ $269,000

The objective of this program is the understanding of a variety of electrochemical and photoelectrochemical phenomena. Areas of interest comprise both theory and experiment. Theoretical studies comprise (1) analysis of the effect of picosecond irradiations of semiconductor systems (elucidation of factors affecting bulk and surface electron-hole recombination), (2) analysis of the electrochemical switching of conducting polymers (faradaic and capacitive processes are shown to be inseparable–seemingly anomalous data obtained for chemical switching can now be shown to be consistent with electrochemical data), and (3) analysis of the underlying phenomena of diffusion and conductance in redox polymers (random walk and percolation analysis relate fundamental electron transfer kinetics to diffusion and/or conductivity). Experimental studies comprise (1) investigations of photoelectrochemical cells utilizing junctions between polypyrrole coated semiconductors and poly-(ethylene oxide) doped with KI/I_2, a solvent free solid polymer electrolyte, (2) investigations of the use of doped poly-(ethylene oxide) in electrochemical cells compatible with the ultra high vacuum required by spectroscopic techniques such as ESCA, SEXAFS, and NEXAFS, (3) investigations of modified polypyrrole films incorporating redox species (e.g., phthalocyanines, ferrocene) to catalyze various electron transfer processes such as O_2 reduction, and (4) investigation of the spectro-electrochemistry of polypyrrole to elucidate the mechanism of electrochemical switching. [3.2 FTE]

Colorado State University
Fort Collins, Colorado 80523

296. *Chemically Modified Electrodes and Related Solution Chemistry*
C.M. Elliott, Dept. of Chemistry $70,000

New chemically modified electrodes and related solution chemistry are under study in this research. The goal is to alter the kinetics of electrode reactions in a useful way. Of primary interest is the catalysis of various kinetically inert small molecules that are of economic interest; in particular, the respective four electron and six electron reductions of dioxygen and dinitrogen. Different synthetic procedures appropriate for each of the materials under study are being investigated in order to chemically bind the potential catalyst to the surfaces of bulk electrode materials. Our primary emphasis is the development of polymer coated electrodes containing the potential catalyst and/or other electroactive materials. Several such electrodes have been prepared and are under active investigation. A number of novel metalloporphyrin compounds have been prepared, and their catalytic activity is presently under investigation both in solution and polymer bound. The primary methods of investigation of these surfaces are electrochemical, including such techniques as chronoamperometry, cyclic voltammetry, and the rotated disk electrode technique.

Lawrence Berkeley Laboratory
Berkeley, California 94720

Electrochemical Systems
J. Newman ~ $26,000

This program includes investigation of fluid flow and electrochemical transport, analysis of mass-transfer rates and current distribution, design of practical electrochemical systems, and investigation of corrosion processes. Coupled kinetic, mass-transfer, and fluid-flow phenomena are investigated in semiconductor electrode systems, with emphasis on the optimization of configurational and operating parameters of liquid-junction photovoltaic cells. [0.4 FTE]

University of North Carolina
Chapel Hill, North Carolina 27514

Energy Conversion Processes Based On Molecular Excited States
T.J. Meyer, Dept. of Chemistry $105,000

This research effort is based on the study and exploitation of excited states of transition metal complexes. A particularly important goal is the design and characterization of new classes of photosensitizers, and their application to solar energy related problems. In technical detail the work involves the measurement of the photochemical and photophysical properties of excited states, the application of theory to such processes, synthesis of new types of potential photosensitizers, the preparations and properties of metallopolymers containing metal complex chromophores, the study of electron and energy transfer processes of the photosensitizers in solutions and polymeric films, and possible applications of these materials in photochemical and photoelectrochemical energy conversion processes.

Princeton University
Princeton, New Jersey 08544

Photoelectrochemistry With Chemically Modified Electrodes
T.G. Spiro, Dept. of Chemistry $85,000

The electrochemistry and photoelectrochemistry of metalloporphyrin electrode films is being explored, with a view toward catalyzing useful energy storage reactions, including the splitting of water to H_2O_2. Stable metalloprotoporphyrin films have been prepared via electroinitiated polymerization of the vinyl side-chains, and other porphyrin polymerization schemes are being explored. Cobalt porphyrins are being applied to the catalysis of H_2 production from water. The kinetics of the catalysis have been investigated in homogeneous solution using electrochemical techniques, and cobalt porphyrin electrode films have been developed, which are capable of sustained H_2 production, and their characteristics are being explored. Iron, chromium, and manganese porphyrins are being explored in oxidative chemistry, with the eventual aim of catalyzing water oxidation.

Solar Energy Research Institute
Golden, Colorado 80401

Modified Semiconductor Electrodes For Solar Energy Utilization
A.J. Frank ~ $136,000

This research program addresses the fundamental problems of the photoinstability of n-type semiconductors and the high over-potential associated with specific chemical reactions such as the reduction and oxidation of water. Interfacial chemistry, energetics and surface dynamics are established by (photo)electrochemical measurements, end-product analyses, and surface characterization studies. Information obtained from the physicochemical investigations provides guidance for chemically modifying the semiconductor surface to improve photostability and kinetics of desirable redox reactions. The utility of coating the semiconductor surface with electrically conductive polymers in combination with catalytic dispersions of several transition metals is demonstrated for the visible light-induced water-cleavage reaction. Further development and study of conductive polymers and catalytic surface structures involving coordination metal complexes are in progress. The degree of stability and catalytic activity produced is remarkable and provides encouragement for the potential application of catalytic conductive polymer films to practical photoelectrochemical devices for solar energy conversion. [1.0 FTE]

Basic Photoelectrochemistry Research
A.J. Nozik, J.A. Turner ~ $380,000

Basic research in photoelectrochemistry is being conducted in the following three areas: (1) hot carrier effects; (2) energetics, kinetics, and characterization studies of semiconductor-electrolyte interfaces; and (3) photoelectrochemical properties of colloidal and particulate semiconductors. Studies of hot electron injection processes from semiconductors into electrolytes are being extended to redox couples lying within the semiconductor band gap. Hot electron reduction of H^+ to H_2 on p-InP is being modeled, and theoretical current-voltage characteristics are being compared to experimental results. The relationship of hot carrier processes to catalytic processes is being analyzed, as well as the theoretical conversion efficiency of Type I hot carrier injection. Computer controlled techniques of photocapacitance, photocurrent and photovoltage spectroscopy, and Mott Schottky analysis are being developed. The techniques of pulse radiolysis and Moessbauer spectroscopy are being used to characterize the photoelectrochemical properties of semiconductor colloids and particles. The flat-band potentials and charge transfer kinetics of several semiconductor colloids and powders have been measured as a function of particle size. Size quantization and hot carrier effects in very small sized (<50 Angstrom) semiconductor colloids are being investigated theoretically and experimentally. [2.8 FTE]

University of Texas
Austin, Texas 78712

Organic Redox Phototransformations at Chemically Modified Surfaces
M.A. Fox, Dept. of Chemistry **$70,000**

Exploratory and mechanistic studies of new chemical transformations of organic molecules at native and chemically modified surfaces represent the goal of this research program. New electrode materials are being prepared by adsorption, covalent attachment, polymerization, and mulling with electroactive or light-sensitive materials; and physical studies of the properties of these materials are being conducted. Both photocatalytic and photosynthetic organic reactions can be initiated by electron exchange induced by visible light excitation of either native or chemically modified semiconductor surfaces. Several spectroscopic techniques are being used to evaluate intermediates and surface states: (1) Fourier transform infrared spectroscopy; (2) Resonance Raman spectroscopy; (3) laser-induced flash coulostatic measurements; (4) photochemically induced magnetic resonance; (5) picosecond laser spectroscopy; (6) rotating ring disc electrochemical techniques; and (7) ESCA and Auger spectroscopy. New metal non-oxides and p-type semiconductors are also being investigated, and the search for new reactions on these novel materials is continuing.

MATERIALS SCIENCES

The Materials Sciences Division supports 19 programs related to batteries and fuel cells. The total funding in FY 84 was about \$2.9 million. This number is not expected to change much in the future. In addition to the research programs, the Materials Sciences Division supports several major facilities and collaborative research centers for the study of materials. These facilities are open to outside users. Summaries of the research programs and a brief description of the facilities pertinent to batteries and fuel cells are given below. In some of the summaries, the portion of the program related to batteries and fuel cells is given in parenthesis.

AMES LABORATORY

SURFACE CHEMISTRY AND CATALYSIS

R. S. Hansen, K. G. Baikerikar, D. C. Johnson, P. A. Thiel
Phone: (515)-294-2770

$335,000 (B+FC ~$109,000)

Evaluation of mechanisms of catalytic reactions, especially hydrogenation, hydrogenolysis, methanation, and hydrodesulfurization reactions, by surface characterization and kinetic techniques, with emphasis on single crystal and evaporated film catalysts. Variation of surface intermediates with surface morphology and of surface reactivity with surface structure. Chemistry of electrode reactions, including electrocatalysis and corrosion reactions. Characterization of electrocatalytic materials by modulated hydrodynamic voltammetry. Reactivity of oxidized and doped electrode surfaces, including characterization of oxygen mobility and defect density at such electrodes. Surface chemistry of nucleation and flocculation applied to ceramic processing. Techniques used include low energy electron diffraction, Auger and scanning Auger electron spectroscopy, infra-red emission and electron energy loss spectroscopies, ring-disk and modulated hydrodynamic voltammetry.

ARIZONA STATE UNIVERSITY
Tempe, AZ 85281

TRANSPORT IN SOLID ELECTROLYTES CONTAINING A DISPERSED SECOND PHASE

J. B. Wagner
Center for Solid State Science
Phone: (602)-965-6959, 4544

$84,917 (18 Months)

Characterization of contribution of number and mobility of ionic charge carriers and of space charge layers to conductivity increase mechanisms in a AgI or CuCl matrix containing a second phase such as silica, MgO, flyash, etc. Role of aliovalent doping of the matrix phase. Behavioral effects due to moisture and to added dielectrics such as alcohols or hydrocarbons. SEM, variable frequency ac conductivity, and dc polarization analysis.

ARGONNE NATIONAL LABORATORY

CHEMICAL AND ELECTRONIC STRUCTURE

J. M. Williams, M. A. Beno, C. D. Carlson, A. J. Schultz,
R. J. Thorn, T. J. Emge, K. Eriks, P. C. Leung, H. H. Wang
Phone: (312)-972-3464

$949,000 (B+FC ~$450,000)

New materials synthesis and characterization focussing on synthetic organic metals, organic superconductors, dielectric materials, and organometallic compounds that behave as model catalysts or catalysts; development of structure-property relationships, and electrical properties measurements, of synthetic metals based on TMTSF (tetramethyltetraselenafulvalene) and BEDT-TTF bis(ethylenedithiotetrathiofulvalene); continuing development of the neutron time-of-flight single-crystal diffractometer (SCD), and the associated U.S. university-industrial users group, at the Intense Pulsed Neutron Source; diffuse scattering and crystal structure studies at the SCD as a function of temperature (10-300 K); development of a facility for single crystal X-ray studies centered around a low temperature (10 K) X-ray instrument for electron density and structural studies.

MATERIALS PREPARATION AND CHARACTERIZATION AND FAST ION TRANSPORT IN SOLIDS

S. Susman, T. O. Brun, K. Kuriyama
Phone: (312)-972-5470

$464,000 (B+FC ~$100,000)

Preparation of metal, insulator and semiconductor single crystals with documented physical and chemical properties; solidification of vitreous systems with characterized and reproducible compositions and thermal histories; investigations of mechanisms involved in purification, crystal growth, phase transformations and solidification; materials of current interest include semiconducting chalcogenide glasses, Zintl-phase compounds, complex aluminosilcates and cyanides; basic studies conducted in the microscopics of charge and mass transport in solid electrode and electrolyte materials utilizing X-ray diffraction, nuclear magnetic resonance, ionic conductivity, EXAFS, and optical spectroscopy; fast ion transport examined in mixed electronic and ionic conductors and in fast-ion glasses; these include Li-Al alloys, NASIGLAS, and both crystalline and vitreous eucryptites.

ARGONNE NATIONAL LABORATORY (continued)

AQUEOUS CORROSION

V. A. Maroni, D. M. Gruen, C. A. Melendres, Z. Nagy, M. Pellin, R. M. Yonco
Phone: (312)-972-3513

$150,000 (BLFC~$50,000)

Fundamental aspects of aqueous corrosion with emphasis on mechanisms responsible for stress corrosion cracking (SCC) of iron and iron-based alloys at high temperatures and pressures (300°C, 100 atm); application of in-situ surface-sensitive spectroscopic techniques (laser Raman, Raman gain, second harmonic generation, surface extended X-ray absorption fine structure, and Auger/ESCA) in combination with transient electrochemical methods to unravel the details connecting surface adsorption/reaction initiation and grain boundary effects involved in SCC; supporting theoretical studies using (1) molecular dynamics methods to study interactions at the water-metal interface on the molecular level and (2) porous electrode theory to obtain a macroscopic description of the influence of water chemistry on the corrosion behavior of iron-based alloys.

PARTICLE-SURFACE INTERACTION CHEMISTRY AND CATALYSIS

D. M. Gruen, B. M. Abraham, W. F. Calaway, L. E. Iton, A. R. Krauss, G. J. Lamich, C. A. Melendres, M. H. Mendelsohn, M. J. Pellin, C. E. Young
Phone: (312)-972-3513

$1,022,000 (B4FC~$100,000)

Surface analysis by resonance ionization of sputtered atoms (SARISA) using pico-coulomb ion fluences combined with direct detection techniques; adsorbate structures, velocity and excited state distributions of sputtered species; mechanism of radiation-enhanced surface segregation in dilute alloy systems; synthesis of new shape-selective, catalysts incorporating small metal clusters; characterization and evaluation of catalysts using NMR, EPR, PAS, DTA, and Berty reactor techniques; electronic structure of matrix-isolated ligand-free transition metal clusters by laser fluorescence spectroscopy; electrocatalysis of O_2 reduction on metal-porphyrin and phthalocy-anine-coated electrode surfaces; dependence on pH of the viscosity and of the instantaneous and static shear moduli of biological surfactant monolayers.

COLUMBIA UNIVERSITY
New York, NY 10027

DEFECT INTERACTIONS AT HIGH CONCENTRATION IN SOLID OXIDE ELECTROLYTES

A. S. Nowick
Henry Krumb School of Mines
Phone: (212)-280-2921

$87,295

Defects and their interactions in oxygen-ion solid electrolytes, with special emphasis on ceria-based materials doped with divalent and trivalent cations. Techniques used include ionic conductivity, dielectric relaxation, anelastic relaxation, neutron diffraction and scanning transmission electron microscopy. Defect interactions in trivalent-doped (M^{3+}) ceria and effect of M^{3+} ion radius. Role of silicon phases in producing electrical blocking at grain boundaries. Steps that control the electrode reaction, particularly at Pt electrodes. Protonic conduction studies in $SrCeO_3$, and $KTaO_3$.

UNIVERSITY OF CONNECTICUT
Storrs, CT 06268

ELECTRODE STUDIES IN MOLTEN SALTS

O. F. Devereux
Dept. of Metallurgy and Institute of Materials Science
Phone: (203)-486-4620

$47,611

Deterioration of refractory oxide films on Ni and Fe in sulfide-bearing molten salts. Field and anion effects; 'electrochemical' dissolution of oxides. Film thinning, pore formation, and structure change evaluation by impedance techniques. Formation of anodic chromium sulfides in molten sulfide salts. Current-potential characteristics of anodic sulfide films.

LAWRENCE BERKELEY LABORATORY

ELECTROCHEMICAL PROCESSES

C. W. Tobias
Phone: (415)-642-3764

$120,000

Novel methods for reducing mass transfer resistance in high rate applications, e.g. effects of fixed flow obstacles and of suspended inert solid particles in flowing electrolytes. Nonaqueous ionizing solvents investigated for potential use in ambient temperature electrosynthesis processes. Techniques for the removal of trace impurities in propylene carbonate to below 10 ppb., to improve solvent stability in presence of energetic oxidizing- or reducing-agents.

LAWRENCE BERKELEY LABORATORY (continued)

ELECTROCHEMICAL PHASE BOUNDARIES

R. H. Muller
Phone: (FTS) 451-6079 or (415)-486-6079
$180,000

To advance the understanding of boundary layers and thin films at electrochemical interfaces. New optical techniques for the observation of electrode surfaces in liquid media developed and used: spectroscopic ellipsometry combined with light scattering measurement, Auger spectroscopy, interferometry, thin film interference, and Doppler velocimetry.

UNIVERSITY OF MINNESOTA
128 Pleasant Street, S.E.
Minneapolis, MN 55104

CORROSION RESEARCH CENTER

R. A. Oriani
Dept. of Chemical Engineering and Materials Science
Phone: (612)-373-4864
D. A. Shores
Dept. of Chemical Engineering and Materials Science
Phone: (612)-373-4183
W. H. Smyrl
Dept. of Chemical Engineering and Materials Science
Phone: (612)-373-2763
$540,000 (B+FC ~$150,000)

Basic research and technology transfer in corrosion. Electron transfer at solid-electrolyte interface and capacitance. In-situ IR spectroscopy at the solid-liquid interface. Study of passivating films by inelastic electron tunneling spectroscopy, rotating ring-disc electrode, electrochemical oscillations, and their destruction by mechanical and chemical effects. Photoelectrochemistry and electrochemical oscillation, and their destruction by mechanical and chemical effects. Photoelectrochemistry and electroluminescence of oxides. Dissolution kinetics of oxide films. Surface microtopography and corrosion of GaAs. Cathodic reduction of hydrogen. Corrosion protection by conducting organic polymers. In situ measurement of stresses in oxide scales by energy dispersive X-ray diffraction, and of their relaxation by acoustic emission. Mechanism of break-down of oxide coatings in relation to parameters.

UNIVERSITY OF MISSOURI
Columbia, MO 65211

DEVELOPMENT AND CHARACTERIZATION OF HIGH TEMPERATURE ELECTRICALLY CONDUCTING OXIDES

H. E. Anderson
Dept. of Ceramic Engineering
Phone: (314)-341-4886

$116,000

Interrelationship of electrical conductivity, oxidation-reduction kinetics, defect structure, and composition for n type transition metal oxides TiO_2, $SrTiO_3$, and $BaTiO_3$, and p type transition metal oxides Cr_2O_3, NiO, $LaCrO_3$, and $YCrO_3$. Experimental aspects include specimens preparation, thermogravimetric measurements, x-ray diffraction, transmission electron microscopy, and ERR magnetic susceptibility, Hall, conductivity, and seebeck measurements.

NORTHWESTERN UNIVERSITY
Evanston, IL 60201

FAST ION MOTION IN SELECTED VITREOUS AND CRYSTALLINE SOLID ELECTROLYTES

D. H. Whitmore
Dept. of Materials Science and Engineering
Phone: (312)-492-3533

$74,946

Diffusivity of highly mobile ions in solid electrolytes which may have application in energy storage or conversion is measured using pulsed-field-gradient nuclear magnetic resonance techniques and analyzed using a dynamic bond percolation model. Specific materials to be studied include protonic-conducting crystalline beta-alumina and gallates and fast-ion conducting glasses.

OAK RIDGE NATIONAL LABORATORY

CHARGE TRANSPORT IN SOLID ELECTROLYTES

J. B. Bates, W. E. Brundage, Y. T. Chu, N. J. Dudney, J. C. Wang
Phone: (615)-574-6280

$405,000

Kinetics and thermodynamics of the hydration reaction of beta- and beta"-aluminas; effect of intercalated water on electrical properties; composite electrolytes and the mechanisms of ionic transport in multiphase materials; charge and mass transport at metal-dielectric and dielectric-dielectric interfaces; techniques include impedance spectroscopy, transient signal analysis, Raman scattering, infrared absorption, ATR and internal reflection spectroscopy, and electron microscopy; experimental results are interpreted and correlated by means of model calculations.

PURDUE UNIVERSITY
West Lafayette, IN 47907

NOVEL POLYMERIC Li AND DIVALENT CATION FAST ION CONDUCTING MATERIALS: LI-SALT-IONENIC POLYMER SOLUTIONS, LI CONTAINING PLASTIC CRYSTAL PHASES AND MI_2-$M(PO_3)_2M(PS_3)_2$ GLASSES

C. A. Angell
Dept. of Chemistry
Phone: (317)-494-5256
E. I. Cooper
Dept. of Chemistry
Phone: (317)-494-5256

$82,782

Preparation and characterization of novel fast ion conductors. Formation of a unique type of "molten salt" systems by dissolution of lithium salts in salts of quaternary nitrogen cations in eight polymeric or related structure forms. Studies of Li^+-ion conduction mechanisms. Examination of the possibility of obtaining glasses with a relatively high conductivity in which the charge carrier is a divalent cation. Target systems include MI_2-$M(PO_3)_2M(PS_3)_2$, where M^{2+} is Pb^{2+}, Cd^{2+}. Characterizations include measurements of electrical conductivity, nuclear magnetic resonance, vicsoelastic properties, and glass transition temperatures.

STUDY OF MULTICOMPONENT DIFFUSION AND TRANSPORT PHENOMENA

H. Sato
School of Materials Engineering
Phone: (317)-494-4096
R. Kikuchi
School of Materials Engineering
Phone: (317)-494-4099

$89,119

Research on multicomponent diffusion under general chemical potential gradients. Application of the path probability method of irreversible statistical mechanics to analytically derive the Onsager relations for diffusion on an atomistic basis. The conditions treated are general enabling relations among measurable quantities under a variety of driving forces such as the Nernst-Einstein relation and the Haven ratio in multicomponent systems, to the be clearly understood. The general formalism of multicomponent diffusion and cross terms in the Onsager relations is examined, and the role of apparent vacancy flows and "wind" effects investigated. The method is applied to chemical diffusion problems in multicomponent systems and to understanding established empirical concepts such as "diffusion path" and "zero flux planes."

SANDIA NATIONAL LABORATORIES - ALBUQUERQUE

ORGANIC CONDUCTORS AND SUPERCONDUCTORS

L. J. Azevedo, D. S. Ginley, J. F. Kwak, P. J. Nigrey,
J. E. Schirber
Phone: (FTS) 846-2529 or (505)-846-2529

$300,000

The fundamental physical properties of the charge transfer organic superconductors and the polymeric organic conductors. Directed toward understanding the detailed band structure, doping, and carrier transport in these materials, especially as they pertain to understanding metal-insulator transitions, superconductivity, and the role of disorder in determining transport properties. Unique and specialized instrumental capabilities including high frequency magnetic resonance, conductivity, photoconductivity, thermal conductivity, heat capacity, magnetotransport, de Haas van Alphen, thermopower and tunneling. Experiments at temperatures as low as 0.05 K, magnetic fields up to 120 kOe and hydrostatic pressure to 10 kbar in various combinations. An active in-house synthesis program in collaboration with J. Williams at Argonne National Laboratory supports the measurement programs and develops new materials. The in-house synthesis of novel charge transfer organic superconductors and the chemical and electrochemical growth of very high purity polymeric organic conductors.

UNIVERSITY OF WASHINGTON
Seattle, WA 98195

NUCLEAR MAGNETIC RESONANCE STUDIES OF LOW MOTION IN FAST ION CONDUCTING SOLIDS

J. L. Bjorkstam
Dept. of Electrical Engineering
Phone: (206)-543-2177

$91,720

Nuclear magnetic resonance (NMR) studies of fundamental ion transport processes in fast ion conducting crystals and glasses. Measurements of ion dynamics and ion-lattice dynamics in beta aluminas, lithium ion conductors, and borophosphate glasses, and of ion leaching in glasses. The program includes modeling of correlation functions for ion transport in solids and development of improved microprocessor-based NMR instrumentation.

UNIVERSITY OF WISCONSIN
Madison, WI 53706

ANALYSIS OF MICROPHASE SEPARATION IN ION CONTAINING POLYMERS

S. L. Cooper
Dept. of Chemical Engineering
Phone: (508)-262-1092

$233,050 (24 Months)

Investigations of the microstructure of several ionomer systems using techniques which probe different aspects of the structure. Development of a unified model of the morphology which can rationalize the unique physical properties of these materials. Of special interest, the Nafion[R] ionomers because of their applications in electrochemical processes as selectively permeable membranes. The local arrangement of atoms in the ionic domains studied using Extended X-ray Absorption Fine Structure (EXAFS) analysis and XANES spectroscopy. Information about larger scale structure obtained from X-ray scattering and transmission electron microscopy experiments. To better understand the reason for differences between various ion containing polymers, the effects of several composition and preparation variables explored.

ADVANCED ENERGY PROJECTS

In FY 1984, Advanced Energy Projects supported 4 projects with a total funding of about $614 thousand. This division supports exploratory research on novel concepts. The research is usually aimed at establishing the scientific feasibility and, where appropriate, economic viability of a concept. The concepts supported are typically at too early a stage of scientific verification to qualify for funding by DOE programs responsible for technology development. The division does not support ongoing research. The period of funding usually does not exceed three years. Summaries of the projects supported related to batteries and fuel cells in FY 1984 are given below.

NEW POLYMER ELECTRODES AND CONDUCTORS BASED ON POLY(HYDROQUINONE/QUINONE) OXIDATION/REDUCTION SYSTEMS

CASE WESTERN UNIVERSITY
Cleveland, Ohio 44106

Morton H. Litt
Department of Macromolecular Science

Date Started: September 15, 1983

Funding: FY '83 $277,000 for 14 months

Anticipated Duration: 14 months

This project has the following goals: 1) To synthesize soluble linear fused ring polyaromatic polymers (ladder polymers) which have attached 1,4-hydroxyl groups; 2) To characterize these polymers. The polymer should be a good electrical conductor. It is expected that the hydroxyl groups can be reversibly oxidized and reduced - making this material a good candidate for a very high capacity electrode. High molecular weight polymers will be made into oriented fibers and films and their mechanical properties as well as electrical properties studied. Fiber of these polymers should be like graphite fibers, but should be solution processable. Polymers have been made which have the proposed structure. At present, they are obtained in an insoluble form. Work is going on in two areas. First, the mechanism of polymerization is being studied. The objective here is to get soluble polymers. Secondly, the initial polymers are being oxidized, and their oxidation/reduction properties will be studied.

CATALYSIS OF DIRECT METHANOL ELECTRO-OXIDATION IN BUFFERED ELECTROLYTES

EIC LABORATORIES, INC.
111 Downey Street
Norwood, Massachusetts 02062

S. Barry Brummer
Battery Division

Date Started: July 15, 1983

Funding: FY '84 $146,000 for 12 months

Anticipated Duration: 3 years

The objective of this program is the exploration of the catalysis of methanol oxidation in aqueous, concentrated $K_2CO_3/KHCO_3$ electrolytes for direct methanol/air fuel cells. A major goal of the program is the elimination of all noble metal catalysts. The $K_2CO_3/KHCO_3$ electrolyte has a suitable conductivity, however, its water vapor pressure is higher than desired at the operating condition of 100 to 200°C. It should be possible to reduce the water vapor pressure by addition of a co-electrolyte. The chemical and electrochemical stability of potential non-noble metal catalysts are being determined in the $K_2CO_3/KHCO_3$ electrolyte. The electro-oxidation of methanol is being examined with both stable non-noble and noble metal catalysts.

ENERGY SYSTEMS BASED ON POLYACETYLENE: RECHARGEABLE STORAGE BATTERIES AND SCHOTTKY BARRIER SOLAR CELLS

UNIVERSITY OF PENNSYLVANIA
3451 Walnut Street
Philadelphia, Pennsylvania 19104

A. G. MacDiarmid
Department of Chemistry

Date Started: March 1, 1981

Funding: FY '82 $101,000

Anticipated Duration: 3 years

Research has continued on the evaluation of polyacetylene, $(CH)_x$, the prototype conducting polymer as an electrode-active material in novel rechargeable batteries. There are currently only two, widely used rechargeable batteries -- the lead/acid battery and the nickel/cadmium battery. In view of the adverse environmental effects of cadmium it is essential to evaluate other types of cells as a possible replacement for the Ni/Cd battery, in the event this should become necessary. Conducting polymers offer a potentially enormous new type of non-toxic material for use in rechargeable batteries. The $TiS_2/Li^+A^-/Li$ cell (A^- = anion) which exhibits many excellent properties, suffers from a major disadvahtage caused by the formation of Li dendrites on continued charging and discharging. We have developed a battery of the form $TiS_2/M^+A^-/[M^+y(CH)^{-y}]_x$ where M = Li^+ or Na^+ and A^- = $(ClO_4)^-$ or $(PF_6)^-$ in which this problem has been elminated by replacing the Li with n-doped polyacetylene. This cell exhibits excellent recyclability, coulomb efficiency and retention of charge. Preliminary studies of "polyaniline", which is stable in air and water, show that it might also serve as an excellent electrode-active material.

COGENERATION OF ELECTRIC ENERGY AND USEFUL CHEMICALS IN A HIGH TEMPERATURE FUEL CELL

TUFTS UNIVERSITY
Medford, Massachusetts 02155

Michael Stoukides
Department of Chemical Engineering

Date Started: April 1, 1984

Funding: FY '84 $90,000 for 12 months

Anticipated Duration: 2 years

Solid electrolyte fuel cells can be used to generate simultaneously electric energy and useful industrial products. The present project examines the synthesis of hydrogen cyanide in zirconia cells with appropriate electrodes. A platinum electrode deposited on the outside wall of an yttria stabilized zirconia solid electrolyte is exposed to the ambient air. A platinum-rhodium electrode deposited on the inside wall is exposed to a CH_4-NH_3 mixture and serves as a catalyst as well. At 1 atm total pressure and temperatures about 1000°C oxygen passing through the O^{--} conducting solid electrolyte will oxidize the CH_4-NH_3 mixture to produce HCN and H_2O. In the same time the current produced will convert into electric power part of the free energy of the reaction. The primary goal is to establish optimal operating conditions for maximum HCN yield.

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7. "Summary of Program Information, Department of Energy, Division of Energy Storage", DOE/CE/76245-2DE85000210, U. S. Department of Energy, Washington, D. C.

Technology Base Research

A. Landgrebe, S. Ruby, Doe

The following research activities comprise the technology base research area:

- electrochemical phenomena
- materials and components
- electrocatalysis
- corrosion research
- electrochemical conversion systems
- aluminum/air
- advanced battery research

Electrochemical Phenomena

The purpose of this research is to understand the scientific principles underlying electrochemical reactions and phenomena. The study of rates of chemical reactions at electrodes, rates of transport through electrolytes, and morphology of reagents plated on electrodes will yield understanding of the fundamental physical and chemical properties of these battery components and development of new battery systems.

The purpose of this effort is to establish a scientific engineering base and elucidate phenomena in electrochemical systems and batteries. The studies to be undertaken or that are in progress include:

- electrode morphological studies
- transport thermodynamics
- modeling of electrochemical cell kinetics
- dentrite formation
- chemical/structural analysis
- ionic conduction in ceramic electrolytes

Brookhaven National Laboratory
Upton, NY

Zinc Electrode Morphology in Acid Electrolytes

J. McBreen

The purpose of this research is to more fully explain the factors affecting zinc electrode morphology in acidic zinc chloride and zinc bromide electrolytes. The results will provide fundamental information needed to improve the design and performance of zinc/halogen batteries.

Most of the problems of the zinc electrode are due to the extremely fast kinetics of the deposition reaction. Two important factors affecting the deposition rate are electrolyte composition and crystal orientation. It has been found that the deposition rate can be slowed by use of small quantities of additives such as Pb^{++}, Bi^{++} or Tl^{+++}. Additions of KCl or $AlCl_3$ were found to slow reaction kinetics.

Deposition kinetics will be correlated with electrolyte structure. Other studies include investigation of additive effects on zinc, and extended x-ray adsorption fine structure (EXAFS) studies of various zinc halide electrolytes.

Department of Materials Science and Engineering
Massachusetts Institute of Technology
Cambridge, MA

Principles of Superionic Conduction

Bernhardt J. Wuensch

The objectives of this project are to provide insight into the principles which control fast-ion conduction through performing (a) exploratory synthesis and electrical conductivity measurements on potential new alkali-ion conductors or crystal chemical modifications of known conductors and (b) crystal structure determinations to reveal changes in site occupancy and framework geometry as a function of composition. The measurements of ionic conductivity of ten different alkali silicate glasses have recently been completed.

EMaCC Radioactive Waste Containment Subcommittee Report

Radioactive waste containment research and development activities in the Department of Energy are carried out by the Division of Basic Energy Sciences, Office of Energy Research; Office of Civilian Radioactive Waste Management; Division of Defense Waste and Byproduct Management, Office of Defense Programs; and Division of Storage and Treatment Projects, Office of Nuclear Energy.

The Subcommittee on Radioactive Waste Containment held a joint meeting with EMaCC on February 15, 1985. At this meeting, summaries of relevant activities were presented by persons from the member offices represented on the Subcommittee. Members of the Subcommittee are Bob Gottschall (ER-131), George Kolstad (ER-15), Mark Frei (RW-23), Ray Walton (DP-123), and Henry Walter (NE-25).

A funding summary for FY 1984 and FY 1985, ordered by topics within sponsoring offices, is shown in Table 1. Technical abstracts, identity of contractors, and other details are presented in the following pages.

Table 1. EMaCC Radioactive Waste Containment Subcommittee

SUMMARY OF PROGRAM BUDGETS
(Dollars in millions)

	FY 1984	FY 1985
Office of Civilian Radioactive Waste Management (RW) Repository materials (other than host rock)	57.8	51.9
Defense Waste and Byproduct Management (DP)		
Through SRO: vitrification/salt disposal/ repository interaction	3.2	4.2
Through RLO: salt disposal/vitrification/ in-place disposal	2.0	3.4
Through IDO: volume reduction/crystalline & glass waste forms	0.7	1.2
Low-Level Waste	1.0	0.8
Materials Characterization	2.5	0.5
TOTALS	9.4	10.1
Storage and Treatment Projects (NE)		
Nuclear Waste Treatment	6.9	6.3
West Valley Project technical support	4.6	2.7
Low-Level Waste	0.6	0.5
TOTALS	12.1	9.5
Basic Energy Sciences (ER)		
Materials Sciences	0.9	0.9
Geosciences	2.0	2.0
TOTALS	2.9	2.9

The Nuclear Waste Treatment program in recent years has concentrated on refining the design of the liquid-fed ceramic melter technology, in which joule hearing of a glass melt stirs and homogenizes the glass and simultaneously decomposes nitrates, carbonates, and hydroxides in the feed and drives off the steam and other gases of decomposition. Through a progression of melters from a few literes to several hundred liters capacity, the operating characteristics have been determined. Associated glass properties have been measured for several compositions of waste form. In particular, a number of tests have been conducted using nominal feed composition expected in the West Valley Demonstration Project so as to optimize the operating parameters and feed within the range of adjustment possible given the constraint of the waste composition. A recent report ("West Valley High-Level Nuclear Waste Glass Development: A Statistically Designed Mixture Study," PNL-4992, October 1984) describes the influence of seven composition variables on process paramters of viscosity, conductivity, and leachability. In 1984, a radioactive melter began operation at Pacific Northwest Laboratory, the lead laboratory for this activity.

The only commercial nuclear fuel reprocessing venture in the nation was done at the facility near West Valley, New York, from 1966-1972. Due to several confluent and adverse factors, the reprocessing was suspended and never restarted. High-level liquid waste now stored in underground tanks is to be solidified by the Department of Energy in a demonstration project. The Department selected borosilicate glass as the waste form and the liquid-fed ceramic melter technology as the vitrification process in 1983. Support for specific equipment design, primarily involving the melter and auxiliary systems, has resulted in technology transfer from government laboratory to the private sector.

Responsibility for regulation of low-level waste was assigned to the States by the Low-Level Radioactive Waste Policy Act of 1980. Federal activities consist of helping the States to form compacts to administer the provisions of the law and to evaluate some promising technical ideas.

OFFICE OF NUCLEAR ENERGY

NUCLEAR WASTE TREATMENT PROGRAM

PURPOSE

- DEVELOPMENT OF NUCLEAR WASTE TREATMENT PROCESSES AND WASTE FORMS ACCEPTABLE FOR TRANSPORTATION, STORAGE, AND DISPOSAL
  - HIGH-LEVEL
  - TRANSURANIC
  - DECONTAMINATION & DECOMMISSIONING
  - SODIUM METAL COATED

FUNDING HISTORY

FY 1984	FY 1985	FY 1986
$6.9	$6.3	$6.4

OFFICE OF NUCLEAR ENERGY

WEST VALLEY DEMONSTRATION PROJECT

- BOROSILICATE GLASS WASTE FORM
- AIM 22-28 WT % WASTE (78-72 WT % GLASS FORMERS)
- ABOUT 300 STAINLESS STEEL CANISTERS
  - 0.6 METRE DIAMETER
  - 3.0 METRE TALL
  - ~100,000 Ci TOTAL ACTIVITY (1990)
  - ~300 WATTS NOMINAL (1990)
  - ~36°C NOMINAL CELL TEMPERATURE
  - GLASS CENTERLINE TEMPERATURE UNDER 500°C
  - 1500 KG GLASS EACH CANISTER

OFFICE OF NUCLEAR ENERGY

WEST VALLEY DEMONSTRATION PROJECT

MATERIALS CHARACTERISTICS

- HOMOGENEITY ASSURED BY VIOLENT STIRRING FROM JOULE HEATING IN LIQUID FED CERAMIC MELTER
- 24 HOUR AVERAGE RESIDENCE TIME
- 1150°C NOMINAL OPERATING TEMPERATURE
- SPINEL FORMATION CONTROLLED BY FEED COMPOSITION, OXIDATION POTENTIAL
- FOAMING (SUDDEN RELEASE OF OXYGEN) CONTROLLED BY OXIDATION POTENTIAL
- TWO-PHASE SEPARATION (DUE TO MOLTEN SODIUM SULFATE) CONTROLLED BY WASHING SLUDGE, SENDING DECONTAMINATED SODIUM SALT SOLUTION TO LLW TREATMENT
- PRODUCT QUALITY ASSURED BY PROCESS CONTROL

OFFICE OF NUCLEAR ENERGY

KEY MATERIAL DECISIONS

Waste Form Selection	May 1983
Process Selection - Vitrification	June 1983
Process Selection - Supernatant	November 1983
Reference Hot Flow Sheet	March 1985
Waste Form Composition	November 1985
Container Concept	February 1985
Canister Details	January 1986
Sampling/Certification Plan	September 1986
Final Waste Composition Specification	January 1987
Vitrification - Commence	September 1988
- Conclude Bulk Run	January 1990
- Complete	April 1990

SCHEDULE FOR GLASS TESTING

WV Glass Composition Selected, Begin Testing CTS (Cold) Glass for Homogenity, Density, Strength, etc.	November 1985 (WVNS)
Obtain (Hot) Samples from B cell; Begin Testing for Above Properties and Leach Resistance at PNL	January 1985 (PNL)
Begin Testing Spiked Samples for Leach Resistance at WV	April 1986
WV Waste Glass Qualification Complete	January 1988

OFFICE OF NUCLEAR ENERGY

PLANNED GLASS TESTING

- **MCC-1**
  - Static leach tests
  - Other leach tests if required or requested
- **MCC-6**
  - Radiation stability (leach rate, microstructure, tensile strength)
- **MCC-7**
  - Thermal stability
- **MCC-12**
  - Radiation stability (density changes)
- **MCC-15**
  - Canister drop test (30 ft.)
- ——
  - Canister fire test [~10 CFR 71.73 (c) (3)]

- Select parameters that affect glass properties (e.g. waste loading, flow rate, melt temp.) and cold test max and min. Keep parameters between tested max and min when hot.
- Leach and stability tests may be performed on site (with properly equipped lab) with assistance from MCC, Alfred, etc.
- Canister drop and fire tests may be at MCC where facilities are available.

PROJECT: SPECIAL WASTE FORM LYSIMETER - ARID

OBJECTIVE:

- TO CONDUCT WASTE FORM LEACHING TESTS IN A FIELD FACILITY IN ORDER TO DETERMINE TYPICAL SOURCE TERMS GENERATED BY COMMERCIAL SOLIDIFIED LOW-LEVEL WASTE.
- TO IDENTIFY THE CHEMICAL AND PHYSICAL PROCESSES THAT CONTROL THE CONCENTRATIONS OF RADIONUCLIDES IN THE SOIL SOLUTION SURROUNDING THE WASTE IN AN ARID CLIMATE.
- TO DETERMINE METHODS FOR REPRESENTING SOURCE TERM BOUNDARY CONDITIONS IN RADIONUCLIDE TRANSPORT MODELS.

DURATION: 10/1/82 - 9/30/87

FUNDING:

	FY 82	FY 83	FY 84	FY 85
OPERATING	-0-	300	394	250
CAPITAL	-0-	-0-	-0-	25

373

RECENT ACCOMPLISHMENTS:

LYSIMETER FACILITY BECAME COMPLETELY OPERATIONAL (3/84) AND BITUMEN WASTE FORMS WERE ADDED 9/84. UPGRADED MINTE Q (GEOCHEMICAL) MODEL 6/84 AND PUBLISHED A TOPICAL REPORT ON WASTE STREAM CHARACTERIZATION.

STATUS:

PROJECT IS CURRENTLY IN A MONITORING MODE. REGULAR DOWNHOLE RADIOLOGICAL AND HYDROLOGICAL MONITORING (INCLUDING SOIL SOLUTION MONITORING) ARE CURRENTLY BEING PERFORMED.

FY 85 PROJECTED ACCOMPLISHMENTS:

FY 85 WILL SEE THE INSTALLATION OF TENSIOMETERS, HEAT DISSIPATION UNITS, AND FIBERBLOCKS TO MEASURE SOIL MATRIC POTENTIAL. LABORATORY LEACHING TESTS AT BNL WILL BE EXPANDED TO INCLUDE SOLIDIFIED WASTE AND LYSIMETER SOIL MATERIAL (TOGETHER) AND ANALYSIS OF THE SAMPLE WASTE STREAMS FOR ORGANICS WILL BE PERFORMED.

PROJECT: Special Waste Form Lysimeter - Humid

OBJECTIVE:

- To conduct waste form leaching tests in a field activity in order to determine topical source terms generated by commercial solidified low-level waste.
- To identify the chemical and physical processes that control the concentrations of radionuclides in the soil solution surrounding the waste in a humid climate.
- To compare radionuclide migration from solidified commercial low-level wastes in order to evaluate the benefits of solidification.

DURATION: 9/30/79 - 9/30/90

FUNDING:

	FY 82	FY 83	FY 84	FY 85
Operating	250	210	250	250
Capital	-0-	-0-	-0-	-0-

RECENT ACCOMPLISHMENTS:

Horizontal solid cores were removed from one lysimeter to study radionuclide distribution in the soil column beneath the waste form.

STATUS:

Project is in a monitoring mode. Soil moisture and lysimeter effluent samples are being monitored for select radioisotopes.

FY 85 PROJECTED ACCOMPLISHMENTS:

In FY-1985, lysimeter operation and monitoring will continue. Soil samples from the sacrificial lysimeter will be analyzed to define the three-dimensional radionuclide distributions. Later in the year, a second lysimeter will be selected and cored.

PROJECT: HIGH INTEGRITY CONTAINER

OBJECTIVE:

DEVELOP A LOW-COST HIGH INTEGRITY CONTAINER

DURATION: 9/82 - 12/84

FUNDING:

FY 82	FY 83	FY 84	FY 85
0	94.4K	0	0

RECENT ACCOMPLISHMENTS:

A NEW LID FOR THE HIC WAS DEVELOPED WHICH ALLOWED THE LID TO BE PLACED AND SEALED WITHOUT THE USE OF TWO "O" RINGS. THIS RESULTED IN A $10-15 COST SAVINGS OVER THE PREVIOUS DESIGN.

STATUS:

THE FINAL REPORT ON THE PROJECT IS BEING COMPLETED. ALL PROGRAM SPONSORED WORK IS COMPLETE.

FY 85 PLANNED ACCOMPLISHMENTS:

THE FINAL REPORT IS TO BE SUBMITTED.

PROJECT: PREDICTION AND CONTROL OF THE LEACHABILITY OF GROUTS USED IN LLW RADIOACTIVE WASTE MANAGEMENT

OBJECTIVE:

DETERMINATION OF THE HYDROLOGICAL AND CHEMICAL PROPERTIES OF GROUTS FOR APPLICATION AND STABILIZATION OF CLOSED LLW DISPOSAL SITES AND BACKFILL OF NEW SITES.

DURATION: 4/15/84 - 4/15/85

FUNDING:

FY 82	FY 83	FY 84	FY 85
0	0	37	0

RECENT ACCOMPLISHMENTS:

A REPORT COMPARING THE KNOWN PHYSICAL AND CHEMICAL INFORMATION ON WHICH COMPARED THE PROPERTIES OF THE VARIOUS GROUT FORMULATIONS.

STATUS:

WORK IS CONTINUING ON THE GROUT PROPERTIES MATRIX. AREAS OF NEEDED INFORMATION ARE BEING IDENTIFIED. THE LITERATURE SEARCH PORTION OF THE PROJECT IS COMPLETE.

FY-85 PROJECTED ACCOMPLISHMENTS:

THE FINAL REPORT WILL BE COMPLETED AND SUBMITTED FOR PROGRAM REVIEW. THE FINAL REPORT WILL IDENTIFY THOSE GROUT PROPERTIES WHERE FURTHER RESEARCH IS WARRANTED.

MAJOR ACTIVITIES MANDATED BY THE NUCLEAR WASTE POLICY ACT OF 1982

- IDENTIFY POTENTIALLY ACCEPTABLE SITES FOR THE FIRST REPOSITORY
- ESTABLISH SITING GUIDELINES
- PREPARE FINAL ENVIRONMENTAL ASSESSMENTS AND NOMINATE AT LEAST FIVE SITES FOR CHARACTERIZATION
- RECOMMEND THREE SITES FOR CHARACTERIZATION
- PERFORM SITE CHARACTERIZATION
- SELECT FIRST REPOSITORY SITE
- CONSTRUCT FIRST REPOSITORY
- SELECT SECOND REPOSITORY SITE
- RECEIVE LICENSE FOR WASTE DISPOSAL IN 1998

Geologic Repository Deployment Program Objective

To provide facilities for the permanent disposal of commercial radioactive wastes for which the federal government is responsible. This program includes:

- Site exploration, characterization, and selection
- Design, licensing, construction, and operation of commercial repositories in various geologic media
- Comprehensive technology development supporting the above.

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

REPOSITORY MATERIALS*

WASTE PACKAGE

- o COMPOSED OF WASTE FORM, CANISTER, DISPOSAL CONTAINER, AND PACKING MATERIAL
- o WASTE FORMS: SPENT NUCLEAR FUEL, BOROSILICATE GLASS FROM DHLW OR CHLW ACTIVITIES, ETC.
- o CANISTER: STAINLESS OR CARBON STEELS
- o CONTAINER: CARBON STEELS (BASALT, SALT); STAINLESS STEEL (TUFF); ALTERNATIVES INCLUDE INCOLOY, CHROME-MOLY, COPPER-BASED ALLOYS
- o PACKING: MIXTURE OF CRUSHED HOST ROCK AND CLAYS (BENTONITE)

REPOSITORY AND SHAFT SEALS

- o COMBINATIONS OF CRUSHED HOST ROCK, CLAYS, CEMENTS, AND SPECIAL CHEMICAL SEALS

* Other than the Host Rock

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

REPOSITORY MATERIALS*

--BUDGET--

FIRST REPOSITORY	FY 1983	FY 1984	FY 1985
WASTE PACKAGE	$15.3	21.4	21.9
REPOSITORY	$25.4	36.4	30.0
TOTAL BA	$40.7	$57.8	$51.9

* Other than the Host Rock

DEFENSE WASTE MANAGEMENT PLAN
DISPOSAL POLICY

- READILY RETRIEVABLE WASTE TO GEOLOGIC DISPOSAL
- ALL OTHER TO BE RETRIEVED IF BENEFITS JUSTIFY COSTS AND RISKS
- OTHERWISE: STABILIZE IN PLACE
- RETRIEVED TRU WILL BE MADE ACCEPTABLE TO WIPP
- IMMOBILIZED HIGH LEVEL WASTE TO COMMERCIAL REPOSITORY

LONG-TERM WASTE MANAGEMENT TECHNOLOGY

OBJECTIVES — HLW SHALL BE CONVERTED TO SUITABLE PHYSICAL AND CHEMICAL FORMS AND CONFINED IN A MANNER WHICH SHALL PROVIDE HIGH ASSURANCE OF ISOLATION FROM MAN'S ENVIRONMENT WITH MINIMAL RELIANCE ON PERPETUAL MAINTENANCE AND SURVEILLANCE BY MAN UNDER CONDITIONS OF CREDIBLE NATURALLY OCCURRING EVENTS.

ACTIVITY
- DEFINE LONG-TERM ALTERNATIVES AT SR,ID, AND RL
- DEVELOP TECHNOLOGY FOR ALTERNATIVES
- ASSESS HAZARDS,COSTS,AND ENVIRONMENTAL IMPACT OF ALTERNATIVE
- SELECT AND IMPLEMENT OPTIMUM ALTERNATIVES AT SR,ID AND RL

ALTERNATIVE HIGH—LEVEL WASTE FORM PROGRAM

PURPOSE

TO ASSURE THAT OPTIMIZED WASTE FORM(S) WILL BE AVAILABLE FOR HIGH—LEVEL WASTES AT SAVANNAH RIVER, RICHLAND, IDAHO, NFS

DEFENSE PROGRAMS
DEFENSE WASTE MANAGEMENT PLAN

HLW Supporting Technology

- Product and Process Technology
  - Pretreatment
  - Immobilization
  - Canister Sealing and Storage
  - Quality Control
- Waste Form Testing and Verification
  - To Meet Repository Requirements
- Transportation Research and Development
  - Licensable Shipping Cask

DEFENSE PROGRAMS
DEFENSE WASTE AND BYPRODUCTS MANAGEMENT

FY 1986 BUDGET BACK-UP
HLW TECHNOLOGY

ACTIVITY	FY 84	FY 85	FY 86
LEAD OFFICE AND INDEPENDENT ASSESSMENT	1,800	925	1,060
DWPF SUPPORT			
• SALT DISPOSAL	700	1,533	1,945
• HOT CELL VITRIFICATION	4,635	4,700	4,845
• WASTE FORM/REPOSITORY INTERACTION	1,100	2,250	2,350
• CANISTER CLEANING AND WELDING	1,374	1,400	1,450
• LARGE SCALE VITRIFICATION	2,000	0	0
TRANSPORTATION AND CASK DESIGN	1,850	1,275	1,150
SUBTOTAL SAVANNAH RIVER HLW TECHNOLOGY	13,459	12,085	12,800
RICHLAND HLW SITE TECHNOLOGY	3,951	6,808	7,149
IDAHO HLW SITE TECHNOLOGY	750	1,250	1,330
MATERIALS CHARACTERIZATION	2,520	475	485
TOTALS	20,680	20,618	21,764

DEFENSE PROGRAMS
DEFENSE WASTE AND BYPRODUCTS MANAGEMENT

HIGH-LEVEL WASTE TECHNOLOGY - MATERIALS RELATED FUNDING

ACTIVITY	FY 84	FY 85	FY 86
SR			
SALT DISPOSAL, VITRIFICATION, REPOSITORY INTERACTION, ETC.	3,200	4,200	4,600
RL			
SALT DISPOSAL, VITRIFICATION, IN-PLACE DISPOSAL	2,000	3,400	3,600
ID			
WASTE VOLUME REDUCTION, CRYSTALLINE/GLASS WASTE FORMS	700	1,200	1,300
MATERIALS CHARACTERIZATION MIO, MCC, MRB, LEACH MECHANISM	2,500	500	500
TOTAL	8,400	9,300	10,000

DEFENSE PROGRAMS
DEFENSE WASTE AND BYPRODUCTS MANAGEMENT

PROJECT: WASTE FORM EVALUATION

OBJECTIVE: TO EVALUATE SOLIDIFICATION AGENTS FOR LOW-LEVEL WASTE STREAMS.

DURATION: THROUGH FY 1986

FUNDING:	FY 1982	FY 1983	FY 1984	FY 1985
(100K)	410	270	250	250

RECENT ACCOMPLISHMENTS

o WASTE FORM PROCESS DEVELOPMENT STUDIES FOR THE INCORPORATION OF INCINERATOR ASH AND ION EXCHANGE RESIN IN MODIFIED SULFUR CEMENT HAVE BEEN COMPLETED. EARLIER STUDIES (FY 1984) WERE MADE ON PROCESS DEVELOPMENT OF POLYETHYLENE AS A SOLIDIFICATION AGENT FOR INCINERATOR ASH, EVAPORATOR CONCENTRATE, AND ION EXCHANGE RESINS.

STATUS

o CURRENT WORK IS DIRECTED TO EVALUATING THE PROPERTIES OF MODIFIED SULFUR CEMENT WASTE FORMS BY TESTING COMPRESSIVE STRENGTH, AND RESISTANCE TO THERMAL CYCLING, WATER IMMERSION, AND LEACHING. CURRENT WORK INCLUDES SELECTION, ACQUISITION, AND INSTALLATION OF PROCESS DEMONSTRATION EQUIPMENT.

FY 1985 PROJECTED ACCOMPLISHMENTS

o FINAL REPORT ON MODIFIED SULFUR CEMENT (4/85).
o LETTER REPORT ON WASTE SELECTION FOR PROCESS DEMONSTRATION STUDIES (6/85).
o LETTER REPORT ON POTENTIAL PROCESSES FOR TREATMENT AND SOLIDIFICATION OF DOE PROBLEM WASTES (6/85)
o ANNUAL REPORT (9/85).

DEFENSE PROGRAMS
DEFENSE WASTE AND BYPRODUCTS MANAGEMENT

PROJECT: ACCELERATED LEACH TEST

OBJECTIVE: TO DEVELOP AND VALIDATE AN ACCELERATED LEACH TEST FOR LONG TERM PREDICTION OF LEACH RATES FROM WASTE FORMS FOR PROBLEM WASTES.

DURATION: THROUGH FY 1988

FUNDING: (100K)	FY 1982	FY 1983	FY 1984	FY 1985
	--	--	--	222.5

RECENT ACCOMPLISHMENTS

- PERFORMED LITERATURE SEARCH. PREPARED DATA BASE SCHEMA. ENTERED LITERATURE AND BROOKHAVEN DATA INTO DATA BASE.

STATUS

- CURRENT WORK IS DIRECTED TO CONDUCTING LEACH TESTS AND ANALYZING LEACHATE. COMPUTER PROCEDURES FOR DIRECT APPLICATION OF STATISTICAL PROGRAMS TO THE DATA BASE ARE BEING PREPARED.

FY 1985 PROJECTED ACCOMPLISHMENTS

- CONVENE PANEL OF EXPERTS ON LEACHING TO REVIEW DRAFT TEST PLAN (3/85).
- COMPLETE TEST PLAN FOR ACCELERATED LEACH TEST TASK (3/85).
- ANNUAL REPORT (9/85).

DEFENSE PROGRAMS
DEFENSE WASTE AND BYPRODUCTS MANAGEMENT

PROJECT: ENGINEERED SORBENT BARRIERS FOR LOW-LEVEL WASTE

OBJECTIVE: TO EVALUATE COST-EFFECTIVE TECHNOLOGY FOR RETARDING THE MIGRATION OF RADIONUCLIDES FROM LOW-LEVEL WASTE DISPOSAL SITES.

DURATION: THROUGH FY 1986

FUNDING: (100K)	FY 1982	FY 1983	FY 1984	FY 1985
	--	--	56	100

RECENT ACCOMPLISHMENTS

- o APPROXIMATELY 18 MATERIALS HAVE BEEN SELECTED FOR BATCH CONTACT TEST STUDIES.
- o THE EXPERIMENTAL PLAN FOR THE BATCH CONTACT TESTS HAVE BEEN COMPLETED.

STATUS

- o SIMULATED RADIOACTIVE LEACHATE SOLUTIONS HAVE BEEN PREPARED FOR THE FIRST SET OF BATCH CONTACT TESTS.

FY 1985 PROJECTED ACCOMPLISHMENTS

- o BATCH CONTACT TESTS WILL BE COMPLETED (9/85).
- o FOUR MATERIALS FROM BATCH CONTACT TESTS WILL BE SELECTED FOR EXPOSURE COLUMN TESTS (9/85).

DEFENSE PROGRAMS
DEFENSE WASTE AND BYPRODUCTS MANAGEMENT

PROJECT: CORRECTIVE MEASURES TECHNOLOGY FOR HUMID REGIONS

OBJECTIVE: TO DEMONSTRATE THAT BURIED WASTE CAN BE HYDROLOGICALLY ISOLATED IN PLACE BY GROUT INJECTION.

DURATION: FY 1982 THROUGH FY 1984

FUNDING:	FY 1982	FY 1983	FY 1984	FY 1985
(100K)	100	100	50	--

RECENT ACCOMPLISHMENTS

- LABORATORY TESTS OF SEVEN GROUT FORMULATIONS WERE COMPLETED. SODIUM SILICATE AND POLYACRYLAMIDE FORMULATIONS PERFORMED BEST.
- THREE FIELD PILOT-SCALE MINI-TRENCHES WERE GROUTED. SODIUM SILICATE AND POLYACRYLAMIDE FORMULATIONS PERFORMED WELL UNDER DRY TRENCH CONDITIONS.

STATUS

- TASK COMPLETED.
- TECHNOLOGY TESTED ON LARGE SCALE AT MAXEY FLATS IN FY 84. PRELIMINARY FINDINGS ARE ENCOURAGING.
- ORNL, INEL, AND HANFORD ARE CONSIDERING INCORPORATING GROUTING AS A PART OF THEIR OVERALL CORRECTIVE MEASURES PROGRAM.

DEFENSE PROGRAMS
DEFENSE WASTE AND BYPRODUCTS MANAGEMENT

PROJECT: GREATER CONFINEMENT DISPOSAL TEST

OBJECTIVE: TO DEMONSTRATE THE EFFECTIVE ISOLATION BY THE GCDT AT THE NTS, TO DETERMINE THE COSTS OF USING THE LARGE-DIAMETER BOREHOLE CONCEPT, AND DOCUMENT OPERATING PROCEDURES.

DURATION: THROUGH FY 1989

FUNDING: (100K)	FY 1982	FY 1983	FY 1984	FY 1985
	529	793	531	215

RECENT ACCOMPLISHMENTS

- COMPLETED DISPOSAL OF OVER ONE MILLION CURIES OF HIGH-SPECIFIC- ACTIVITY WASTES.
- ISSUED "GREATER CONFINEMENT DISPOSAL TEST: OPERATIONAL TECHNOLOGY REPORT".
- COMPLETED "TRACER TECHNOLOGY" REPORT.

STATUS

- THE CURRENT EFFORT IS DIRECTED TO CONDUCTING A SERIES OF TESTS TO CHARACTERIZE THE DISPOSAL CAPABILITIES OF THE GCDT. IN ADDITION TO THE GCDT, STUDIES IN THE SHALLOW TEST PLOT AND RECIRCULATION TEST CONTAINER WILL BE CONTINUED TO CALIBRATE AND OPTIMIZE TRACER TESTS FOR THE GCDT. A MAJOR EFFORT WILL BE THE PREPARATION OF A PROBABILISTIC RISK ASSESSMENT.

FY 1985 PROJECTED ACCOMPLISHMENTS

- COMPLETE DRAFT PROBABILISTIC RISK ASSESSMENT FOR THE GCDT (9/85).
- COMPLETE SUMMARY REPORT ON GCDT AND STP TRACER AND MONITORING DATA (9/85).

DEFENSE PROGRAMS
DEFENSE WASTE AND BYPRODUCTS MANAGEMENT

PROJECT: GCD INVESTIGATIONS -- HUMID

OBJECTIVE: TO EVALUATE DEEPER BURIAL OF PROBLEM WASTES USING ENGINEERED BARRIERS BY MONITORING GCD TEST SITES AT THE SRP.

DURATION: THROUGH FY 1988

FUNDING:	FY 1982	FY 1983	FY 1984	FY 1985
(100K)	200	100	70	50

RECENT ACCOMPLISHMENTS
- ISSUED REPORT ON EFFECTIVENESS OF CLAY CAP FOR GCD TEST FACILITY.
- ISSUED REPORT ON "GREATER CONFINEMENT DISPOSAL TECHNOLOGY AT THE SRP".

STATUS
- CURRENT WORK IS DIRECTED TO CONTINUED MONITORING AND EVALUATION OF THE GCD LANDFILL LYSIMETER. ADDITIONAL CONSULTATION ON GCD TECHNOLOGY WILL BE PROVIDED AS NEEDED.

FY 1985 PROJECTED ACCOMPLISHMENTS
- ISSUE REPORT ON SECOND YEAR OF MONITORING GCD FACILITY (12/84).
- PROVIDE COST AND OPERATIONAL INFORMATION ON LARGE DIAMETER BOREHOLE DISPOSAL AT SRP (AS NEEDED BY LLWMP).

ILLINOIS, UNIVERSITY OF

118. DEVITRIFICATION BEHAVIOR IN METAL-CONTAINING SILICATE AND BOROSILICATE GLASSES

H. Chen
Phone: (217)-333-7636

$80,000 01-3

Investigation of devitrification kinetics and associated microstructural and compositional changes in silicate and borosilicate based glasses containing metal oxides using EXAFS, small and wide angle x-ray scattering and SEM methods. Mechanisms of metal-silicide thin film formation. Kinetics of layer growth.

LABORATORIES

LOS ALAMOS NATIONAL LABORATORY
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Materials Science and Technology Division - 01, 03

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200. THE EFFECT OF SELF-IRRADIATION ON STABILITY OF CERAMIC NUCLEAR WASTE

F. W. Clinard Jr.
Phone: (505)-667-5102

$310,000 01-4

Alpha decay self-damage in zirconolite, perovskite, pyrochlore, and multiphase SYNROC ceramic waste. Doping with short half-life actinides and examination of natural mineral analogues. Role of starting composition and crystal structure. Evolution of the metamict state; localized and generalized atomic disorder; alpha recoil tracks. Simulation of damage by ion irradiation. Characterization of damage effects by x-ray and electron diffraction, optical and electron microscopy, EXAFS, dilatometry, calorimetry, and fractography. Changes in density (swelling), microhardness, fracture toughness, and resistance to microcracking. Effect of elevated temperature during self-damage; post-irradiation annealing and recovery.

LABORATORIES

OAK RIDGE NATIONAL LABORATORY

Chemistry Division - 03 -

M. L. Poutsma - Phone (FTS) 624-5028 or 615-574-5028

245. CHEMICAL STRUCTURE OF ENERGY RELATED MATERIALS

W. R. Busing, B. K. Annis, G. M. Brown, E. Johnson, A. H. Narten, D. W. Noid, W. E. Thiessen
Phone: (FTS) 624-4976 or (615)-574-4976
$850,000 03-1

Atomic and molecular arrangements in crystals and in liquids determined by neutron and X-ray diffraction studies; atom-atom pair correlation functions for liquids; precise electron densities in crystals; neutron spectroscopy; development of synchrotron radiation facilities. Computational methods for dynamic correction of neutron scattering intensities; improvement of statistical mechanics techniques for application to ionic solutions or molten salts; use of computational models to interpret the effects of intermolecular packing forces on the geometry of molecules in crystals; calculation of physical properties of crystals. Materials studied include amorphous metal alloys, compounds which are potential catalysts for hydrogenation and hydrogen production, molten salts, aqueous lanthanide and actinide solutions, and silicate minerals of the earth's mantle.

LABORATORIES

PACIFIC NORTHWEST LABORTORY (continued)

264. LEACHING OF GLASS AND CERAMICS

G. L. McVay, L. R. Pederson, D. S. Goldman
Phone: (509)-375-3762
$250,000 01-3

Mechanistic studies of the interactions of silicate glasses and crystalline ceramics with water, by systematic variation of bulk structure, surface properties, and solution chemistry. Structural studies consider the influence of bridging/nonbridging oxygen ratios, extent of polymerization, and redox effects on leachability. Surface electrical properties in solution, sorption phenomena, and the nature of an altered surface layer are included in studies of the effects of surface properties on leaching. Solution chemistry parameters of interest include pH, Eh, ionic strength, saturation with respect to key glass components, and the use of isotopically-labelled water.

BOEING AEROSPACE COMPANY
P. O. Box 3999
Seattle, WA 98124

305. X-RAY SPECTROSCOPIC INVESTIGATION OF METAMICTIZATION & ANNEALING IN CRYSTALLINE PHOSPHATES, SILICATES AND COMPLEX TI-NB-TA OXIDES

R. B. Greegor
Phone: (206)-655-0514
F. W. Lytle
Phone: (206)-655-5574

$60,030 01-1

Detailed examination of the near neighbor site geometries of metal atoms in metamic minerals (e.g., A (U,TH) and B (Ti,Nb,Ta) site cations) as determined by extended X-ray absorption fine structure (EXAFS) and X-ray absorption near edge structure (XANES) spectroscopy performed at the SSRL. Study of radiation damage annealing and leaching mechanisms of metamict minerals. Determination of the structure of the metamict state. Assessment of long-term stability of crystalline titanate, phosphate, and silicate radioactive wasteforms (e.g., SYNROC, Sandia Titanate) which would be subject to the same processes of radiation damage and geochemical alteration in applications as a primary host for radioactive wastes.

UNIVERSITY OF CALIFORNIA/DAVIS
Davis, CA 95616

313. RADIATION DAMAGE AND STABILITY OF NUCLEAR WASTE STORAGE MATERIALS

D. G. Howitt
Dept. of Mechanical Engineering
Phone: (916)-752-1164, 0580

$97,000 01-1

Evaluation of fundamental processes of radiation damage in silicate based glasses and the leaching behavior of multicomponent glasses and ceramics. Concerns include the chemical role of helium in the radiation damage process, the size of damage volumes involved in the crystalline to amorphous transformation, and the radiation damage processes that contribute to the radiolytic decomposition of cements.

373. IRRADIATION DAMAGE MICROSTRUCTURES IN NUCLEAR CERAMICS WITH APPLICATION IN FUSION ENERGY TECHNOLOGY AND NUCLEAR WASTE DISPOSAL

L. W. Hobbs
Ceramics and Materials Science Dept.
Phone: (617)-253-6835

$141,103 01-4

Fundamental research to characterize the irradiation stability and radiation damage microstructure of crystalline ceramic solids with application to nuclear energy production and disposal of high-level nuclear waste. The principal mode of investigation is transmission electron microscopy. Materials to be examined include BeO, $MgO.nAl_2O_3$, CaF_2, PuO_2, ZrO_2, SiC, Si_3N_4, Li_2O, $LiAlO_2$, $LiAl_5O_8$, Li_2ZrO_3, $Ca(Zr,Pu)Ti_2O_7$, titanate pyrochlores, SiO_2, GeO_2, $ZrSiO_4$. Neutron, ion and electron irradiation damage will be studied, including the effects of massive recoil nuclei and fission fragments.

UNIVERSITY OF NEW MEXICO
Albuquerque, NM 87131

397. RADIATION EFFECTS AND ANNEALING KINETICS IN CRYSTALLINE COMPLEX NB-TA-TI OXIDES, PHOSPHATES AND SILICATES

R. C. Ewing
Geology Dept.
Phone: (505)-277-2030

$71,500 01-1

Comparative study of the properties of selected metamict minerals and synthetic irradiated phases of similar compositions. Research includes characterization of changes in properties of crystalline materials as a function of a alpha-recoil dose for natural materials; characterization of the structure of the metamict state in various silicates, phosphates, and oxides using X-ray diffraction, electron microscopy, extended X-ray absorption fine structure and near edge structure (EXAFS/XANES) spectroscopy; determination of kinetics of annealing of natural zircons, pyrochlores and silicate apatites, and complex Nb-Ta-Ti oxides which are partially or completely metamict; and correlation of recrystallization and fission track fading kinetics to predict the role of thermal annealing on long-term radiation effects.

PENNSYLVANIA STATE UNIVERSITY
University Park, PA 16802

424. PHYSICAL CHEMISTRY OF PORTLAND-CEMENT HYDRATE, RADIOACTIVE WASTE-HOSTS

M. W. Grutzeck
Materials Research Laboratory
Phone: (814)-865-3539

$59,817 01-1

Physical and crystal chemistry of three portland-cement hydrates: calcium silicate hydrates, calcium aluminum hydrates, and calcium alumino silicate hydrates. Phase-equilibrium relationships governing the hydration of portland cement, both with and without radioactive waste. Fixation of iodine by calcium aluminate hydrates and the feasibility of using Stratling's compound and its associated hydrates as host phases for cesium and strontium fixation. Identification fo phases best suited for hosting selected radioactive-waste ions, and synthesis and crystallographic characterization of such phases. Solubility/leachability study of synthesized host phases both individually and encapsulated in a suitable cementitious matrix.

RUTGERS UNIVERSITY
Busch Campus/P. O. Box 909
Piscataway, NJ 08854

460. LOCAL STRUCTURE OF METAL ATOMS IN SILICA AND SILICATES

S. H. Garofalini
Dept. of Ceramics
Phone: (201)-932-2216

$70,092 01-3

Local structure and bulk and surface diffusion of metal ions in vitreous silica and silicated glasses investigated using a combination of extended X-ray absorption fine structure (EXAFS) measurements and computer simulations using molecular dynamics methods. Studies of the effects of local structure, interatomic potential functions, atom size, ion clustering and sample preparation on the mobility of metal species in alkali-zinc-silicates, sol-gel-prepared zinc silicates, and platinum on silica.

GEOSCIENCES RESEARCH

Related to:

Radioactive Waste Isolation

Contractor: ARGONNE NATIONAL LABORATORY
Argonne, Illinois 60439

Trace Element Migration in the Earth's Crust (M. Seitz, N. Sturchio, S. Boggs, Jr., and D. Livermore)

An understanding of the distribution and mobilization of trace elements in natural rock-water systems is fundamentally important and is part of the basis for developing rational policies regarding the management of our environment and the evaluation and exploitation of our energy and minerals resources. In this program, we are currently concentrating on two main areas of research: (1) chemical mobility during hydrothermal alteration in active geothermal systems, and (2) the effects of organic compounds in groundwaters on the mobility of heavy elements.

Active geothermal systems provide excellent opportunities for the study of chemical mobility in rock-water systems at relatively high temperatures. This is especially true when rock cores and thermal water (or brine) samples are available from various depths and physical conditions are known. We are now performing a detailed study of hydrothermally altered rhyolitic vitrophyre samples from the Y7 and Y8 shallow research drill holes in Yellowstone National Park, using electron microprobe, instrumental neutron activation analysis, inductively-coupled plasma atomic emission spectrometry, and mass spectrometry. This work is being done to quantify the chemical mobility concomitant with hydrothermal alteration in these rocks at temperatures of 110°-160° C. We have also analyzed several thermal water samples from the vitrophyre unit in these holes. In a separate study, granite from the 2 km deep drill hole at the Marysville Geothermal Anomaly, Montana, is being investigated to determine the effects of protracted interaction between this rock and the coexisting 95°C dilute sodium bicarbonate-sulfate water.

Organic compounds in groundwaters are known to form stable complexes with heavy elements. We are now investigating the effects of dissolved organics on the distribution ratios of 237-neptunium and 241-americium between basalt and groundwater, using both natural and synthetic groundwater compositions at 25° and 90°C. Special techniques for studying these effects in natural groundwaters are being developed. This work will have important implications regarding the influence of groundwater composition in the transport properties of hazardous waste elements in groundwater aquifers. In related work, we have examined the mobility of phenols in dolomite aquifers. Also under investigation is the use of catalysts in low temperature geochemical experimentation.

Migration of Heavy Element Chemical Species in Geologic Media
(F. Schreiner and A. M. Friedman)

The mechanisms of transport of heavy elements in natural geologic formations determine the rate and extent of their dispersal, and the potential localized concentration of these elements in the environment. The objective of the present program is the investigation of the chemical factors that are important in the transport of elements with atomic numbers of 92 and beyond. Chemical properties of importance include redox and hydrolysis equilibria and complex formation. To unravel the complex aggregate of physicochemical interaction modes a number of techniques are being utilized. Oxidation states and reaction rates are determined spectrophotometrically, and equilibrium parameters are established by calorimetry. Rate measurements are made on the microsecond time scale by using the temperature jump technique. The acquired data should provide information potentially useful in the assessment of the safety of nuclear waste repositories, and in the modeling of dispersion patterns for hazardous radionuclides after accidental release.

In recent months calorimetry of the system of complex uranium carbonates has received special attention, along with enthalpy measurements on the reaction of uranyl (VI) ions with such common anions as chloride and sulfate. The calorimeter used for these measurements is a commercial titration microcalorimeter modified for special use with radioactive elements. The instrument is capable of measuring heat releases to ± 0.0005 K-degrees. The results show the calorimetric enthalpies for the carbonato complexes of uranium to be consistent with published equilibrium data based on potentiometric and spectrophotometric measurements. Literature values for the equilibrium constants of the stepwise formation of the dicarbonato- and the tricarbonato uranate ions are 10^{14} and 10^{18}, respectively, indicating very high stabilities for the complex ions. The bond energy for attachment of a carbonato group to the uranyl ion deduced from our calorimetric measurements is near 29 kilojoules, confirming the strong affinity of the carbonate group to the uranium central atom. Calorimeric measurements in the future will concentrate on the complexing reactions of neptunium and plutonium in systems analogous to the uranium systems. At the same time spectrophotometric techniques will be used to identify the reacting species and to establish kinetic parameters. By comparative evaluation of the chemistry of the closely related elements uranium, neptunium, and plutonium we expect to develop correlations which can be used to predict the unknown behavior of transuranium elements in geologic formations.

Thermochemistry of Geothermal Materials (P. A. G. O'Hare and G. K. Johnson)

The objective of this program is to measure precisely, by calorimetry, thermodynamic properties of zeolites, silicates, and structurally related compounds. Materials selected for study are often key components of geologic ensembles, they may have real or potential technological value, or they may be of basic scientific interest in terms of structure or chemical bonding. Calorimetric techniques are as follows: solution calorimetry in aqueous HF for the determination of enthalpies of formation, $\Delta_f H_m^o$; low-temperature Calorimetry (5-350 K) for the determination of heat capacities, $C_{p,m}^o$; and the derived standard entropy, S_m^o; drop calorimetry ($T \geq$ 350 K) for the determination of enthalpy increments, $H_m^o(T) - H_m^o(298.15)$, and the derived $C_{p,m}^o$; and differential scanning calorimetry for the determination of $C_{p,m}^o$ and temperatures and enthalpies of transition. Measurements cover the temperature range from 5 to 1500 K or the upper temperatures limit of stability.

Based on our published value for the Gibbs free energy of formation of analcime we have been able to estimate the effect that variations in the Si/Al ratios, and applied those estimated to naturally-occurring systems. Our estimated values for $\Delta_f G_m^o$ of analcimes of composition $Na_{0.8}Al_{0.8}Si_{2.2}O_6 \cdot H_2O$ along with our experimental values for $Na_{0.96}Al_{0.96}Si_{2.04}O_6 \cdot H_2O$ suggest that solid solution of quartz in analcime is nearly ideal. These new Gibbs energies have been used to construct a log $_{SiO_2(aq)}$ against T phase diagram which depicts the stability of the analcimes with respect to quartz. This diagram is in complete harmony with geologic field observations and with the experimental determined stability limits of the analcimes.

In order to more completely understand the (heulandite-laumontite-SiO_2) and (heulandite-analcime-SiO_2) equilibria, our earlier studies on heulandite are being extended to include additional specimens with different Si-to-Al ratios.

Currently, the thermodynamic properties of mordenite and dehydrated mordenite are being determined in order, inter alia, to obtain a better understanding of the properties of zeolitic water.

Contractor: LAWRENCE BERKELEY LABORATORY
University of California
Berkeley, California 94720

Thermodynamics of High-Temperatures Brines (K. S. Pitzer)

This project covers theoretical and experimental studies concerning the thermodynamic properties of aqueous electrolytes. The components important in natural waters and brines are emphasized. The resulting data are important in understanding certain geothermal and other natural resources. Moreover, this information has a wide range of applicability, since similar solutions arise in many industrial processes and in high-pressure steam power plants.

A theoretically based equation was developed for the thermodynamic properties of aqueous NaCl valid form 373-823 K, to 1 kbar, and to saturation with the solid. This extends to higher temperature the earlier treatment valid from 273-573 K.

The experimental program involves measuring the heat capacity and the density of solutions in the range 0 to 300°C and 0 to 1 kbar. These measurements suffice to give a comprehensive equation of state, provided that other thermodynamic properties are known for a particular system at room temperature and pressure.

Other recent theoretical work has yielded equations predicting the properties of mixtures based on the knowledge of the pure component solutions in water. In a number of cases, the calculated results for mixed brines are well verified by direct measurement. Phase equilibria can be predicted. Recent calculations have included solubility calculations of Na_2SO_4 and several alkali halides in a variety of mixed electrolytes usually to about 250°. Densities were measured recently for Na_2SO_4 and $MgSO_4$, and the heat capacity of the latter is now being measured. When these data are combined with earlier results, a comprehensive treatment can be given of phase equilibria over a range of temperatures for solutions containing the geochemically important ions Na^+, Mg^{+2}, Ca^{+2}, and Cl^-, SO_4^{-2}, HCO_3^-, OH^-, K^+.

<u>Chemical Transport in Natural Systems</u> (C. L. Carnahan)

The objective of this research program is to better understand and characterize certain chemical and physical phenomena that influence the movement of chemically reactive solutes in groundwater flow systems. The results of the research are applicable, for example, to the migration of contaminants away from nuclear waste repositories and uranium mill tailings ponds, as well as to studies of geothermal energy reservoirs, hydro-thermal ore deposits, and other energy-related topics.

The principal focal point is the nonequilibrium nature of certain processes influential in chemical transport. Computer codes have been developed to study solute transport by advection and hydrodynamic dispersion in three-dimensional, axisymmetric flow systems in which chemical reactions occur between solutes and solid phases. Both linear, and nonlinear kinetic rate laws for these reactions have been used in the numerical models. The thermodynamics of irreversible processes is being used to describe coupled transport processes such as chemical osmosis, thermal osmosis, thermal diffusion, and ultrafiltration. Results obtained during 1983 show that certain coupled processes may be much more significant than previously realized in saturated geologic materials that behave as semi-permeable membranes. Such materials include clay-containing backfills for high-level nuclear waste repositories.

Aqueous Solutions Database (S. L. Phillips)

The twofold objective of this project is the compilation of critically evaluated experimental data on selected equilibria in aqueous solutions to high temperatures, concentrations, and pressures; and, to publish tables of recommended values for these equilibrium quotients. The data are used, for example, in nuclear waste disposal, chemical oceanography, geothermal energy, hydrometallurgy and corrosion problems. However, emphasis is currently on nuclear waste disposal.

Besides chemical equilibria, data covered include electrode potentials, diffusion coefficients and adsorption. The basic data are used, for example, to predict solubility and speciation of radioelements in nuclear waste repositories that may be located in salt, basalt, and tuff. A result of this project is identification of gaps where data are lacking or are inadequate, and recommendations for research to provide the needed data.

Besides critical evaluation of data, research is included on calculation of stability constants to high temperatures and concentrations; as well as computerized storage and retrieval of tables of data using desktop computers.

Nonisothermal Reservoir Dynamics (P. A. Witherspoon, C. F. Tsang, T. N. Narasimhan)

This project encompasses a wide range of fundamental studies of fluid, heat, and solute transport in underground formations. These studies are relevant to underground thermal energy storage, geological isolation of nuclear waste, chemical wastes disposal, and other energy-related projects. The goal is to better understand various physical and chemical transport processes in porous or fractured media and their effects through mathematical modeling and laboratory investigations.

Specifically, the following topics are addressed:

Modeling of flows of heat, liquid, vapor and air through a fractured-porous medium. A computer code capable of calculating these processes is being developed. Applications are made to the study of non-isothermal unsaturated flow near an underground heating source.

A new well test method to determine aquifer vertical permeability and layering characteristics. This proposed technique involves the injection of hotter or colder water into an aquifer and monitoring of the temperature variations. Field data are analyzed to validate the new method.

Well test methods to characterize a fractured medium by means of coupled pressure, tracer, and thermal measurements.

Continuation of the validation and applications of the LBL coupled thermo-hydromechanical code to model flow through fractured porous media.

A new technique to improve grid orientation performance of a finite difference method with applications to pattern steam-flood problems.

A study of the possibility of determining the shape and location of a fluid plume by means of coupled hydrologic and geophysical methods.

Fundamental Studies of Fluid Flow in Fractured Rock Masses Under Stress (P. A. Witherspoon and Y. W. Tsang)

The objective of this research program is to gain a fundamental understanding of the factors governing fluid flow through a single rock fracture which is subject to stress. Understanding the fluid flow behavior in a single fracture is prerequisite to the determination of the permeability of fractured rock masses. This is of importance in many areas of practical interest such as the isolation of nuclear and toxic wastes, the recovery of fossil fuels, and the development of geothermal energy. Our theoretical studies show that the geometrical roughness of fracture surfaces holds the key to many hydromechanical properties which cannot be explained if fractures are assumed to be idealized, smooth, parallel plates. By incorporating fracture roughness, we find that: (1) the characteristic stress-strain curves for both well-mated and poorly-mated fractures can be derived, (2) the effect of sample size on the mechanical and hydraulic properties of the fracture are controlled by the large scale roughness of the fracture surfaces and (3) the tortuosity of flow paths may cause the fluid flow rate through the single fracture to be depressed by several orders of magnitude from values predicted from the parallel plate idealization.

Contractor: LAWRENCE LIVERMORE NATIONAL LABORATORY
University of California
Livermore, California 94550

Underground Imaging (R. J. Lytle and A. G. Duba)

A significant portion of the Department of Energy budget is being spent on extracting energy from, or storing nuclear waste within, the subsurface environment. To asses whether the energy extraction or waste storage procedures are properly implemented, it is necessary to obtain detailed images of the subsurface environment. Such images will also be of value for continental drilling interests. LLNL has had success in developing and applying the concept of geophysical tomography to achieve such images. LLNL has also shown that improved interpretations of the subsurface environment can be obtained by combining laboratory data on the relations between remote probing observables (such as seismic attenuation or electromagnetic velocity) and the governing physical phenomena (such as in situ stress of temperature). Demonstrations of seismic shear, seismic compressional and electromagnetic geotomography has been successfully completed. This effort will continue the integrated program for advancing the state-of-art in data collection methods, data processing procedures, data interpretation techniques, and enhanced means of data interpretation.

Contractor: LOS ALAMOS NATIONAL LABORATORY
University of California
Los Alamos, New Mexico 87545

Creep Deformation of Rock (J. D. Blacic)

Assurance of long-term isolation of nuclear wastes in mined cavities in hard rock requires knowledge of time-dependent strength and transport properties of these rocks. Normal, short-time engineering tests do not encompass the full effects of phenomena such as water-aided stress corrosion and hydrolytic weakening. Therefore, we study creep deformation of basalt, granite, and tuff at simulated in situ conditions of temperature, pressure, pore pressure, and differential stress. Emphasis is placed on evaluating effects of water on time-dependent brittle deformation of intact vs. fractured samples and the effect of creep on fluid permeability. Results of the experiments will be formulated into creep constitutive relations in a form amenable to predictive computer models of repository designs.

The Geochemistry of Technetium and Ruthenium and Geochemical Controls on the Redistribution of Multivalent Elements in the Lithosphere (D. B. Curtis, R. E. Perrin, D. J. Rokop, and K. Daniels)

Methods of isotope geochemistry provide powerful tools for studying the alteration of rocks: nuclear processes change the chemical and isotopic composition of natural materials in situ. The relative abundance of these natural nuclear products in a chemically isolated system can be predicted, usually by rather straightforward models of the nuclear processes. Discrepancies between predicted and actual abundances manifest the effects of chemical processes in the lithic environment.

Commonly these methods involve radioactive nuclides and their decay products (^{238}U-^{234}U, ^{87}Rb-^{87}Sr). However, the number of chemical elements represented by radioactive parent-daughter pairs is limited. In contrast, spontaneous fission produces nuclides that represent roughly one third of all the elements on the periodic table. However, the rate of element production by this process is so slow, the rate constant is $8.5x10^{17}$/year, that the quantities of most elements produced in the entire history of the earth are imperceptible relative to those found "naturally" in geologic materials. In the case of a few elements, the "natural" component is sufficiently small that the spontaneous fission product can be detected. Ruthenium and technetium are two such elements. Because the abundances of these spontaneous fission products are so small there have been few efforts to develop the sophisticated analytical techniques and information required to use them as geochemical tools. We are using the unique capabilities of the Los Alamos National Laboratory Isotope Geochemistry Group to make the measurements. The ability to do so permits us to address several matters of importance. Both ruthenium and technetium are multivalent elements. Studies of their stability will provide information about the effects of redox conditions on the long term retention of multivalent elements in a geologic environment. Our work is one of the first attempts to explicitly examine the geochemistry of this rare element. Ruthenium is one of six geochemically similar elements termed platinum group metals. Some of these are important components of critical industrial processes. Studies of the geochemistry of ruthenium will contribute to our understanding of processes that enrich platinum group metals and thus enhance the ability to assess the reserves of these critical resources.

Geologic, Geochemical and Sr, Nd, and Pb Isotopic Studies on an Anomalous Late Cenozoic Basalt Province in the Southwestern Great Basin (B. M. Crowe, D. B. Curtis, and G. L. Farmer)

Field investigations are being undertaken to study the age, and geochemical and isotopic patterns of basaltic volcanism in a narrow strip extending from the western edge of the Nevada Test Site westward to the eastern edge of the Sierra Nevada range. This strip crosses several major structural features including: 1) the Death Valley-Pancake Range volcanic zone; 2) the western edge of the North American craton; and 3) an east-to-west transition in the degree of activity of basin-range tectonism. Associated with these structural features are: 1) a petrological transition in the composition of basaltic rocks from hawaiites to potassium-rich alkali basalts; and 2) a transition in the isotopic composition of neodymium and strontium ranging from mantle array basalts (Sierra Nevada edge) to highly anomalous basalts (Nevada Test Site region). Lead isotopic data for basalts are available only for the eastern and western edges of the strip. These data define a linear array on a $^{207}/^{206}Pb$ versus $^{204}/^{206}Pb$ diagram indicating a common aspect to the geochemical history of the rocks. The lead isotopic compositions of individual samples does not show a recognizable covariance with the neodymium-strontium isotopic composition , with variations in trace element contents or with geographic location of the studies basalts. It is not presently known whether differences in the lead isotopic composition of the basalts reflect a heterogeneous source region or differing degrees of contamination. Selected basalts, rhyolites, and Cretaceous granites will be mapped and sampled in the field and analyzed for age, major and trace element chemistry, and the isotopic composition of lead, neodymium, and strontium. The primary thrusts of the work are: 1) To determine if isotopic covariation exists between the basalts and crustal rocks and if such covariation is consistent with models of crustal contamination; 2) To attempt to relate the isotopic compositions of lead to strontium and neodymium isotopic variations for the basalts, the rhyolites, and the granites; and 3) To attempt to related the lead isotopic compositions of studied basalts to lead isotopic data for basalts from larger region of the southwestern United States.

Contractor:	PACIFIC NORTHWEST LABORATORIES Battelle Memorial Institute Richland, Washington 99352
Contract:	DE-AC06-76RLO 1830
Title:	III. Chemical Migration by Contact Metamorphism in Granite - Country Rocks
Person in Charge:	J. C. Laul

Scope of Work

The main objective is to investigate the relative migration and transport mechanism of major, minor, and particularly trace elements during contact metamorphism between granite pegmatites and surrounding country rocks. Specific emphasis will be on the rare earth elements (REE) -- Ba, Sr, K, As, Sb, Pb, Cl, Rb, Cs, Zr, Hf, Ni, Th, and U. The applications of this study may enable us to understand and predict the long-term (10^3 to 10^7 years) behavior and movement of radionuclide in diverse geologically confined nuclear waste.

The first geological site was the granite intrusion at Notch Peak in Southwest Utah. Some of the important findings were: 1) the granite stock is composed of three concentric sequentially intruded rock types, 2) maximum temperature near the contact between the quartz monzonite intrusion and the Cambrian sediments was 575-600°C, 3) relative to silts, limestones were impermeable to fluids and the flow of fluids was confined to silt beds and fractures, and 4) in silt, elements Na, K, Rb, Ba, Sr, As, Sb, Pb, and Cs have migrated over tens of meters, while there is no detectable migration of REE, V, Cr, Sc, Zr, Hf, and Al.

The second geological site is pegmatite - country rocks in the Black Hills, South Dakota. Five different pegmatites have been chosen to address (a) composition of fluids, (b) capability of dispensing fluids into country rocks, and (c) partitioning of mobile elements between mineral phases and fluids derived from pegmatites. Preliminary studies of the Tin Mountain, Etta, and Bob Ingersoll pegmatites show that there is virtually no migration of REE, Al, V, Sc, Cr, Hf, and Th elements. On the other hand, elements K, Li, Rb, Cs, As, Sb, Zn, and Pb have migrated 4 to 90 meters. The degree of migration varies depending on the element. Minerals biotite and muscovite are effective trace element traps for Li, Rb, and Cs. However, biotite has a greater affinity for Li, Rb, and Cs than muscovite and their relative affinities can be explained in terms of crystal chemistry. The REE concentrations in biotite and muscovite are high and indigenous. Similar types of chemical studies in other pegmatites emphasizing minerals such as apatite and tourmaline as a recorder of melt/fluid evolution are under progress. The chemical data on some 40 major and minor trace elements are obtained by neutron activation analysis and x-ray fluorescence.

This study is in collaboration with J. J. Papike of South Dakota School of Mines and Technology, Rapid City, South Dakota, who will obtain mineralogic and petrologic data on the same samples.

Contractor: SANDIA NATIONAL LABORATORIES
Albuquerque, New Mexico 87185

<u>Creep Response of NaCl at Low Stresses and Temperatures</u> (D.H. Zeuch and W. R. Wawersik)

The objective of this program is to investigate the creep mechanics of sodium chloride at low temperatures and stresses. The creep response of sodium chloride has been studies extensively at temperatures above approximately one-half the absolute melting point, where it appears that dislocation climb is the creep mechanism; however, relatively little work has been carried out at lower temperatures. Such results as are available suggest that the dominant creep mechanism under lower-temperature conditions may be a thermally activated glide or cross-slip process. This in turn implies that creep history and initial substructure may exert a profound influence on the creep behavior of sodium chloride, because recovery is (implicitly) slow.

Work is in progress to conduct creep experiments on sodium chloride single crystals under low stress, low temperature conditions outside the range of any previous testing. Single-stage creep tests will be performed to assess the basic creep properties and substructural evolution of the single crystals. In addition, multistage temperature and stress-changing experiments will be carried out to determine the activation parameters and stress dependence of creep in order to: (1) identify the deformation mechanism(s); (2) quantify the kinetics of recovery; and (3) determine the influence of initial substructure on creep.

A specialized creep frame has been constructed to perform the tests, and a series of cold-working/annealing tests have been carried out in order to develop techniques for the alteration of the initial substructure of the synthetic single crystals. The substructural modification tests also provided preliminary results on the kinetics of recovery of chloride; the apparent activation energy associated with the recovery process is consistent with a cross-slip mechanism at lower temperatures.

Clay-H_2O Interactions (J. L. Krumhansl)

The ability to predict the course of rock-water interactions at temperatures up to 350°C is critical to a large number of geochemical, geophysical, and energy related problems. To a large degree these predictions depend on a knowledge of the kinetic and thermodynamic constraints governing clay mineral dissolution. This problem has been approached through the use of a Dickson hydrothermal apparatus, and by employing standardized clays. To date the Wyoming bentonite SWy-1 has been subjected to tests of at least two months duration at 200 and 300°C, and in both acidic (pH = 2.1) and neutral solutions. The results of these tests indicate that clay dissolution is highly incongruent, that hydroxide complexing of both aluminum and iron is an important factor in governing the overall solubility, and that when compared to theoretical estimates derived using a Tardy-Garrels type approximation, the clay is somewhat more stable than would have been anticipated. It was also found that run times of at least six weeks were required for the system to achieve steady state; consequently, evaluation of a wide range of clays (of differing compositions) will proceed somewhat more slowly than had been anticipated in the original proposal.

Contractor:	CALIFORNIA INSTITUTE OF TECHNOLOGY Seismological Laboratory, Division of Geological and Planetary Sciences Pasadena, California 91125
Contract:	DE-AT03-83ER13120
Title:	In Situ Stress in Deep Boreholes
Person in Charge:	T. J. Ahrens

Scope of Work

Knowledge of the in situ stress in the earth is important to our understanding of contemporary tectonic, geothermal, and rock-forming processes, and provides information which is required to exploit energy resources and store waste in the earth.

We are developing a new type of stressmeter which employs interference holography and by means of laboratory and field measurements, we are attempting to turn it into a useful geophysical tool.

This development was carried out with a 12" diameter device which is lowered into boreholes and first locks in place. Then a holographic exposure is taken of the borehole wall, a side-core hole is drilled which relieves in situ stress and a second hologram is taken. The resulting interference hologram yields a map of displacement, which is inverted to obtain the 6 components of the in situ stress tensor.

Current Activities (J. Bass, D. Schmitt, and T. J. Ahrens)

We have completed laboratory and initial field tests of this new device, which we believe will become a useful tool in borehole geophysics. Laboratory tests included carrying out measurements on samples, under known prestress, and developing the numerical methods for calculating synthetic interference holograms for inverting field data. In 1983, we carried out a successful series of field tests of the holographic tool at depth in the Union Oil Co. oil shale mine in a series of 12" holes especially drilled for us. We obtained an outstanding set of good results. We have performed a preliminary analysis of these data to yield values of maximum and minimum horizontal stress and stress orientation which agrees well with values obtained by other methods (hydrofracture) in this region by Bredehoeft et al. (1978). These results and the description of the operation of the instrument are currently being described in a scientific paper, "In situ stress measurements with borehole interference holography."

Because most uncased scientific drillholes in the U.S. are 6" or less in diameter, we are currently developing a 5 1/2" diameter field version of the earlier instrument. We expect that this instrument will be compatible with both standard and high temperature 7-conductor borehole logging cable. Many details of design include film transport, optical systems, rotation, locking, orientation transducing, internal pressurization, mud-filtering, and side-hole coring, are being improved as a result of our experience with the 12" "laboratory-field" apparatus. We expect this device could operate initially at depths of several hundred meters using film. With a new indium-oxide coated photoconductor polyvinylcarbozole film which is erasable, and an electronic-optic scanner on-board the apparatus, we expect to eventually provide a television-like display of interference fringes on the surface. With this remote read-out device, we expect that the apparatus will have a depth capability of several km.

A final series of tests of the 12" apparatus is now scheduled for June 1984. After this point we will put all our effort into fielding a 6" device in existing scientific boreholes in S. California and other holes of opportunity.

Contractor: UNIVERSITY OF CALIFORNIA
Department of Geology and Geophysics
Berkeley, California 94720

Contract: DE-AM03-83ER13100

Title: Advective-Diffusive/Dispersive Transport of Chemically Reacting Species in Hydrothermal Systems

Person in Charge: H. C. Helgeson

Scope of Work

A phenomenological transport code based on continuum theory is being developed to describe fluid flow and simultaneous chemical reactions representing ion association, oxidation/reduction, ion exchange, and mineral hydrolysis in hydrothermal systems. Mass and heat transfer coupled to reversible reactions by the law of mass action and irreversible reactions described by kinetic rate laws are included in the code. Transport equations representing conservation of mass and energy are solved numerically for transient conditions of fluid flow in porous and fractured media. The fluid flux equation contains an advective term corresponding to Darcy's law and a diffusive/dispersive term based on Fick's first law.

Preliminary tests of the code so far developed include validation of the chemical algorithms used in the code by comparison with the equilibrium speciation and mass transfer program package EQ3/EQ6 developed by Wolery (1979), as modified by Helgeson and Murphy (1983) to include mineral dissolution kinetics. The results of calculations for reaction paths in a closed system obtained by considering a single node in the transport code with appropriate boundary conditions for complex systems involving activity coefficients, aqueous complexes, and reaction products compare favorably with the partial equilibrium model. Furthermore, the computation time is considerably faster, which is indispensible for integrating chemistry with fluid flow. The transport code has also been tested for the case of diffusional mass transfer coupled to reversible precipitation/dissolution reactions by comparing numerical results with the analytical steady-state limit obtained by Helfferich and Katchalsky (1970) for a two-component system. In the transient case considered, the calculations indicate that the zone of mineral precipitation first oversteps the steady-state limit and then dissolves at its boundaries, shrinking in size until steady-state is reached. Multi-mineralic zones were found to move in a complicated fashion before reaching steady-state.

Contractor: LAMONT-DOHERTY GEOLOGICAL OBSERVATORY
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Contract: DE-AC02-76ER04054

Title: Fluid Transport Properties of Rock Fracture

Person in Charge: T. Engelder and C. Scholz

Scope of Work

Our problem is to understand the parameters that limit fluid flow within the crust of the earth. Because the major flow paths are through joints within the crust the rock-water interaction along joints is of most interest to our project. This problem is important to the DOE because the extraction of hydrocarbons and geothermal energy is critically dependent on flow along fractures toward well bores. Yet, the burial of nuclear waste requires conditions which limit or stop the flow of fluid away from the waste repository.

Flow is governed by the mechanical closure of joints as well as the dissolution and precipitation of components within the joints. During the past year our attention has been divided between two projects: 1) the correlation between flow rate and the change in water chemistry along joints; and 2) the closure of random surfaces in contact.

A. Chemistry

Experiments on the correlation between flow rate and the change in water chemistry were run in a triaxial testing machine with confining pressures up to 100 MPa and pore fluid pressures some predetermined fraction of 100 MPa. Temperatures were up to 100 C. The experiments were accomplished by recycling an 80 cc charge through the rock sample (primarily) a quartzite with some impurities and a granite). Usually the sample consisted of a split cylinder to simulate a joint. Samples were taken at predetermined intervals until the 80 cc charge was exhausted.

For very rough joints the flow rate did not change with time as the fluid chemistry approached equilibrium values. At room temperature, 14 days were required for equilibrium between the water and rock. For chemical components such as Ca, Na, K, and Mg equilibrium was approached asymptotically. For a polished joint with smaller apertures equilibrium was established at about the same rate, but the flow rate decreased with time with the rate of decrease slowing after a couple of days. Future work includes identifying the mechanism for this time-dependent flow rate.

B. Closure

The Greenwood-Williamson-Walsh-Grosenbaugh theory describing the elastic deformation of joints has been written in a more general form. We have tested this theory quantitatively in the laboratory. This has been done by comparing joint closure from experiment with joint closure predicted by the theory. These comparisons were made using actual topography data from the surfaces of the joints used in the experiments.

Joint closure experiments were done using fused silica glass as a materials because of its isotropy and its well-known elastic moduli. Joints consisted of saw-cuts whose faces were ground with #220, #120, #80, and #60 polishing grits. Experiments were done where one rough surface was in contact with a flat surface and where two similar rough surfaces were in contact. Maximum stresses reached in these experiments ranged from 7.5 MPa to 10 MPa.

The maximum joint closure at a given normal stress does not, in general, depend solely on the rms height of the surfaces in contact. The amount of joint closure depends more strongly on the shape of the uppermost tail of the probability density function for summits (local maxima) on the surfaces. To compute the surface topography parameters in the joint closure theory using one-dimensional profiles, a model for surface topography must be assumed. The best agreement between theory and experiment is obtained with a model that includes the true skewed nature of the probability density functions associated with the surfaces in contact. For these experiments, the inverted chi squared model for surface topography of Adler and Firman (1981) shows much better agreement with experiment than does the gaussian model of Nayak (1971).

Contractor:	MASSACHUSETTS INSTITUTE OF TECHNOLOGY Department of Earth, Atmospheric, and Planetary Sciences Cambridge, Massachusetts 02139
Contract:	DE-AC02-78ER04972
Title:	Microcracks and Energy
Person in Charge	G. Simmons

<u>Scope of Work</u>

The objective of this project is to develop the scientific basis for the practical utilization of microcracks in DOE energy programs.

Open microcracks control such important properties as hydraulic permeability, electrical conductivity, compressibility, thermal expansion, and the velocities of elastic waves. Healed microcracks provide data on the pressure-temperature-stress history of a rock and may be useful in estimating the properties at the time the healed cracks were open. The potential applications include (1) site characterization for waste repositories; (2) estimation of the changes of permeability of rock in situ due to changes of temperature associated with production in a hot-dry-rocks geothermal system; (3) prediction of the behaviour of certain isotopes in radioactive waste emplaced in granitic rocks; and (4) improvements in the exploration techniques for uranium in crystalline rocks.

We use the petrographic microscope, the scanning electron microscope (SEM) equipped with both high energy resolution backscattered electron detector and imaging system and an energy dispersive x-ray system, and various physical properties measured as a function of pressure to characterize microcracks. The SEM yields information on healed cracks (composition and extent of the minerals that fill formerly open microcracks, extent of healing, and the physical dimensions). Presently open microfractures are characterized with the SEM and also with a high precision technique for the measurement of strain as a function of pressure (differential strain analysis, DSA).

We have examined the mobilization of uranium and rare earth elements in several igneous rocks: Conway and Mount Osceola granites of New Hampshire, Sherman granite of Wyoming and Colorado, the Carnmenellis granite of southwest England, and various granites and contiguous metasedimentary rocks near Augusta, Maine. Several different uranium-bearing and REE-bearing minerals occur in the microcrack in these rocks over extensive geographical areas and vertical depths - at least 250 square kilometers and a vertical extent of one kilometer for the New Hampshire granites. Because thorium-bearing secondary minerals also occur in the same microcracks, it now appears that thorium may have been mobilized along with U and the REEs.

Uranium and REEs were mobilized in the Sherman granite over distances of at least 50 kilometers and vertical extent of 350 meters. They have remained immobile for one billion years. It would appear that this granite provides a guide to the type of crystalline rock for use as a high level rad-waste repository: namely, a granite pluton that has been altered and in which the microcracks are sealed.

Contractor:	STANFORD UNIVERSITY DEPARTMENT OF APPLIED EARTH SCIENCES Stanford, California 94305
Contract:	DE-AT03-84ER12016
Title:	III. The Hydrothermal Solubility of Uraninite
Persons in Charge:	G. A. Parks and D. C. Pohl

Scope of Work

The equilibrium solubility of uranium (IV) dioxide (UO_2) in aqueous solution is a function of solution composition (pH, ligand concentration, and ionic strength), oxidation-reduction potential, temperature, and pressure. The limiting concentration of uranium in natural aqueous systems depends on these factors as well as adsorption and more complex rock- and soil-water interactions. These constraints must be recognized and accounted for in solution transport and fixation models. The thermodynamic data required to utilize these models and to compute the solubility limit of uranium exist for near-surface conditions of low temperature and high oxidation potential, but data for higher temperatures and pressures is limited both in extent and precision. This is especially true for tetravalent uranium species.

The major thrust of this work is to obtain equilibrium solubility data for stoichiometric UO_2 in the system UO_2-H_2O while varying pH but while maintaining f_{O2} conditions at sufficiently low levels to maintain the low oxidation state both in the solid and solution. The temperature range of the experiments is from 100 to 400°C at 500 bars total pressure.

The experimental approach involves reacting spherical, uranium dioxide pellets with solution in Dickson-Gordon hydrothermal apparatus which permits solution samples to be withdrawn into gastight containers at ambient P/T conditions of the experiement. Equilibrium is approached both from over-saturated and under-saturated conditions. The UO_2 solid is characterized both before and after each experiment. The oxygen fugacity (redox potential) is controlled in the experimental apparatus by maintaining a fixed partial pressure of hydrogen within the reaction cell. Attempts to monitor in situ pH at ambient P/T conditions of the experiment have not been successful as it proved impossible to maintain stable electrode potentials for the duration of the experiments. Hydrogen ion activity is now measured at 20°C and extrapolated to the P/T conditions of the experiment by computer.

We have completed a series of fifteen solubility experiments from pH 1 to pH 7 at 200 and 300°C and eleven in the range from 100 to 400°C. Preliminary analysis of the results indicates that total uranium in solution is at least an order of magnitude higher than predicted from thermodynamic calculations using the data base of Lemire and Tremaine (1980) and EQ3/6 (Wolery, 1978). The results show only a very slight increase in solubility from 100 to 300°C.

Our UO_2 is pre-reduced in H_2 at 900°C and NiO in crimp-sealed Pt capsules included in some runs is reduced to Ni metal, verifying that the low f_{O2} desired, is achieved. Other investigators have had difficulty in achieving reduction of uranium to U(IV) in solution. We are concerned that persistent surface oxidation of our samples may be responsible for the high solubility and scatter observed.

Because the predicted and measured uranium solubility of UO^2 approaches or falls below the limit of detection of our analytical method (2×10^{-10}M) near neutral pH, we hope to complete the UO_2-H_2O (NaCl - NaOH) system experiments by conducting experiments at high pH to extend and confirm the high temperature solubility data of Tremaine et. al., 1981.

Contractor:	SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY Rapid City, South Dakota 57701-3995
Contract:	DE-AC01-82ER-12050
Title:	Thermally Induced Chemical Migration: A Natural Analog Approach
Person in Charge:	J. J. Papike

Scope of Work

The major objective of this research is to gain a quantitative understanding of chemical migration in the geologic environment over a range of temperatures and pressures and in diverse geologic media. Contact metamorphic occurrences serve as geologic analogs with the igneous intrusion providing the neat and trace element source, and the country rock the medium through which migration takes place. The specific sites for this study are pegmatite/wallrock interaction zones in the Black Hills, SD. This type of study provides information on chemical migration over geologic times; a time span that cannot be duplicated in laboratory experiments or with presently available calculation procedures.

Key Questions Being Addressed

1. What is the extent of chemical migration under differing geologic conditions, e.g., P, T, composition of solutions, and nature of country rock?
2. What are the relative mobilities of elements of interest, e.g., Cs, Rb, Li, Sr, etc.?
3. What are the mechanisms of migration, e.g., nature of fluid phase, speciation, etc.?
4. What are the mechanisms of retardation, e.g., sorption, equilibrium cation exchange, etc.?
5. What is the partitioning behavior of the elements of interest among the mineral phases in the host rock and migrating fluid phase?
6. What are the mechanisms of fluid and chemical migration through granite complexes? How does this migration manifest itself?

Some Initial Findings from Pegmatite/Wallrock Studies

1. Maximum temperature of country rock was approximately 510-540°C.
2. The migration of Li and Cs has taken place to distances greater than 90 meters. Rb has migrated up to 10 meters.
3. The relative mobilities of Li, Cs, and Rb are: Li > Cs >> Rb.
4. There is no detectable migration of REE, Al, V, Sc, Cr, Hf, U, Th.
5. Sheet silicates are effective trace element traps. Biotite is a much more effective trap as indicated by Kd's for biotite/muscovite pairs: Cs-12.3, Rb-2.5, and Li-4. These partition coefficients agree with experimentally determined coefficients for phlogopite and muscovite and can be rationalized in terms of the crystal chemistry of these sheet silicates. This work is being done in collaboration with J. C. Laul (Pacific Northwest Laboratories), who is conducting the INAA and RNAA analyses.

MISCELLANEOUS
(Natural Analogs, Computer Modeling, Workshops)

Examples: "Chemical Migration by Contact Metamorphism in Granite-Country Rocks" (PNL/Laul; SDSM/Papike)

"Workshop [6/84] on Fundamental Geochemistry Needs for Nuclear Waste Isolation" (LANL/Erdal)

Totals: National Labs (3; 245K$)
Universities (2; 195K$)

NWI/Geosciences (22; 2,748K$) (12; 1,252K$)

GEOSCIENCES PROGRAM FOR NUCLEAR WASTE ISOLATION
(DOE/OBES)

NWI is a complex and long-term problem

- **Continuing production of waste**
- **Continuing evolution of ideas on isolation strategy**
  e.g., solid earth (salt, basalt, granite, tuff, etc.)?
  ocean bed?
  space?

Geologic barriers have long time scale

• **Waste form, canister, overpack**	$\sim 10^3$y
• **Back-fill & near-field**	$\sim 10^4$y
• **Geologic/hydrologic stability**	$\sim 10^{5+}$y

BES/Geosciences program must be generic, basic, long-range

HOST ROCK PROPERTIES

(Physical Properties, Seismic, In Situ Measurements)

Examples: "Creep Response and Substructure of NaCl at low Stresses and Temperatures" (SNL/Zeuch)

"Underground Imaging" (LLNL/Duba)

"In Situ Stress in Deep Boreholes" (CIT/Ahrens)

Totals: National Labs (8; 1085K$) Universities (5; 432K$)

GEOLOGY

(Regional Setting of Sites)

Examples: "Geologic, Geochemical and Sr, Nd and Pb Isotopic Studies of an Anomalous Late Cenozoic Basalt Province in the South Central Great Basin"

(LANL/Curtis)

"Remote Sensing and Geoscience Data Base"

(PNL/Foote)

Totals: National Labs (2; 215K$)

THERMODYNAMICS
(Thermochemical Data Base, Modeling)

Examples: "Thermodynamics of High Temperature Brines"

(LBL/Pitzer)

"Thermochemistry of Geothermal Materials"

(ANL/O'Hara)

Totals: National Labs (4; 425K$)
Universities (1; 185K$)

GEOCHEMISTRY
(Waste-Water-Rock Interaction in Open System)

Examples: "Migration of Heavy Element Chemical Species in Geologic Strata"
(ANL/Fried)

"Hydrothermal Solubility of Uraninite"
(Stanford/Parks)

"Geochemistry of Technetium"
(LANL/Curtis)

Totals: National Labs (5; 493K$)
Universities (2; 110K$)

HYDROLOGY

(Porosity, Permeability, Flow of Reactive Fluids)

Examples: "Fundamental Studies of Fluid Flow in Fractured Rock Masses Under Stress" (LBL/Witherspoon)

Totals: National Labs (3; 280K$)

Universities (2; 330K$)

THE 1984-85 EMaCC MEETING PROGRAM

Date and Place	Special Meeting Subjects	Guest Speakers and EMaCC Subcommittee Chairman
June 15, 1984 Germantown	Impacts of U. S. Export Controls on Transfer of DOE Materials Programs Technology	Jeff Tripp and Jim Seevaratnam Office of Export Administration U. S. Department of Commerce
Sept. 21, 1984 Forrestal	The DARPA Materials Sciences Program	Benjamin Wilcox Assistant Director for Materials Sciences Defense Advanced Research Projects Agency (DARPA)
Sept. 21, 1984 Forrestal	The DOE-BES Materials Sciences Program	Louis Ianniello Director, Division of Materials Sciences, BES
Oct. 19, 1984 Germantown	DOE On-Line Numeric Data Network: A Materials Data Demonstration	Bonnie C. Carroll Director, Office of Program Development, DOE/OSTI
Dec. 3, 1984 Forrestal	Workshop on How to Obtain Information on Materials Science Research	Dora Moneyhun Director, Office of Scientific and Technical Information (OSTI)
Jan. 8, 1985 Forrestal	Structural Ceramics Subcommittee Joint Meeting	Sandy Dapkunas, Chairman
Jan. 25, 1985 Forrestal	Batteries and Fuel Cells Subcommittee Joint Meeting	Iran Thomas, Chairman
Feb. 15, 1985 Germantown	Radioactive Waste Containment Subcommittee Joint Meeting	Henry Walter, Chairman
Feb. 15, 1985 Germantown	Structural Ceramics (Part 2)	Sandy Dapkunas, Chairman
May 14, 1985 Germantown	Steel Subcommittee Joint Meeting	Ted Reuther, Chairman

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Keyword Index
(Numbers refer to project numbers in the text.)

*U.S. GOVERNMENT PRINTING OFFICE: 1985-461-209:30052

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