DOE/ER-0340

ENERGY MATERIALS COORDINATING COMMITTEE (EMaCC)

Fiscal Year 1986

May 1987

ANNUAL TECHNICAL REPORT

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

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Washington, D.C. 20545

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INTRODUCTION

The DOE Energy Materials Coordinating Committee (EMaCC) serves primarily to enhance coordination among the Department's materials programs and to further the effective use of materials expertise within the Department. These functions are accomplished through the exchange of budgetary and planning information among program managers and through technical meeting/ workshops on selected topics involving both DOE and major contractors. Four topical subcommittees on Structural Ceramics, Batteries and Fuel Cells, Radioactive Waste Containment, and Steel are established and are continuing their own program. The FY 1986 meeting program is given on Page 5. In addition, the EMaCC aids in obtaining materials-related inputs for both intra- and inter-agency compilations.

Memberships in the EMaCC is open to any Department organizational unit; participants are appointed by Division or Office Directors. The current active membership is listed on the following three pages.

The EMaCC reports to the Director of the Office of Energy Research in his capacity as overseer of the technical programs of the Department. This annual technical report is mandated by the EMaCC terms of reference. This report summarizes EMaCC activities for FY 1986 and describes the materials research programs of various offices and divisions within the Department.

The Chairman of EMaCC for FY 1986 was Robert B. Schulz and Iran L. Thomas was Executive Secretary. I am grateful to EMaCC subcommittee chairmen Stanley J. Dapkunas, Alan Landgrebe, Henry F. Walter, and Donald Keefer for their contributions to our program in FY 1986. The compilation of this report was assisted by DHR, Incorporated.

Iran L. Thomas
Office of Basic Energy Sciences
Division of Materials Sciences
Chairman of EMaCC, FY 1987

MEMBERSHIP LIST
DEPARTMENT OF ENERGY
ENERGY MATERIALS COORDINATION COMMITTEE

Organization	Representative	Phone No.
CONSERVATION AND RENEWABLE ENERGY		
Energy Utilization Res.	James J. Eberhardt, CE-12	586-5377
	Terry M. Levinson, CE-12	586-5377
Buildings and Community Systems		
Building Systems	William Gerken, CE-131	586-9187
Building Equipment	John Ryan, CE-132	586-9130
	Ronald Fiskum, CE-132	586-9130
	Danny C. Lim, CE-132	586-9130
Industrial Programs		
Waste Energy Reduction	Matthew McMonigle, CE-142	586-2082
	Scott Richlen, CE-141	586-2078
Improved Energy Prod.	Robert Massey, CE-142	586-8668
Transportation Systems		
Heat Engine Propulsion	Robert B. Schulz, CE-151	586-8032
	Charles H. Craig, CE-151	586-1506
Energy Storage and Dist.	Russel Eaton, CE-32	586-1506
	Michael Gurevich, CE-32	586-1495
	Eberhart Reimers, CE-32	586-4563
	Stanley S. Ruby, CE-32	586-1482
Solar Heat Technologies		
Solar Thermal Technology	Frank Wilkins, CE-331	586-1684
Solar Buildings Tech.	John Goldsmith, CE-332	586-8779
	David Pellish, CE-332	586-6436
Renewable Energy		
Biofuels and Mun. Waste	Donald Walter, CE-341	586-6104
Geothermal Technology	Raymond LaSala, CE-342	586-4198
Solar Electric Technologies		
Wind/Ocean Technologies	William Richards, CE-351	586-5540
Photovoltaic Technology	Morton B. Prince, CE-352	586-1725

MEMBERSHIP LIST (Continued)

Organization	Representative	Phone No.
DEFENSE PROGRAMS		
Defense Waste and Byproducts		
R&D and Byproducts	Ray D. Walton, Jr. DP-123	353-4970
Weapons Research Development and Testing		
Weapons Research	A. E. Evans	353-3098
	Robert A. Jones, DP-225.2	353-5492
Inertial Fusion		
Fusion Research	Carl B. Hilland, DP-232	353-3687
ENERGY RESEARCH		
Basic Energy Sciences		
Materials Sciences	Iran L. Thomas, ER-132	353-3426
Metallurgy and Ceram.	Robert J. Gottschall, ER-131	353-3428
Solid State Physics & Materials Chemistry	B. Chalmers Frazer, ER-132	353-3426
Eng. and Geosciences	Oscar P. Manley, ER-15	353-5822
Advanced Energy Proj.	Ryszard Gajewski, ER-16	353-5995
Fusion Energy		
Reactor Technologies	Theodore C. Reuther, ER-533	353-4963
Health and Environmental Research		
Physical and Tech.	Gerald Goldstein, ER-74	353-5348
FOSSIL ENERGY		
Management, Planning, and Technical Coordination		
Technical Coordination	E. E. Hoffman	(615) 576-0735
Coal Utilization, Advanced Conversion and Gasification		
Surface Coal Gasif.	James P. Carr, FE-24	353-5985

MEMBERSHIP LIST (Continued)

Organization	Representative	Phone No.
NUCLEAR ENERGY		
Program Support		
Safety QA and Safeguards	Benjamin C. Wei, NE-141	353-3927
Remedial Action and Waste Technology		
Waste Treatment Projects	Henry F. Walter, NE-24	353-5510
Uranium Enrichment		
Technology Deployment & Strategic Planning	Arnold Litman, NE-34	353-5777
Reactor Systems Development and Technology		
Defense Energy Projects & Special Applications	William Barnett, NE-522	353-3097
Advanced Reactor Prog.	Andrew Van Echo, NE-542	353-3930
	J. Edward Fox, NE-531	353-3985
	Arthur S. Mehner, NE-531	353-4474
Naval Reactors	Robert H. Steele, NE-60	557-5561
CIVILIAN RADIOACTIVE WASTE MANAGEMENT		
Engineering Licensing	Mark Frei, RW-23	586-9322
Transportation and Waste	Tien Nguyen, RW-33	586-2834

FY 1986* EMaCC MEETING PROGRAM

Date and Place	Special Meeting Subjects	Guest Speakers and EMaCC Subcommittee Chairman
Nov. 15, 1985 Germantown	Structural Ceramics Subcommittee Joint Meeting	Sandy Dapkunas, Chairman
Jan. 10, 1986 Germantown	Polymeric Materials Meeting	Iran Thomas, Chairman
Mar. 26, 1986 Forrestal	Batteries and Fuel Cells Subcommittee Joint Meeting	Alan Landgrebe, Chairman
Apr. 17, 1986 Germantown	Radioactive Waste Containment Subcommittee Joint Meeting	Henry Walter, Chairman
June 16, 1986	Steel Subcommittee Joint Meeting	Donald Keefer, Chairman

*During FY 1986, Robert B. Schulz, CE-151, was EMaCC Chairman and Iran L. Thomas, ER-132, was Executive Secretary.

ORGANIZATION OF THE REPORT

The first part of the Program Descriptions consists of a funding summary for each Assistant Secretary office and the Office of Energy Research. This is followed by a summary of project titles and objectives, including the program/project manager(s) and principal investigator (listed in the Directory, pages 432).

The second part of the Program Descriptions (starting on page 201) consists of more detailed project summaries with project goals and accomplishments. Each of these are numbered for purposes of reference in the Keyword Index (pages 465).

The Table of Contents lists two (2) page numbers for each entry: the first page number gives the funding summary or first program description; the second page number gives the first detailed project description.

The FY 1986 Budget Summary for materials activities in each of the 29 programs within the DOE are presented on pages 7 and 8.

FY 1986 BUDGET SUMMARY TABLE 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).

	FY 1986
Energy Conservation	$ 36,902,805
Office of Energy Utilization Research	7,195,000
Office of Buildings and Community Systems	1,684,505
Office of Industrial Programs	4,366,300
Office of Transportation Systems	23,657,000
Renewable Energy	$ 35,953,000
Office of Energy Storage and Distribution	6,809,000
Office of Solar Heat Technologies	3,837,000
Office of Solar Electric Technologies	23,900,000
Office of Renewable Technology	1,407,000
Office of Energy Research	$171,849,452
Office of Basic Energy Sciences	138,518,294
Office of Health and Environmental Research	650,000
Office of Fusion Energy	19,350,000
Small Business Innovation Research Program	13,331,158
Office of Nuclear Energy	$129,294,000
High Temperature Gas Cooled Reactors Division	6,180,000
Office of Terminal Waste Disposal and Remedial Action	5,995,000
Office of Uranium Enrichment	37,332,000
Office of Reactor Systems, Development and Technology	2,305,000
Office of Breeder Technology Projects	17,482,000
Office of Naval Reactors	6,000,000*
Office of Civilian Radioactive Waste Management	$ 21,907,000
Office of Storage and Transportation Systems	760,000
Basalt Waste Isolation Project Waste Package Materials Development	6,230,000
Office of Geological Repositions - Nevada Nuclear Waste Storage Investigations Projects	10,335,000

*Approximate

FY 1986 BUDGET SUMMARY TABLE FOR DOE MATERIALS ACTIVITIES (continued)

	FY 1986
Office of Civilian Radioactive Waste Management (Continued)	
Salt Repository Project	$ 4,257,000
Sandia National Laboratories: Brittle Fracture Technology Program	325,000
Office of Defense Programs	$ 44,962,000
Office of Inertial Fusion	3,000,000
Office of Military Applications	41,962,000
Office of Fossil Energy	$ 7,328,000
Office of Technical Coordination	5,628,000
Office of Surface Coal Gasification	580,000
Office of Oil, Gas, Shale, and Coal Liquids	0
Office of Coal Utilization	1,120,000
TOTAL	$448,196,257

PROGRAM SUMMARIES

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 1986 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.

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.

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

FY 1986

1.	Energy Conservation		$36,902,805
	a. Office of Energy Utilization Research		$ 7,195,000
		(1) Energy Conversion and Utilization Technologies Division	7,195,000
	b. Office of Buildings and Community Systems		$ 1,684,505
		(1) Building Systems Division	543,505
		(2) Building Equipment Division	1,141,000
	c. Office of Industrial Programs		$ 4,366,300
		(1) Improved Energy Productivity Division	2,125,300
		(2) Waste Energy Reduction Division	2,241,000
	d. Office of Transportation Systems		$23,657,000
2.	Renewable Energy		$35,953,000
	a. Office of Energy Storage and Distribution		$ 6,809,000
		(1) Energy Storage	4,189,000
		(2) Electric Energy Systems	2,620,000
	b. Office of Solar Heat Technologies		$ 3,837,000
		(1) Solar Buildings Technology Division	2,136,000
		(2) Solar Thermal Technology Division	1,701,000
	c. Office of Solar Electric Technologies		$23,900,000
		(1) Photovoltaic Energy Technology Division	23,900,000
	d. Office of Renewable Technology		$ 1,407,000
		(1) Geothermal Technologies Division	1,257,000
		(2) Biofuels and Municipal Waste Division	150,000

OFFICE OF ENERGY UTILIZATION RESEARCH

	FY 1986
Office of Energy Utilization Research Grand Total	$ 7,195,000
Energy Conversion and Utilization Technologies Division	$ 7,195,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 2,874,000
Solid Lubricants Deposited From the Gas Phase	50,000
Tribological Surface Modifications and Coatings	847,000
Modeling of Hard Coatings for Tribological Systems Operating Under Extreme Conditions	80,000
Tribological Studies on Coated High Speed Steel Cutting Tools	80,000
Abrasion and Impact Resistant Coatings	150,000
Mechanical Interactions of Rough Surfaces	75,000
Coordination of ECUT Plastics Recycling and Reuse Efforts	57,000
Assessment of the Economic Potential of Plastics Reuse	40,000
Laser Surface Modifications of Ceramics	100,000
Plasma-Assisted Sintering of Ceramics	145,000
Ion Implantation of Ceramics	385,000
Compositionally Modified Ceramics	150,000
Injection Molding of Electrosterically-Stabilized Oxide Suspensions in an Aqueous Medium	60,000
High Density Sol-Gel	150,000
Chemical Vapor Deposition of Ceramic Composites	145,000
Thin-Wall Hollow Ceramic Spheres from Slurries	150,000
Synthesis of SiC Whisker - $MoSi_2$ Matrix Composites for Elevated Temperature Applications	50,000
Ordered Metallic Alloys for Lightweight Applications	160,000
Materials Structures and Composition	$1,746,000
Mechanisms of Adherence at Ceramic-Metal Joints	156,000
Assessment of the State of the Art in Machining and Surface Preparation of Ceramics	0
Modeling of Boron-Effect in Ni_3AL	920,000
Predictions of Cubic Ordered Intermetallics	85,000
Predictions of Super-Strong Liquid Crystal Polymers	100,000
Predictions of Polymer Decompositions	75,000
Influence of Electronic Structure on Ordered Intermetallics	50,000

OFFICE OF ENERGY UTILIZATION RESEARCH (Continued)

	FY 1986
Materials Structures and Composition (continued)	
Reactive Polymer Processing Assessment	$ 65,000
Liquid Crystalline Polymers Assessment	0
Inorganic Polymers Assessment	15,000
Thermosetting Resins with Reversible Crosslinks	100,000
Biobased Polymers	50,000
Assessment of DoD/NASA Thermal Insulation Technology	30,000
Novel Technique for Particulate Removal from Molten Salts	100,000
Materials Properties, Characterization, Behavior, or Testing	$ 895,000
Ordered Metallic Alloys for High Temperature Applications	895,000
Device or Component Fabrication, Behavior, or Testing	$ 1,542,500
Friction and Wear of Ceramics at Elevated Temperatures	377,500
Observations of "Hot Spots" on Ceramics and Development of Theory	125,000
Lubricant Qualities of the Constituents of Base Stock Oil	490,000
Energy Efficient Gears	50,000
Modeling of Solid Ceramic Joints	175,000
Electromagnetic Joining of Ceramics - Laboratory Proof of Concept	0
Development of Tests for Ceramic-Ceramic and Ceramic-Metal Joints	150,000
Nondestructive Evaluation (NDE) of Ceramic Joints	100,000
NMR of Green State Ceramics	75,000
Instrumentation and Facilities	$ 137,500
Assessment of X-ray Methods for Investigations of Ceramic Wear Surfaces	37,500
Thin Film Thermocouples for Heat Engines	100,000

OFFICE OF ENERGY UTILIZATION 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.

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 two projects, the Materials Project and the Tribology Project. The Tribology Project is managed by Argonne National Laboratory (ANL) and the Materials Project by the Oak Ridge National Laboratory (ORNL). 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) 586-5377 for the Materials Project and Terry Levinson, (202) 586-5377 for the Tribology Project.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Solid Lubricants Deposited From the Gas Phase - DOE Contact T. Levinson, 202-586-5377; Pennsylvania State University Contact E. E. Klaus, 814-865-2574

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

Tribological Surface Modifications and Coatings - DOE Contact T. Levinson, 202-586-5377; ANL Contact Fred Nichols, 312-972-8292; Borg-Warner Contact William Sproul, 312-827-3131

- o Emphasis in FY 1986 is on hard coatings for cutting tool wear.

- Modeling of surface modification by ion-implanation is underway.

Modeling of Hard Coatings for Tribological Systems Operating Under Extreme Conditions - DOE Contact T. Levinson, 202-586-5377; George Washington University Contact Bruce Kramer, 202-676-8237

- Work based on Kramer's Thermomechanical-Mechanical Theory for tool wear, and predictions for increased wear resistance.

- Theory confirmed for coatings on Carbide inserts.

- Current tests of theory focusing on TiC, TiN, ZrC, ZrN, HfC, HfN coatings on T-15 High Speed Cutting Tool Steel inserts.

Tribological Studies on Coated High Speed Steel Cutting Tools - DOE Contact T. Levinson, 202-586-5377; University of California in Los Angeles Contact Rointan Bunshah, 213-825-2210

- Preparing coatings by a patented Activated Reactive Evaporation Process, for characterization and evaluation at ANL, as part of the program to confirm and exploit Professor Kramer's theory.

Abrasion and Impact Resistant Coatings - DOE Contact T. Levinson, 202-586-5377; LLNL Contact William Steele, 415-423-2949

- Development and testing of innovative wear resistant coatings constructed by anchoring high density mat of very fine, hard filaments or "hairs" into surface of bulk matrix, at near vertical angles.

- Tests established that dense mat of 2 to 5 micron diameter carbon fibers embedded in the surface of any epoxy matrix provided complete protection to the matrix in a sandblast tester (which completely destroyed unprotected specimens).

- Future tests are focusing on metal matrices, and on C, B, SiC, Al_2O_3, and ZrO fibers.

Mechanical Interactions of Rough Surfaces - DOE Contact T. Levinson, 202-586-5377; SKF Industries, Incorporated Contact John McCool, 215-265-1900, ext. 267

- Joint effort with Office of Basic Energy Sciences.

- Developing guidelines and techniques for the processing of surface roughness data generated in analog form.

Coordination of ECUT Plastics Recycling and Reuse Efforts- DOE Contact J. Eberhardt, 202-586-5377; Plastics Institute of America Contact Mike Curry or Al Spaak, 201-420-5552

- Study of various methods for recycling or recovering value from post-consumer plastic wastes.

Assessment of the Economic Potential of Plastics Reuse - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Randy Curlee, 615-576-4864

- Study of the economic viability of plastics reuse and the institutional incentives and barriers impacting market acceptance of recycle technologies.

Laser Surface Modifications of Ceramics - DOE Contact J. Eberhardt, 202-586-5377; North Carolina State Contact Jagdish Narayan, 919-248-1902 and 919-737-7874

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

- Work has expanded from silicon carbide to silicon nitride materials.

Plasma-Assisted Sintering of Ceramics - DOE Contact J. Eberhardt, 202-586-5377; Northwestern University Contact Lynn Johnson, 312-492-3537

- Investigation of the acceleration of sintering of ceramics via plasmas.

Ion Implantation of Ceramics - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Carl McHargue, 615-575-4344; Georgia Tech Contact Joe Cochran, 404-891-2051; Universal Energy Systems Contact Peter Pronko, 513-426-6900, ext. 113

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

- Current work is on ion implantation into TiB_2, ZrO_2, Al_2O_3, SiC, and Si_3N_4.

Compositionally Modified Ceramics - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Rodney McKee, 615-574-5144

- o Synthesis and characterization of layered structures of aluminum oxide and titanium oxides.
- o Study of the mechanics and mechanical behavior of the system.
- o Measurement of electrical and optical properties.

Injection Molding of Electrosterically-Stabilized Oxide Suspensions in an Aqueous Medium - DOE Contact J. Eberhardt, 202-586-5377; University of Washington Contact Ilhan Aksay, 206-543-2625

- o Attempts to produce a ceramic oxide suspension suitable for higher speed injection modeling but using an aqueous solvent and minimum organic additives.
- o Approach is to absorb polymer onto surface of submicron particle in suspension.
- o Concentrating on alpha-Al_2O_3.

High Density Sol-Gel - DOE Contact J. Eberhardt, 202-586-5377; LBL Contact Arlon Hunt, 415-486-5370

- o Development of process to produce controlled porosity materials with tailored thermal, optical, and physical characteristics.
- o Determination of the properties of the finished material as related to the preparation technique.

Chemical Vapor Deposition of Ceramic Composites - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Dave Stinton, 615-574-4556

- o Production of toughened ceramic matrix coatings via simultaneous chemical vapor deposition of dispersoid and matrix phases.
- o Development of silicon nitride-boron nitride coatings prepared from dichlorosilane, boron trichloride, and ammonia.

Thin-Wall Hollow Ceramic Spheres from Slurries - DOE Contact J. Eberhardt, 202-586-5377; Georgia Tech Contact Ted Chapman, 404-894-4815

- o Development of a technique for producing thin-wall hollow ceramic spheres in the .1-5mm diameter range using conventional dispersions of ceramic powders (slurries).

- o Initial work on Al_2O_3.

Synthesis of SiC Whisker-$MoSi_2$ Matrix Composites for Elevated Temperature Applications - DOE Contact J. Eberhardt, 202-586-5377; LANL Contact John Petrovic, 505-667-5452

- o Examination of SiC whisker-$MoSi_2$ matrix composites for potential elevated temperature structural applications in oxidizing environments.

Ordered Metallic Alloys for Lightweight Applications - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Wally Porter, 615-574-5143; Dartmouth Contact Erland Schusen, 603-646-2888

- o Identification and development of ordered metallic alloys as potential lightweight structural materials.

Materials Structures and Composition

Mechanisms of Adherence at Ceramic-Metal Joints - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Mike Santella, 615-574-4805

- o Investigations of the mechanisms of adherence at ceramic-metal joints.

- o Develop thermodynamic models to predict reaction of ceramics with liquid metal alloys.

Assessment of the State of the Art in Machining and Surface Preparation of Ceramics - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Dave Stinton, 415-574-4456

- o Assessment of the current state-of-the-art in the technologies of machining and surface preparation of ceramics.

- o Formulate recommendations for the need for further research and development.

Modeling of Boron-Effect on Ni_3Al - DOE Contact J. Eberhardt, 202-586-5377; LANL Contact Jeff Hay, 505-667-2097

- o Computer modeling of the interfacial properties of Ni_3Al and the role of solute atoms such as B in preventing brittle fracture at grain boundaries.

- o Modeling of electronic properties, interatomic potentials, atomistic simulation, and crack propagation.

Predictions of Cubic Ordered Intermetallics - DOE Contact J. Eberhardt, 202-586-5377; Imperial College of London Contact David Pettifor, 1-589-5111, ext. 5756 (England); ORNL Contact Don Nicholson, 615-575-5873

- o Develop and experimentally verify models for predicting ordered intermetallic alloys with cubic ordered crystal structures.

Predictions of Super-Strong Liquid Crystal Polymers - DOE Contact J. Eberhardt, 202-586-5377; LANL Contact Flonnie Dowell

- o Originate and develop advanced, first-principles, microscopic, molecular statistical-plysics theories into mathematical models to predict new molecular structures most likely to form liquid crystal polymers.

- o Chemical synthesis and experimental characterization of liquid crystal polymers.

Predictions of Polymer Decompositions - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Bill Thiessen, 615-574-4973

- o Develop computer models at the atomic/molecular level to guide the development and optimization of polymers.

- o Discover how to tailor polymers to allow recovery of value from waste plastics by approaches based on molecular decomposition and/or rearrangements.

Influence of Electroic Structure on Ordered Intermetallics- DOE Contact J. Eberhardt, 202-586-5377; Carnegie-Mellon Contact T. B. Massalski, 412-578-2708

- o Identification of phenomenological corrlations between the electronic structure and the ordering temperature and stacking arrangement in ordered intermetallics.

- Initiation of electronic-level calculations to explain the correlations in terms of valence electronic energies as functions of the atomic arrangements in various stacking sequences.

<u>Reactive Polymer Processing Assessment</u> - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Joseph Carpenter, 615-574-4571; University of Tennessee Contact Paul Phillips, 615-974-5304

- Assessment of base technology research in the area of reactive polymer processing in order to facilitate the greater use of lightweight polymer-based structural components.

<u>Liquid Crystalline Polymers Assessment</u> - DOE Contact J. Eberhardt, 202-586-5377; University of Tennessee Contact Paul Phillips, 615-974-5304

- Identification of research activities currently underway in the area of liquid crystalline polymers.

- Define research program to augment knowledge base.

<u>Inorganic Polymers Assessment</u> - DOE Contact J. Eberhardt, 202-586-5377; Pennsylvania State University Contact Harry Allock, 814-865-3527

- Assessment of research and development support of inorganic polymers.

<u>Thermosetting Resins with Reversible Crosslinks</u> - DOE Contact J. Eberhardt, 202-586-5377; Polytechnic of New York Contact Giuliana Tesoro, 718-643-5244

- Determination of the possibility of developing thermosetting resins with "reversible crosslinks."

- Production of plastics with the strengths, toughnesses, temperature capabilities, and corrosion resistances typical of thermoset resins but which can be easily reprocessed like a thermoplastic.

<u>Biobased Polymers</u> - DOE Contact J. Eberhardt, 202-586-5377; SERI Contact Helena Chum, 303-231-7249

- Exploration of the potential of innovative polymers from biomass, as well as biobased materials in general, for the production of inexpensive materials at a substantial overall energy savings.

- Formulation of a research program for the development of biobased materials: biomass-derived plastics, innovative bioprocessing, and biotechnology-produced lightweight materials.

Assessment of DoD/NASA Thermal Insulation Technology - DOE Contact J. Eberhardt, 202-586-5377; University of Kentucky Contact Alan Fine, 606-257-3713

- Assessment of the possibilities of technology transfer of specialized concepts from aerospace and other government programs to energy conservation applications in the civilian sector.

Novel Technique for Particulate Removal from Molten Salts- DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact D. O. Hobson, 615-574-5109

- Development of a device to remove particulates from a flowing molten metal stream just before it solidifies.

- Work focusing on molten aluminum with Al_2O_3 particles.

Materials Properties, Characterization, Behavior, or Testing

Ordered Metallic Alloys for High Temperature Applications- DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Chain Liu, 615-574-4459; several subcontractors

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

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

Device or Component Fabrication, Behavior, or Testing

Friction and Wear of Ceramics at Elevated Temperatures - DOE Contact T. Levinson, 202-586-5377; 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 $800^{o}F$.

Observations of "Hot Spots" on Ceramics and Development of Theory - DOE Contact T. Levinson, 202-586-5377; 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- DOE Contact T. Levinson, 202-586-5377; 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.

Energy Efficient Gears - DOE Contact T. Levinson, 202-586-5377; Northwestern University Contact Herbert Cheng, 312-491-7062

- Develop friction model to predict power losses in spur gears.

- Conduct experiment to validate the model.

Modeling of Solid Ceramic Joints - DOE Contact J. Eberhardt, 202-586-5377; Norton Company Contact Pierre Charreyron, 617-393-5962

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

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

Electromagnetic Joining of Ceramics - Laboratory Proof of Concept - DOE Contact J. Eberhardt, 202-586-5377; DHR, Inc. Contact Richard Silberglitt, 703-883-0833; NRL Contact Dave Lewis, 202-767-2131

o Develop methods for joining ceramic materials to one another by microwave-induced heating of the joint interface.

Development of Tests for Ceramic-Ceramic and Ceramic-Metal Joints - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Artie Moorhead, 615-574-5153

o Development of test specimens for measurement of fracture toughness of ceramic-ceramic and ceramic-metal brazements.

o Fabricate and test brazed fracture toughness specimens for comparison with theoretical data generated by finite models.

Nondestructive Evaluation (NDE) of Ceramic Joints - DOE Contact J. Eberhardt, 202-586-5377; ORNL Contact Bob McClung, 615-574-4466

o Investigation of methods for non-destructive evaluation of ceramic joints in order to increase body of knowledge concerning properties and characteristics that affect serviceability of the joints.

NMR of Green State Ceramics - DOE Contact J. Eberhardt, 202-586-5377; ANL Contact Bill Ellingson, 312-972-5068

o Exploration of the use of advanced nuclear magnetic resonance (NMR) imaging methods to characterize green-state ceramic materials.

Instrumentation and Facilities

Assessment of X-Ray Methods for Investigation of Ceramic Wear Surfaces - DOE Contact J. Eberhardt, 202-586-5377; Virginia Polytechnic Institute and State University Contact Charles Houska, 703-961-5652

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

Thin Film Thermocouples for Heat Engines - DOE Contact J. Eberhardt, 202-586-5377; NBS-Gaithersburg Contact Ken Kreider, 301-921-3281

- o Demonstration of the feasibility of a materials system and fabrication technique for measuring temperature inside the combustion chamber of ceramic insulated engines using thin film thermocouples.

OFFICE OF BUILDINGS AND COMMUNITY SYSTEMS

	FY 1986
Office of Buildings and Community Systems Grand Total	$ 1,684,505
Building Systems Division	$ 543,505
Materials Properties, Behavior, Characterization, or Testing	$ 543,505
Unguarded Flat Insulation Nichrome Wire Screen Tester	100,000
Settled Density Studies of Loose-fill Insulation	70,000
Heat Flow Modeling	50,000
Gas Diffusion and Effective Conductivity of Foam Insulation Versus Age	40,000
Corrosiveness of Thermal Insulating Materials	8,000
Improved Standard Reference Materials	50,000
High Temperature Insulation Standard Reference Materials	50,000
Theory of Radiative Heat Transport in Low-Density Insulations	0
Dynamic Latent Heat Storage Effects of Building Construction Materials	0
Assessment of the Physical and Thermal Properties of Masonry Block Products	0
Assessment of Spray-Applied Urethane Foam Materials	15,183
Assessment of Low Density Concretes and Cement Insulation	50,000
Radiative Properties of Insulating Materials	50,322
Acoustic Measurement of Attic Insulation	60,000
Building Equipment Division	$ 1,141,000
Materials Properties, Behavior, Characterization, or Testing	$ 666,000
Materials for Condensing Heat Exchangers	120,000
Non-Azeotropic Refrigerant Mixtures	521,000
New Gases/Diagnostics for High and Low Pressure Discharge Lamps	25,000

		FY 1986
Device or Component Fabrication, Behavior, or Testing	$	375,000
Mercury Isotope Enrichment		175,000
Zeeman Effect on Lamp Gas Plasma		175,000
Explore Performance of New Ingredients in High Intensity Discharge Lamps		25,000
Instrumentation and Facilities	$	100,000
Absorption Fluid Pairs Research		100,000

OFFICE OF BUILDINGS AND COMMUNITY SYSTEMS

The Office of Buildings and Community Systems 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 and building energy performance standards. 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 thermal energy performance effectiveness, durability, safety, and health impacts; to develop and verify analytical models that are useful to building designers and researchers for predicting the thermal performance characteristics of materials; to develop methods for measuring the thermal performance characteristics of materials; and to provide technical assistance, advice and data to organizations that develop consensus standards for the performance characteristics of materials. The DOE contact is Bill Gerken, 202-252-9446.

Materials Properties, Behavior, Characterization, or Testing

Unguarded Flat Insulation Nichrome Wire Screen Tester - DOE Contact B. Gerken, 202-586-9193; ORNL Contact David McElroy, 615-574-5976

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

Settled Density Studies of Loose-Fill Insulation - DOE Contact B. Gerken, 202-586-9193; ORNL Contact David McElroy, 615-574-5976

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

Heat Flow Modeling - DOE Contact B. Gerken, 202-586-9193; ORNL Contact David McElroy, 615-574-5976

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

Gas Diffusion and Effective Conductivity of Foam Insulation Versus Age - DOE Contact B. Gerken, 202-586-9193; MIT Contact Dr. Leon Glicksman, 617-253-2233

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

Corrosiveness of Thermal Insulating Materials - DOE Contact B. Gerken, 202-586-9193; Stevens Institute of Technology Contact Dr. Rolf Weil, 201-420-5257

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

Improved Standard Reference Materials - DOE Contact B. Gerken, 202-586-9193; NBS Contact Hunter Fanney, 301-975-5864

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

High Temperature Insulation Standard Reference Materials - DOE Contact B. Gerken, 202-586-9193; National Bureau of Standards Contact Jerome Hust, 303-497-3733

- Ceraboard 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.

Theory of Radiative Heat Transport in Low-Density Insulations - DOE Contact B. Gerken, 202-586-9193; 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.

Dynamic Latent Storage Effects of Building Construction Materials - DOE Contact B. Gerken, 202-586-9193; Manville Corp. Contact Jack Verschoor, 303-972-2262

- Acquisition of data concerning time rate of moisture adsorption and desorption in building construction materials and furnishings as a function of temperature and humidity changes.

Assessment of the Physical and Thermal Properties of Masonry Block Products - DOE Contact B. Gerken, 202-586-9193; Steven Winter Assoc. Contact Deane Evans, 212-564-5800

- Identification of available data regarding thermal properties of concrete and masonry units typically encountered in building practice.

Assessment of Spray-Applied Urethane Foam Materials - DOE Contact - Bill Gerken, 202-586-9193; Dynatech Contact- Ronald Tye, 617-868-8050

- o A technical assessment of material types used, production and installation procedures, application areas in buildings, properties that influence performance, new developments, and technical information gaps.

Assessment of Low Density Concretes and Cement Insulation- DOE Contact - Bill Gerken, 202-586-9193; NBS Contact- Walter Rossiter, 301-975-6719

- o Review of existing information and building practices concerning the use of lightweight concrete and foamed cement insulation.

- o Properties and composition of the materials, test methods used for evaluating the materials, the effect of the materials on other building components, types of applications and constructions for which they are used, and installation techniques.

Radiative Properties of Insulating Materials - DOE Contact- Bill Gerken, 202-586-9193; University of Mississippi Contact - Jeffery Roux, 601-232-5375

- o Laboratory reflectance measurements in the 3 to 50 micron wavelength range for several types of thermal insulation to determine their spectral absorption and scattering coefficients.

Acoustic Measurement of Attic Insulation - DOE Contact- Bill Gerken, 202-586-9193; NBS Contact - Daniel Flynn, 301-975-6634

- o A laboratory feasibility study to determine the value of using acoustical techniques to evaluate the density, thickness and thermal resistance of installed loose fill thermal insulations.

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, 202-586-9130; Battelle Contact George Stickford, 614-424-4210; 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.

Non-Azeotropic Refrigerant Mixtures - DOE Contact Terry Statt, 202-586-9127; 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.

New Gases/Diagnostics for High and Low Pressure Discharge Lamps - DOE Contact John D. Ryan, 201-586-9130; GTE Contact Dr. Jacob Maya, 617-777-2309

- Establish the viability of Laser Induced Fluorescence (LIF) technique for measuring radial excited state distributions in low and high pressure discharges as well as novel discharges such as isotopically enriched and magnetic fluid enhanced fluorescent lamps.

Device or Component Fabrication, Behavior, or Testing

Mercury Isotope Enrichment - DOE Contact John D. Ryan, 202-586-9130; 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 John D. Ryan, 202-586-9130; LBL Contact Dr. Sam Berman, 415-486-5682

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

Explore Performance of New Ingredients in High Intensity Discharge Lamps - DOE Contact John D. Ryan, 202-586-9130 and Michael Lopez, 415-273-4264; GE Contact Dr. V.D. Roberts, 518-385-8983

o Examine the performance (efficacy, electrical properties) of new ingredients in high intensity discharge lamps.

Instrumentation and Facilities

Absorption Fluid Pairs Research - DOE Contact Ronald Fiskum, 202-586-9130; ORNL Contact George Privon, 615-574-1013

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

OFFICE OF INDUSTRIAL PROGRAMS

	FY 1986
Office of Industrial Programs Grand Total	$ 4,366,300
Improved Energy Productivity Division	$ 2,125,300
Materials Preparation, Synthesis, Deposition, Growth or Forming	$ 400,000
Corrosion Resistant Amorphous Metallic Films	200,000
Investigation of Material for Inert Electrodes in Aluminum Electrodeposition Cells	200,000
Materials Properties, Behavior, Characterization or Testing	$ 1,285,000
Diagnostic Sources of Current Inefficiency in Industrial Molten Salt Electrolytic Cells by Raman Spectroscopy	180,000
Expand and Control Inert Electrode Cell Operating Conditions	1,105,000
Instrumentation and Facilities	$ 440,300
Rapid In-Situ Analysis of Molten Metal	265,000
Direct Measurement of Thermal State of Solids	175,300
Waste Energy Reduction Division	$ 2,241,000
Materials Properties, Behavior, Characterization or Testing	$ 1,061,000
Advanced Heat Exchanger Material Technology Development	600,000
Assessment of Strength Limiting Flaws in Ceramic Heat Exchanger Components	395,000
National Laboratory Support to Assessment of Strength Limiting Flaws in Ceramic Heat Exchanger Components	66,000
Device or Component Fabrication, Behavior or Testing	$ 1,180,000
R&D of a CVD Composite Heat Exchanger	500,000
R&D of a Ceramic Tubular Distributor Plate for Advanced Fluidized Bed Heat Recovery	180,000
R&D of a Ceramic Fiber Composite Heat Exchanger	500,000

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. It also encourages the private sector to implement and deploy such technologies as they are developed. Materials research is done in support of the technologies under development, to develop materials with lower embodied energy and to provide materials for use in equipment/ systems which can improve energy efficiency.

Improved Energy Productivity Division

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

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Investigation of Material for Inert Electrodes in Aluminum Electro-Deposition Cells - DOE Contact M. J. McMonigle, 202-586-2087; MIT Contact J. S. Haggarty, 617-253-3300

- Generation of ultra pure powders and single crystals of candidate ceramic inert anodes using laser units and testing via pendant droplet technique.

Corrosion Resistant Amorphous Metallic Films - DOE Contact Robert Massey, 202-586-8668; JPL Contact Edward Cuddihy, 818-354-3188

- Development of magnetron sputtering of MoCrB and TiCrPC on carbon steel to provide corrosion resistant surface.

Materials Properties, Behavior, Characterization, or Testing

Diagnostic Sources of Current Inefficiency in Industrial Molten Salt Electrolytic Cells by Raman Spectroscopy- DOE Contact M. J. McMonigle, 202-586-2087; MIT Contact D. R. Sadoway, 617-253-3300.

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

Expand and Control Inert Electrode Cell Operating Conditions - DOE Contact M. J. McMonigle, 202-586-2087; MIT Contact John Haggarty, 617-253-3487.

- Development of cermets for inert anodes and testing of attachment techniques for TiB_2 stable cathode.

Instrumentation and Facilities

Rapid In-Situ Analysis of Molten Metal - DOE Contact W. E. Eckhart, 202-586-9549; LANL Contact L. Balir, 505-667-6250

- o Development of a laser-based system for spectrographic analysis of liquid steel to provide for a faster analytical method in order to increase productivity in the steel industry.

Direct Measurement of Thermal State of Solids - DOE Contact W. E. Eckhart, 202-586-9549; PNL Contact Douglas Lemon, 509-375-2306

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

Waste Energy Reduction Division

Waste Energy Reduction is concerned with the efficient conversion of fuel to a more useful energy form and with the utilization of energy embodied in waste products--solids, liquids, and gases. This division conducts research to develop advanced waste energy recovery technologies for the industrial sector.

Materials Properties, Behavior, Characterization, or Testing

Advanced Heat Exchanger Material Technology Development- DOE Contact S. Richlen, 202-586-2078; ORNL Contact E. Long, 615-574-5172.

- o Development of improved materials and fabrication processes for advanced ceramic heat exchangers.
- o Expanding the material data base for advanced ceramic heat exchangers.
- o Evaluation of corrosive waste stream constituents on candidate ceramic materials.
- o Development of techniques for extrusion of toughened oxide ceramic heat exchanger components.

Assessment of Strength Limiting Flaws in Ceramic Heat Exchanger Components - DOE Contact S. Richlen, 202-586-2078; Babcock & Wilcox Contact T. Powers, 804-522-5038

- o Evaluation of the effect of operating environments on flaw populations of ceramic heat exchanger components using advanced NDE methods.

National Laboratory Support to Assessment of Strength Limiting Flaws in Ceramic Heat Exchanger Components- DOE Contact S. Richlen, 202- 586-2078, Idaho National Laboratory Contact D. Kunerth, 208-526-0103

- o Development of advanced NDE, test methods, and other key technologies to support Babcock & Wilcox studies of strength limiting flaws in ceramics.

Device or Component Fabrication, Behavior or Testing

R&D of a CVD Composite Heat Exchanger - DOE Contact S. Richlen, 202-586-2078; Thermo-Electron Co. Contact W. Cole, 617-890-8700

- o Study of problem areas in materials and fabrication techniques for chemical vapor deposition (CVD) of ceramic materials on ceramic fibers.

R&D of a Ceramic Tubular Distributor Plate for Advanced Fluidized Bed Heat Recovery - DOE Contact S. Richlen, 202-586-2078; Aerojet Energy Conversion Co. Contact M. Rudnicki, 916-355-2493

- o Study of fabrication and material problems of forming a ceramic tubular distributor plate.

R&D of a Ceramic Fiber Composite Heat Exchanger - DOE Contact S. Richlen, 202-586-2078; Babcock & Wilcox Contact W. Parks, 804-525-8660

- o Evaluation of critical problems of fabricating a ceramic fiber reinforced ceramic matrix.
- o Characterization of potential ceramic fibers and chemical systems for matrix formation.
- o Study of matrix fabrication techniques, with analytical and exposure testing of the formed matrices.

OFFICE OF TRANSPORTATION SYSTEMS

	FY 1986
Office Of Transportation Systems Grand Total	$23,657,000
Materials Preparation, Synthesis, Deposition, Growth or Forming	$ 4,683,000
Silicon Carbide Powder Synthesis	266,000
Sintered Silicon Nitride	86,000
High Pressure Sintering Furnace	91,000
Si_3N_4 Powder Synthesis	144,000
Processing of Monolithics	1,365,000
Whisker Toughened Si_3N_4	349,000
Transformation Toughened Si_3N_4	373,000
Dispersion Toughened Si_3N_4	347,000
Composite Development	202,000
Advanced Composites	10,000
Oxide Matrix Composites	355,000
Transformation Toughened Ceramic Processing	0
Layered Ceramic Composites	0
Sol Gel Oxide Powder	100,000
Advanced Transformation Toughened Oxides	112,000
Injection Molded Composites	220,000
Fiber Reinforced Silicates	93,000
Low Expansion Ceramics	155,000
Active Metal Brazing PSZ-Iron	280,000
Intermetallic Materials Development	30,000
Cast Iron Alloy Nonstrategic Elements	105,000
Materials Properties, Behavior, Characterization or Testing	$2,532,000
Adherence Coatings Deposited On Substrates	18,000
Dynamic Interfaces	196,000
Solid Lubrication Design Methodology	0
Advanced Statistical Calculations	62,000
Advanced Statistics Calculations	120,000
Physical Properties of Structural Ceramics	120,000
Translucence Engineering Ceramics	66,000
Reliability of Structural Ceramics Literature Search	26,000
Mechanical Testing of Structural Ceramics	35,000
Characterization of Transformation-Toughened Ceramics	102,000
Fracture Behavior of Toughened Ceramics	166,000
Cyclic Fatigue of Toughened Ceramics	280,000
Static Behavior of Toughened Ceramics	102,000
Ceramic Corrosion Evaluation AGT	120,000

	FY 1986
Materials Properties, Behavior, Characterization or Testing (Continued)	
Corrosion/Erosion Effects	$ 51,000
Ceramic Durability Evaluation AGT	100,000
Environmental Effects In Toughened Ceramics	168,000
High Temperature Fracture Toughness Measurement	119,000
High Temperature Tensile Testing	0
Standard Tensile Test Development	122,000
Non-Destructive Characterization	195,000
Ceramic Component NDE Technology	90,000
Materials Characterization	132,000
Computer-Tomography	52,000
Ceramics For Stirling Engine Applications	25,000
High Temperature Creep Evaluation Stirling	65,000
Technology Transfer and Management Coordination	$ 1,133,000
Standard Reference Ceramic Powder	182,000
Technology Transfer Assessment, Support Contracts, IEA	311,000
Management And Coordination	640,000
Device or Component Fabrication or Testing	$14,999,000
Metal-Ceramic Joints AGT	104,000
Ceramic-Ceramic Joints AGT	103,000
Advanced Coating Technology AGT	147,000
Advanced Coating Technology AGT	259,000
Thermal Barrier Coatings	300,000
Thermal Barrier Coatings	456,000
Sliding Seal Materials for Diesel	150,000
Advanced Gas Turbine Technology (AGT-100)	6,625,000
Advanced Gas Turbine Technology (AGT-101)	6,855,000
Instrumentation and Facilities	$ 310,000
HTML Preoperational Support	310,000

OFFICE OF TRANSPORTATION SYSTEMS

The Office of Transportation Systems has established a number of programs to conserve energy used for transportation and to shift transportation energy demand to non-petroleum fuels.

The Heat Engine Propulsion 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's objective 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) 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 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 under construction at ORNL.

Key elements of each program are organized and described briefly in the following. Robert B. Schulz is the DOE contact, (202) 586-8032, for overall coordination of the following Office of Transportation Systems material projects.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Silicon Carbide Powder Synthesis - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832

- o Develop improved, sinterable silicon carbide powder by plasma torch system that is scalable, evironmentally acceptable, amenable to doping, low-cost (<$20/lb), submicron particle size, narrow distribution, high surface area, and high purity.

Sintered Silicon Nitride - DOE Contact, Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; AMTL Contact G. E. Gazza, 617-923-5408

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

High Pressure Sintering Furnace - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; AMTL/GEO Contact G. E. Gazza, 617-923-5408

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

Si_3N_4 Powder Synthesis - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Ford Contact G. M. Crosbie, 313-574-1208

- o Develop improved, sinterable, high-purity and low-cost silicon nitride powder, involving a low temperature reaction of silicon tetrachloride with liquid ammonia to form a diimide silicon nitride precursor.

Processing Of Monolithics - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Contractor Contact New procurement in 1987

- o Develop advanced, cost-effective, near-net-shape processing methods that result in dense, high performance ceramics with fewer and smaller flaws than state-of-the-art.
- o Develop materials with high Weibull modulus and good high-temperature strength.

Whisker Toughened Si_3N_4 - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Air Research Casting Contact H. C. Yeh, 213-618-7449

- o 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 automotive engines.

Transformation Toughened Si_3N_4 - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Rockwell, Rocketdyne Div. Contact H. W. Carpenter, 818-700-3411

- o Develop a transformation-toughened silicon nitride matrix composite based on a commercially available silicon nitride powder and a proprietary hafnia-rich mixed oxide toughened agent.

- o Develop a low-cost, near-net-shape process (injection molding).

Dispersion Toughened Si_3N_4 - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; GTE Contact S. T. Buljan, 617-890-8460

- o Development of whisker-and particulate-toughened silicon nitride matrix ceramics for AGT applications.

Composite Development - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Norton Contact C. A. Ebel, 617-393-5950

- o Development of toughened silicon nitride composites by glass encapsulated hot isostatic pressure.

Advanced Composites - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; University Of Michigan Contact T. Y. Tien, 313-764-9449

- o Study feasibility of the formation of Si_3N_4 matrix composites containing Si_3N_4 whiskers by transient liquid phase sintering.

Oxide Matrix Composites - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832 and T. N. Tiegs, 615-574-5173

- o Develop whisker-toughened alumina and mullite matrix composites with improved strength and toughness over monolithic oxide ceramics.

- o Investigate pressureless sintering of whisker composites.

Transformation Toughened Ceramics Processing - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Norton Co. Contact Giulio A. Rossi, 617-393-6600

- o Production of improved zirconia toughened ceramics (ZTC) for advanced engine applications.

- o Powder synthesis and characterization of the sintered ceramics.

- o Evaluation of a rapid solidification from-the-melt powder and two chemically derived powders.

Layered Ceramic Composites - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Ceramatic Contact R. A. Cutler, 801-486-5071

- o Develop layered ceramic composites which incorporate zirconia as a second phase to achieve improved strength and toughness at temperatures of up to 1000 C.

- o Study processing methods for fabricating these layered composites via sintering.

Sol Gel Oxide Powder - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832 and W. D. Bond, 615-574-7071

- o Determine processing requirements to provide homogeneous submicron dispersion of zirconia (yttria) and zirconia (hafnia-yttria) in alumina powders and provide coatings for silicon carbide whiskers.

Advanced Transformation Toughened Oxides - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; AMTL/University Of Michigan Contact T. Y. Tien, 313-764-9449

- o Development of low thermal conductivity transformation-toughened alumina and mullite ceramics.

Injection Molded Composites - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832 and M. A. Janney, 615-574-4281

- o Development of advanced methods for forming ceramic matrix composites, such as injection molding with short burnout time.

Fiber Reinforced Silicates - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; GE-Valley Forge Contact S. Musikant, 215-354-3020

- o Development of toughened mullite ceramic matrix composites which are amenable to low cost near-net-shape forming for adiabatic diesel application.

Low Expansion Ceramics - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Virginia Polytechnic Institute (VPI) Contact J. J. Brown, Jr., 703-961-6640

- o Develop an isotropic, ultra-low expansion ceramic which can be used above 1200 degrees centigrade and which is relatively inexpensive.

Active Metal Brazing PSZ-Iron - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832 and M. L. Santella, 615-574-4805

- o Develop brazing processes for joining ceramic components to nodular cast iron for adiabatic diesel application.

Intermetallic Materials Development - DOE Contact Patrick L. Sutton, 202-586-8012; NASA LeRC Contact Joseph R. Stephens, 216-433-3195

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

Cast Iron Alloy Nonstrategic Elements - DOE Contact Patrick L. Sutton, 202-586-8032; NASA LeRC Contact C. M. Schevermann, 216-433-3205; United Technology Research Center Contact F. D. Lemkey, 203-727-7318

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

Materials, Properties, Behavior, Characterization, or Testing

Adherence Coatings Deposited On Substrates - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; University of Tennessee Contact J. E. Stoneking, 615-974-2171

- o Conduct studies on adherence of coatings deposited on substrates subjected to ion beam mixing.

Dynamic Interfaces - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Battelle Columbus Labs Contact K. F. Dufrane, 614-424-4618

- o Develop generic understanding of the friction and wear behavior of material interfaced between monolithic ceramics and ceramic-coated alloys in which the materials experience motion as in adiabatic diesel engines.

Solid Lubrication Design Methodology - DOE Contact John Fairbanks, 202-586-8012; NASA LeRC Contact James C. Wood, 216-433-3419; SKF Industries Contact R. A. Pallini

- o Develop a design methodology for solid lubricated rolling element bearing contacts operating at conditions representative of high temperature insulated diesel engines.

Advanced Statistical Calculations - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832 and W. P. Eatherly, 615-574-5220

- o Develop advanced statistical tools for characterization strength of structural ceramics in a meaningful and realistic way for use in design codes.

Advanced Statistics Calculations - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; GE Labs Contact C. A. Johnson, 518-387-6421

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

Physical Properties of Structural Ceramics - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832 and D. L. McElroy, 615-574-5976

- Develop an improved understanding of the factors which determine the thermal conductiveness of structural ceramics at high temperatures.

Translucence Engineering Ceramics - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Integral Technologies (ITI) Contact Thomas Morel, 312-789-0003

- Evaluate effects of translucence on diesel engines that use ceramics for heat barriers.

Reliability of Structural Ceramics Literature Search - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; University Of Tennessee Contact J. A. M. Boulet, 615-974-8376

- Literature survey of ceramic life prediction models.

Mechanical Testing of Structural Ceramics - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832 and M. K. Booker, 615-574-5113

- Develop a computer data base of mechanical property data generated in the program.

Characterization of Transformation Toughened Ceramics - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; AMTL Contact Jeffrey J. Swab, 617-923-5410

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

Fracture Behavior of Toughened Ceramics - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832 and P. F. Becher, 615-574-5157

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

Cyclic Fatigue of Toughened Ceramics - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832 and K. C. Liu, 615-574-5116

- o Develop and demonstrate the capability of performing uniaxial tension-tension dynamic fatigue testing of structural ceramics at elevated temperatures.

Static Behavior Of Toughened Ceramics - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact Victor J. Tennery, 615-574-5123; University of Illinois Contact M. K. Ferber, 217-333-7579

- o Study the long-term mechanical stability of toughened ceramics for diesel engine applications.

Ceramic Corrosion Evaluation AGT - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; NASA LeRC Contact Carl A. Stearns, 216-433-5500

- o Determine the effects of fuel and ingested impurities on the most promising of the durability tested ceramic materials.

Corrosion/Erosion Effects - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; NBS Contact S. M. Wiederhorn, 301-975-2000

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

Ceramic Durability Evaluation AGT - DOE Contact Saunders B. Kramer, 202-586-8012; NASA LeRC Contact Sunil Dutta, 216-433-3282; Garrett Turbine Engine Contact K. W. Benn, 602-231-4373

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

Environmental Effects In Toughened Ceramics - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact Victor J. Tennery, 615-574-5123; University of Dayton Contact N. L. Hecht, 513-229-4341

- o Investigate effects of water vapor (in combustion gas from adiabatic diesel) on time-dependent strength of transformation-toughened ceramics.

High Temperature Fracture Toughness Measurement - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact Victor J. Tennery, 615-574-5123; University Of Washington Contact R. C. Bradt, 206-543-2600

- o Develop and demonstrate improved fracture toughness test(s).

High Temperature Tensile Testing - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; North Carolina A&T State University Contact V. S. Avva, 919-334-7620

- o Test and evaluate advanced ceramic materials at temperatures up to 1500°C in uniaxial tension.

Standard Tensile Test Development - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; NBS Contact S. M. Widerhorn, 301-921-2901

- o Development of tensile test standards for characterizing strength and creep behavior of ceramic specimens at elevated temperature.

Non-Destructive Characterization - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832 and R. W. McClung, 615-574-4466

- o Develop and demonstrate non-destructive characterization tools for structural ceramics.

Ceramic Component NDE Technology - DOE Contact Saunders B. Kramer, 202-586-8012; NASA LeRC Contact Alex Vary, 216-433-6019

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

Materials Characterization - DOE Contact Robert B. Schulz, 202-586-8012; ORNL Contact D. Ray Johnson, 615-576-6832; AMTL Contact J. W. McCauley, 617-923-5238

- o Develop a quantifiable powder characterization database and methodology for intelligent processing of reliable engineering ceramics.

Computer-Tomography - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Argonne National Lab Contact W. A. Ellingson, 312-972-5068

- o Develop X-ray beam hardening corrections for polychromatic X-ray sources when used with computed tomography machines to inspect structural ceramics, and develop appropriate test phantoms for calibration of polychromatic X-ray source CT scanners when used to inspect ceramic materials.

Ceramics For Stirling Engine Applications - DOE Contact Patrick L. Sutton, 202-586-8012; NASA LeRC Contact Tom Herbell, 216-433-3246

- o Assess the potential of several candidate ceramics for application to Stirling engines, with emphasis on mullite.

High Temperature Creep Evaluation Stirling - DOE Contact Patrick L. Sutton, 202-586-8012; NASA LeRC Contact R. H. Titran, 216-433-3198

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

Technology Transfer and Management Coordination

Standard Reference Ceramic Powder - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; NBS Contact A. L. Dragoo, 301-975-2000

- o Develop standard reference material from the ceramic powder chosen by the U. S. consulting committee for the IEA agreement.

Technology Transfer Assessment, Support Contracts, IEA - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832

- o Facilitate the transfer of technology to private industry.

Management And Coordination - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832

- o Assess the ceramic technology needs for advanced automotive head engines, formulate technical plans to meet these needs, and prioritize and implement a long-range research and development program.

Device or Component Fabrication or Testing

Metal-Ceramic Joints - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832

- o Development of the technology required to reliably join advanced gas turbine (AGT) ceramic rotors to the high-temperature alloy rotor shafts.

Ceramic-Ceramic Joints AGT - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832

- o Develop appropriate technology for reliable silicon carbide/silicon carbide and silicon nitride/silicon nitride joints.

Advanced Coating Technology AGT - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; Vapor Technologies, Inc. Contact E. Pinkhasov, 914-664-1495

- o Develop an oxidation resistant by the low temperature arc vapor process adherent coating for SiC and Si_3N_4 that will reduce contact stress between ceramic parts.

Advanced Coating Technology AGT - DOE Contact Robert B. Schulz, 202-586-8032; ORNL Contact D. Ray Johnson, 615-576-6832; GTE Contact V. K. Sarin, 617-890-8460

- o Development of coating compositions and procedures that will yield long term adherence and reduce or eliminate contact-stress damage to silicon nitride, silicon carbide, or other ceramic materials when utilized in advanced gas turbine engines. Multiple/graded coatings will be applied by computer controlled CVD process.

Thermal Barrier Coatings - DOE Contact John Fairbanks, 202--586-8012; NASA LeRC Contact M. Murray Bailey, 216-433-3416; Cummins Contact Thomas M. Yonushonis, 812-377-7078

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

Thermal Barrier Coatings - DOE Contact John Fairbanks, 202--586-8012; NASA LeRC Contact M. Murray Bailey, 216-433-3416; Caterpillar, Inc. Contact H. J. Larson, 309-578-6549

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

Sliding Seal Materials for Diesel - DOE Contact John Fairbanks, 202-586-8012; NASA LeRC Contact Howard Yacobucci, 216-433-3415; Southwest Research Institute Contact J. Lankford, 512-684-5111

- o Refine the information base on carbide seal/ceramic cylinder liner combinations for use in the high performance near-adiabatic diesel engine.

Advanced Gas Turbine Engine Technology (AGT-100) - DOE Contact Saunders B. Kramer 202-586-8012; NASA LeRC Contact P. Kerwin, 216-586-3409; General Motors, Allison Gas Turbine Division Co. Contact H. E. Helms, 317-242-5355

- o 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, 202-586-8012; NASA LeRC Contact T. N. Strom, 216-433-3408; Garret Turbine Engine Contact E. E. Strain, 602-231-2797

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

Instrumentation and Facilities

HTML Preoperational Support - DOE Contact William McDonough, 202-586-8032; ORNL Contact V. J. Tennery, 615-574-5123

- o Provide preoperational support for the high temperature materials lab (HTML) in FY 1985.

OFFICE OF ENERGY STORAGE AND DISTRIBUTION

	FY 1986
Office of Energy Storage and Distribution Grand Total	$ 6,809,000
Energy Storage	$ 4,189,000
Materials Preparation, Synthesis, Deposition, Growth or Forming	$ 3,148,000
Hydrogen Technology Evaluation Center	50,000
Medium Temperature Solid Electrolytes - Proton Conductors	125,000
Ceramics Research	1,300,000
Metals and Alloys	500,000
Organometallic Compounds	300,000
Polymers	300,000
Composite High Temperature Thermal Storage Media	350,000
Formation of Encapsulated Metallic Eutectic Thermal Storage Alloy	100,000
Materials for Advanced High-Temperature Molten Salt Storage	20,000
Water Electrolysis with Protonic Beta" Alumina Electrochemical Cells	53,000
Hydrogen Production with Photoactive Semiconductor Catalysts	50,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,036,000
Solid State Radiative Heat Pump	50,000
Use of Micro Particles as Heat Exchangers and Catalysts	50,000
Formation and Dissolution of Gas Clathrates	150,000
Evaluation of Advanced Thermal Energy Storage Media	350,000
High Temperature Water Electrolysis	200,000
Hydrogen Embrittlement of Pipeline Steels	16,000
Geochemical Stability of Sandstones	60,000
Metal-Assisted Cold Storage (MACS) of Hydrogen on Activated Carbon	135,000
Electrochemical Techniques for H_2 Storage in Metal Hydrides	20,000
Advanced Hydrogen Storage - Modified Vanadium Hydride	5,000

	FY 1986
Instrumentation and Facilities	$ 5,000
Analysis of Zeolite Augmented Ice Storage	5,000
Electric Energy Systems	$ 2,620,000
Materials Properties, Behavior, Characterization or Testing	$ 1,750,000
High Voltage Breakdown Strengths of Insulating Gases and Liquids	400,000
Factors Influencing Aging in Extruded Dielectrics	800,000
Threshold and Maximum Operating Electric Stresses for Selected High Voltage Insulations	0
Multifactor Aging and Evaluation of Polymeric Materials	150,000
Solid Dielectrics and Interfacial Breakdown	125,000
Investigation of Interfacial Phenomena in Compressed Gases	0
Interfacial Aging Phenomena in Power Cable Insulation Systems	100,000
Study of Dynamic Insulation with Advanced Metal Oxide (ZnO) Materials	50,000
Development of Amorphous Ferromagnetic Alloy for Motors and Transformers	125,000
Device or Component Fabrication, Behavior or Testing	$ 870,000
AC Superconducting Power Transmission Cable Development	870,000

OFFICE OF ENERGY STORAGE AND DISTRIBUTION

Energy Storage

The Energy Storage program supports research and development of advanced energy storage and electrochemical conversion systems that will facilitate the substitution of oil and gas fuels by nuclear and renewable energy sources, and will increase the reliability and efficiency of the energy economy. The research is divided into three subprograms: Electrochemical Energy Storage, Thermal Energy Storage and Chemical/Hydrogen Energy Storage.

Materials Preparation, Synthesis, Deposition, Growth or Forming

Hydrogen Technology Evaluation Center - DOE Contact M. Gurevich, 202-586-1495; BNL Contact P.D. Metz, 516-282-3123

- o Operation of a hydrogen test/simulation facility which includes a 5 kW photovoltaic array and a 15 kW Hamilton-Standard (General Electric) SPE electrolyzer.

- o Evaluation of a metal hydride hydrogen compressor provided by Ergenics, Inc. in both the closed and open cycle modes.

Medium Temperature Solid Electrolytes - Proton Conductors - DOE Contact M. Gurevich, 202-586-1495; BNL Contact C. Linkous, 516-282-7949

- o Investigation of candidate electrolytes capable of operating in 300-600°C temperature regime.

Water Electrolysis with Protonic Beta" Alumina Electrochemical Cells - DOE Contact M. Gurevich, 202-586-1495; University of Pennsylvania Contact G. Farrington, 215-898-8337

- o Preparation and evaluation of proton (or hydronium ion) conducting membranes suitable for use in medium temperature (300-600°C) water vapor electrolysis.

Hydrogen Production with Photoactive Semiconductor Catalysts - DOE Contact M. Gurevich, 202-586-1495; Battelle Columbus Lab Contact R. Schwerzel, 614-424-5637

- o Obtain metallized plasma-polymerized films of suitable transparency and conductivity that exhibit stable long life and are compatible with the semiconductor band gap requirements for photo-assisted electrolysis.

- Characterization of single-crystal and powdered photocatalysts using advanced coatings prior to conducting aqueous electrolysis experiments.

<u>Ceramics Research</u> - DOE Contact A. Landgrebe, 202-586-1483; LBL Contact E. Cairns, 415-486-5028; SNL Contact R. Clark, 505-844-6332

- Develop superconducting ionic materials.

- Investigate materials for electrochemical corrosion prevention in batteries.

<u>Metals and Alloys</u> - DOE Contact A. Landgrebe, 202-586-1483; LBL Contact E. Cairns, 415-486-5028

- Evaluate aluminum alloys for use as negative electrodes in aluminum-air batteries.

- Assess platinum alloys prepared for use as electrocatalysts in fuel cells and aluminum/air batteries.

<u>Organometallic Compounds</u> - DOE Contact A. Landgrebe, 202-586-1483; Eltech Systems Corporation Contact R. W. Fenn, 216-357-4075

- Develop macrocyclic compounds of transition metals for use as electrocatalysts in fuel cells.

<u>Polymers</u> - DOE Contact A. Landgrebe, 202-586-1483; LBL Contact E. Cairns, 415-486-5028

- Design electronically and ionically conducting polymers for use as electrodes and electrolytes in batteries and fuel cells.

<u>Composite High Temperature Thermal Storage Media</u> - DOE Contact Eberhart Reimers, 202-586-4844; 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 Eberhart Reimers, 202-586-4844; 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 for Advanced High Temperature Molten Salt Storage - DOE Contact M. Gurevich, 202-586-1507; SERI Contact B. Goodman, 303-231-1005

- Evaluation of candidate materials for a conical molten salt hot storage tank.

- Determination of the coefficient of friction between the hot tank liner and wall using a glass fiber mat, a ceramic fiber blanket, and stainless steel knitted-wire mesh as interface materials.

- Application of conical hot storage tank concept to a carbonate salt system.

Materials Properties, Behavior, Characterization, or Testing

High Temperature Water Electrolysis - DOE Contact M. Gurevich, 202-586-1495; Westinghouse R&D Center Contact N. Mascalick, 412-256-2020

- Development of solid oxide electrolyte cells operated in the high temperature electrolysis mode at 1000^{o}C for hydrogen production.

Hydrogen Embrittlement of Pipeline Steels - DOE Contact M. Gurevich, 202-586-1495; Battelle Columbus Contact J. Holbrook, 614-424-4347

- Conduct laboratory and pipeline tests to quantify hydrogen embrittlement of pipeline steels under low cycle fatigue conditions.

- Identification of inhibitors to reduce/eliminate H_2 embrittlement and characterization of chemical reaction mechanisms.

Metal-Assisted Cold Storage (MACS) of Hydrogen on Activated Carbon - DOE Contact M. Gurevich, 202-586-1495; Syracuse University Contact J. Schwartz, 315-423-2807

- o Operation of macrobalance apparatus at cryogenic temperatures to permit verification of enhanced hydrogen storage on catalyzed activated carbons.

- o Identify optimum carbon/catalyst system useful in the operating temperature-pressure ranges appropriate to vehicle applications.

Electrochemical Techniques for H_2 Storage in Metal Hydrides - DOE Contact M. Gurevich, 202-586-1495; Stanford University Contact R. Huggins, 415-497-4110

- o Study of a low melting organometallic salt ($NaAlEt_4$) saturated with NaH in which the H- ions act as hydrogen transmitters.

- o Investigate alternate systems aiming for compatibility between electrolytes, H- ion carrier, alloy electrodes and useful operating P-C-T conditions.

Advanced Hydrogen Storage - Modified Vanadium Hydride - DOE Contact M. Gurevich, 202-586-1495; Allied Corporation Contact G. Libowitz, 201-455-9571

- o Studying desorption of hydrogen at conditions compatible with practical applications.

- o Study substitutional metals to allow hydrogen desorption at pressures above 1 atm at temperatures of 175^{o}C to bring two P-C-T plateaus closer together.

Solid State Radiative Heat Pump - DOE Contact Eberhart Reimers, 202-586-4563; LBL Contact Paul Berdal, 415-486-5278

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

Use of Micro Particles as Heat Exchangers and Catalysts- DOE Contact Eberhart Reimbers, 202-586-4563; LBL Contact Arlon Hunt, 415-586-5370

- o 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 Eberhart Reimers, 202-586-4563; ORNL Contact Jim Martin 615-576-3977.

- o 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 Eberhart Reimers, 202-586-4563; ORNL Contact Jim Martin 615-576-3977.

- o Development of dual temperature TES media for heat and chill storage.
- o Evaluation of heats of mixing and crystallization in multi-component solutions.
- o Determine phase behavior of selected singly-complexing and multiply-complexing ammoniated salts in phase regions appropriate to dual temperature storage.

Geochemical Stability of Sandstones - DOE Contact Eberhart Reimers, 202-586-4563; PNL Contact Landis Kannberg, 509-375-3919.

- o Laboratory testing and analysis of the effects of 150°C water flowing through porous sandstones under pressure.

Instrumentation and Facilities

Analysis of Zeolite Augmented Ice Storage - DOE Contact Eberhart Reimers, 202-586-4844; PNL Contact Landis Kannberg, 509-375-3919

- o 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.
- o Facility will involve cyclic absorptive capacity of several types of zeolites under highly varied operating conditions.

Electric Energy Systems

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, 202-586-4844.

Materials Properties, Behavior, Characterization, or Testing

High Voltage Breakdown Strengths of Insulating Gases and Liquids - DOE Contact Russell Eaton, 202-586-4844; ORNL Contact Lucas Christophorou, 615-574-6199

- Determine physiochemical factors of breakdown strength of gaseous and liquid dielectrics

Factors Influencing Aging in Extruded Dielectrics - DOE Contact Russell Eaton, 202-586-4844; Battelle Columbus Contact Mike Epstein, 614-424-6424

- Identify aging mechanisms of extruded dielectrics using advanced techniques, such as thermally stimulated currents, mechanical spectroscopy, and differential scanning calorimetry.

Threshold and Maximum Operating Electric Stresses for Selected High Voltage Insulations - DOE Contact Russell Eaton, 202-586-4844; Cable Technology Lab Contact Carlos Katz, 201-846-3220

- Determine threshold voltage and maximum operating electric field strengths for selected high voltage insulation systems

Multifactor Aging and Evaluation of Polymeric Materials - DOE Contact Russell Eaton, 202-586-4844; 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, 202-586-4844; 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, 202-586-4844; ORNL Contact Steinar Dale, 415-574-4829

- o 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, 202-586-4844; ORNL Contact Steinar Dale, 415-574-4829

- o Investigate aging of semi-conducting/polymer insulator 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, 202-586-4844; ORNL Contact Steinar Dale, 415-574-4829

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

Development of Amorphous Ferromagnetic Alloy for Motors and Transformers - DOE Contact Russell Eaton, 202-586-4844; ORNL Contact Steinar Dale, 615-574-4829

- o 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- DOE Contact Russell Eaton, 202-586-4844; BNL Contact E. Forsyth, 516-282-4676

- o Develop underground AC superconducting cable system (138 kV, 4000 A) employing superconducting Nb_3Sn tape and insulation consisting of synthetic tape impregnated with supercritical helium.

- Develop underground transmission cables using oil-impregnated, fully synthetic insulating tapes as an alternative to conventional oil-impregnated kraft paper insulation used throughout the cable industry.

OFFICE OF SOLAR HEAT TECHNOLOGIES

	FY 1986
Office of Solar Heat Technologies Grand Total	$ 3,837,000
Solar Buildings Technology Division	$ 2,136,000
Materials Preparation, Synthetic, Deposition Growth or Formation	$ 1,093,000
Thermochromic Materials	248,000
Optical Switching Aperatures	180,000
Optical Switching Materials	100,000
Transparent Insulating Materials	60,000
Phase Change Thermal Storage Materials	505,000
Materials Properties, Behavior, Characterization or Testing	$ 918,000
Daylight Enhancement	100,000
Low-Emittance, High Transmittance Materials	100,000
Thin Film Materials Research	248,000
Sorption Studies of Desiccant Materials	340,000
Advanced Desiccant Materials	130,000
Device or Component Fabrication, Behavior or Testing	$ 125,000
Evaluation of Aperture Glazing Materials	125,000
Solar Thermal Technology Division	$ 1,701,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 962,000
Silver/Polymer Reflector Research	721,000
Front Surface Reflector on Metal Substrates	241,000
Materials Properties, Behavior, Characterization or Testing	$ 739,000
High Temperature Materials	352,000
Composite Materials for Concentrators	100,000
High Flux Effects on Materials	287,000

OFFICE OF SOLAR HEAT TECHNOLOGIES

Solar Buildings Technology Division

The mission of the Solar Buildings Technology Program is to support the national energy policy goal of fostering an adequate energy supply at reasonable costs by providing for the development of solar building technologies. The program goal is to provide industry with the technology base needed to develop solar energy products and designs which are economically competitive and can contribute significantly to building energy supplies. These goals translated into technology objectives are to:

- o Develop solar energy technologies that supply up to 80 percent of building space heating, hot water, cooling, and lighting requirements at competitive costs when integrated with conventional energy conserving technologies.

- o Assist industry to improve component, system reliability and durability to achieve acceptable performance and equipment service life.

Materials Preparation, Synthetic, Deposition, Growth or Forming

Thermochromic Materials - DOE Contact Ted Kurkowski, 202-586-1788; DOE SAN Contact Janet Neville, 415-273-6362

- o Evaluate Thermochromatic Materials doped so as to decrease their transition temperature.

Optical Switching Apertures - DOE Contact Ted Kurkowski, 202-586-1788; SERI Contact Dave Benson, 303-231-1162

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

Optical Switching Materials - DOE Contact Ted Kurkowski, 202-586-1788; LBL Contact Carl M. Lampert, 415-486-6093

- o Research and synthesize new electrochromic materials (e.g., NiO_x) with broad band and response characteristics.

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

Transparent Insulating Materials - DOE Contact Ted Kurkowski, 202-586-1788; LBL Contact Arlon Hunt, 415-486-5370

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

Phase Change Thermal Storage Materials - DOE Contact Ted Kurkowski, 202-586-1788; SERI Contact Dave Benson, 303-231-1162

- o Study of solid state phase change materials (SS PCM's) for use in thermal energy storage components of buildings.

Materials Properties, Behavior, Characterization, or Testing

Daylight Enhancement - DOE Contact Ted Kurkowski, 202-586-1788; LBL Contact Mike Rubin, 415-486-7124

- o Development of light guide materials and systems which collect and transmit daylight.

Low-Emittance, High-Transmittance Materials - DOE Contact Ted Kurkowski, 202-586-1788; LBL Contact Mike Rubin, 415-486-7124

- o Identify, characterize and produce intrinsically durable low-emittance coatings with improved optical and thermal properties.

Thin Film Materials Research - DOE Contact John Goldsmith, 202-586-8779; SAN Operations Office Contact Janet Neville, 415-273-6362

- o 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, 202-586-8779; SERI Contact Frederica Zangrando, 303-231-1761

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

Advanced Desiccant Materials - DOE Contact John Goldsmith, 202-586-8779; SERI Contact A. Czanderna, 303-231-1240

- o Determine how the desired sorption performance of desiccant materials can be predicted.

- o Conduct desiccant analysis and materials research in enhanced heat and mass diffusion rates.

Device or Component Fabrication, Behavior, or Testing

Evaluation of Aperture Glazing Materials - DOE Contact Ted Kurkowski, 202-586-1788; LBL Contact

- o Develop and evaluate methods for determining the performance and durability of low-emittance glazing materials.

- o Characterize the energy savings potential for low-emittance windows by measuring thermal performance under realistic field conditions.

Solar Thermal Technology Division

Solar Thermal Technology is developing central receivers, parabolic dishes, and parabolic troughs to concentrate the sun's energy. This concentrated energy can then be used for industrial process heat, generating electricity, or producing fuels and chemicals. The combination of concentrated direct solar flux (to 2000 suns) and high temperature (to 2000^{o}F) cause unique materials problems that are now being characterized in areas of heat transfer fluids, metals, 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.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Silver/Polymer Reflector Research - DOE Contact Frank Wilkins, 202-586-1684; SERI Contact Daniel M. Blake, 303-231-1202

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

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

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

- Improve durability of polymers in solar thermal applications.

Materials Properties, Behavior, Characterization, or Testing

High Temperature Materials - DOE Contact Frank Wilkins, 202-586-1684; SERI Contact Daniel M. Blake, 303-231-1202

- Characterize the phase diagrams of mixed carbonate salts from 500°C to 900°C.

- Establish the stability limits of suspensions of metal oxide powders in molten nitrate salt mixtures.

- Identify and define failure modes of metal tubes that have been subjected to high flux, high temperature, and thermal cycling.

- Investigate durability of ceramic and metallic parts under cyclic heating typical of solar thermal systems.

High Flux Effects on Materials - DOE Contact Frank Wilkins, 202-586-1684; SERI Contact Daniel M. Blake, 303-231-1222

- Investigate high flux photo-enhanced degradation of materials, and identify possible changes in coatings to reduce these effects.

- Characterize the effects of high solar flux on carbon fibers and carbon-carbon composites.

- Compare the effects on materials caused by heat only with those produced by high solar flux.

Front Surface Reflector on Metal Substrates - DOE Contact Frank Wilkins, 202-586-1684; SERI Contact Daniel M. Blake, 303-231-1202

- Identify the production steps which limit the surface smoothness for stainless steel.

- Produce sample runs of rolled stainless steel with state-of-the- art smoothness.

Composite Materials for Concentrators - DOE Contact Frank Wilkins, 202-586-1684; SERI Contact Daniel M. Blake, 303-231-1202

- Determine feasibility of using advanced composite materials and wood laminates for low cost heliostats.

OFFICE OF SOLAR ELECTRIC TECHNOLOGIES

	FY 1986
Office of Solar Electric Technologies Grand Total	$23,900,000
Photovoltaic Energy Technology Division	$23,900,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$19,100,000
Amorphous Silicon for Solar Cells	10,000,000
Polycrystalline Thin Film Materials for Solar Cells	4,600,000
Growth of Silicon Ribbons For Solar Cells	1,000,000
Deposition of III-V Semiconductors for High-Efficiency Solar Cells	3,500,000
Materials Properties, Behavior, Characterization or Testing	$ 3,000,000
Materials and Device Characterization	3,000,000
Device or Component Fabrication, Behavior, or Testing	$ 1,800,000
High-Efficiency Crystal Silicon Solar Cells	1,800,000

OFFICE OF SOLAR ELECTRIC TECHNOLOGIES

Photovoltaic Energy Technology Division

The National Photovoltaics Program sponsors high-risk, potentially high-payoff research and development in photovoltaic energy technology that will result in a technology base from which private enterprise can choose options for further development and competitive application in U.S. electrical markets. The objective of materials research is to overcome the technical barriers currently limiting the efficiency and cost of photovoltaic cells. Theoretical conversion efficiency of photovoltaic cells is limited by the portion of the solar spectrum that the cell's semiconductor material can respond, and by the extent to which these materials can convert each photon to electricity. The practical efficiency is constrained by the amount of light captured by the cell, the cell's uniformity, and a variety of loss mechanisms for the photo-generated carriers. Cost is affected by the expense and amount of materials required, the complexity of processes for fabricating the appropriate materials, and the complexity and efficiency of converting these materials into cells.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Amorphous Silicon for Solar Cells - DOE Contact Morton B. Prince, 202-586-1725; SERI Contact Ed Sabisky, 303-231-1483

- Plasma enhanced chemical vapor deposition (CVD), 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 - DOE Contact Morton B. Prince, 202-586-1725; SERI Contact Kenneth Zweibel, 303-231-7141

- Investigation of chemical and physical vapor deposition, electrodeposition, and sputtering techniques for depositing stoichiometric films of $CuInSe_2$ and CdTe.

- Large area (1000 cm^2) control of interlayer diffusion, lattice matching and stoichiometry for long-term enhancement of 15% efficient large area solar cells.

Growth of Silicon Ribbons for Solar Cells - DOE Contact Morton B. Prince, 202-586-1725; SNLA Contact Dan Arvizu, 505-846-0387

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

- o Study of fundamental problems of ribbon growth.

Deposition of III-V Semiconductors for High-Efficiency Solar Cells - DOE Contact Morton B. Prince, 202-586-1725; SERI Contact John Benner, 303-231-1396; SNLA Contact Dan Arvizu, 505-846-0387

- o Deposition by CVD, liquid phase epitaxy (LPE), and molecular beam epitaxy (MBE) of III-V's in order to study interfaces between layers and for precise control of thickness and uniformity.

- o 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 - DOE Contact Morton B. Prince, 202-586-1725; SERI Contact Larry Kazmerski, 303-231-1115

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

- o 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 - DOE Contact Morton B. Prince, 202-586-1725; SERI Contact John Benner, 303-231-7299; SNLA Contact Dan Arvizu, 505-846-0387

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

- o Research to optimize silicon material type, material resistivity, cell thickness, surface passivation, light trapping, cell metallization, and cell processing procedures.

OFFICE OF RENEWABLE TECHNOLOGY

	FY 1986
<u>Office of Renewable Technology Grand Total</u>	$ 1,407,000
<u>Geothermal Technologies Division</u>	$ 1,257,000
<u>Materials Preparation, Synthesis, Deposition, Growth, or Forming</u>	$ 577,000
High Temperature Elastomers for Dynamic Sealing Applications	112,000
Advanced Materials for Lost Circulation Control	75,000
Geothermal Waste Utilization and Disposal	125,000
Materials for Non-Metallic Heat Exchangers	135,000
Biochemical Concentration and Removal of Toxic Components from Geothermal Wastes	130,000
<u>Materials Properties, Behavior, Characterization or Testing</u>	$ 305,000
Corrosion Resistant Elastomeric Liners for Well Casing	61,000
Advanced High Temperature Geothermal Well Cements	125,000
Corrosion in Binary Geothermal Systems	69,000
Metallic Liners for Well Casing	50,000
<u>Device or Component Fabrication, Behavior, or Testing</u>	$ 375,000
Field Tests of Advanced Monitoring Instruments	100,000
Particle Measurement In-Line Instrument	150,000
pH and Carbon Dioxide Sensors	125,000
<u>Biofuels and Municipal Waste Division</u>	$ 150,000
<u>Materials Properties, Behavior, Characterization or Testing</u>	$ 150,000
Refuse Derived Fuel (RDF) Binder Research	150,000

Geothermal Technology 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 GTD-sponsored materials R&D.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

High Temperature Elastomers for Dynamic Sealing Applications - DOE Contact R. LaSala, 202-586-4198; BNL Contact L.E. Kukacka, 516-282-3065

- Chemical modification of previously developed and tested Y-267 EPDM 260°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 R. LaSala, 202-586-4198; BNL Contact L.E. Kukacka, 516-282-3065

- Investigation of hydrothermally stable and pumpable chemical systems for use as lost circulation control materials in geothermal well drilling operations.

Geothermal Waste Utilization and Disposal - DOE Contact R. LaSala, 202-586-4198; 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.

Materials for Non-Metallic Heat Exchangers - DOE Contact R. LaSala, 202-586-4198; 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.

Biochemical Concentration and Removal of Toxic Components From Geothermal Wastes - DOE Contact G. J. Hooper, 202-586-4153; BNL Contact L. E. Kukacka, 516-282-3065

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

- o Establish optimum conditions for microorganism-metal interactions.

Materials Properties, Behavior, Characterization, or Testing

Corrosion Resistant Elastomeric Liners for Well Casing - DOE Contact R. LaSala, 202-586-4198; BNL Contact L. E. Kukacka, 516-282-3065

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

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

Advanced High Temperature Geothermal Well Cements - DOE Contact R. LaSala, 202-586-4198; BNL Contact L. E. Kukacka, 516-282-3065

- o Preliminary screening tests on lightweight cement slurries.

- o Characterization of promising light weight, high temperature well cements under placement and downhole environmental conditions.

- o Mechanisms of cement deterioration in high CO_2-containing geothermal brines.

Corrosion in Binary Geothermal Systems - DOE Contact R. LaSala, 202-586-4198; BNL Contact D. van Rooyen, 516-282-4050

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

Metallic Liners for Well Casing - DOE Contact R. LaSala, 202-586-4198; BNL Contact D. van Rooyen, 516-282-4050

- o Quantitative corrosion data from laboratory and field test of metals being considered for use as lines on geothermal well casings.

Geothermal Technology Division

The primary goal of the geothermal advanced instrumentation program is to reduce costs of geothermal powerplant design, construction, and operation by extending component life, reducing maintenance and equipment replacement, and minimizing powerplant outages.

Device of Component Fabrication Behavior or Testing

Field Tests of Advanced Monitoring Instruments - DOE Contact G. J. Hooper, 202-586-1146; PNL Contact D. W. Shannon, 509-376-3139

- o Field testing of advanced instruments to monitor brine chemistry, corrosion, scaling and suspended solids in geothermal waters.

Particle Measurement In-Line Instrument - DOE Contact G.J. Hooper, 202-586-1146; PNL Contact D.W. Shannon, 509-376-3139

- o Development and testing of instruments capable of measuring total amount of solid material pumped into geothermal injection wells.

- o Measurement of the particle counts in each size range as a function of time and total fluid injections.

pH and Carbon Dioxide Sensors - DOE Contact G. J. Hooper, 202-586-1146; PNL Contact D. W. Shannon, 509-376-3139

- o Development and testing of sensors capable of measuring the acidity and the carbon dioxide content of geothermal brines.

Biofuels and 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.

Materials Properties, Behavior, Characterization, or Testing

Refuse Derived Fuel (RDF) Binder Research - DOE Contact Donald Walter 202-586-1697; ANL Contact Ole Ohlsson, 312-972-5593

- o Identification and testing of chemical binders that will enhance the storability and overall material integrity of densified RDF.
- o Identification of alternative methods of densifying RDF.
- o Economic evaluation of the applications of identified binders and alternative densification methods vis-a-vis existing technology.

OFFICE OF ENERGY RESEARCH

	FY 1986
Office of Energy Research Grand Total	$171,849,452
Office of Basic Energy Sciences	$138,518,294
Division of Materials Sciences	$134,455,000
Metallurgy and Ceramics	$ 48,897,000
Structure of Materials	18,310,000
Mechanical Properties	5,346,000
Physical Properties	8,567,000
Radiation Effects	6,253,000
Engineering Materials	10,421,000
Solid State Physics	$ 70,185,000
Neutron Scattering	19,730,000
Experimental Research	33,005,000
Theoretical Research	5,718,000
Particle-Solid Interactions	4,416,000
Engineering Physics	7,316,000
Materials Chemistry	$ 15,373,000
Chemical Structure	5,090,000
Engineering Chemistry	5,161,000
High Temperature and Surface Chemistry	5,122,000
Division of Engineering and Geosciences	$ 4,063,294
Materials Properties, Behavior, Characterization or Testing	$ 4,063,294
Bounds on Dynamic Plastic Deformation	123,000
Diffusion, Fluid Flow and Sound Propagation in Disorders Media	65,000
In-Flight Measurement of the Temperature of Small, High Velocity Particles	90,000
Experimental Measurement of the Plasma/Particle Interaction	328,000
Integrated Sensor/Model Development for Automated Welding	496,000
Nondestructive Characterization of Fracture Dynamics and Crack Growth	193,000
Boiling of Aqueous Polymer Solutions	67,000
Plasma Reduction of Metallic Oxide Particles	76,000

FY 1986

Office of Basic Energy Sciences (Continued)

Division of Engineering and Geosciences (Continued)

Materials Properties, Behavior, Characterization, or Testing (Continued)

High-Temperature Gas-Particle Reactions	$ 230,000
Mathematical Modeling of Transport Phenomena in Plasma Systems	102,000
In-Process Control of Residual Stresses and Distortion in Automatic Welding	87,000
Investigation of Visible and Near Visible Light Emissions as Sensors for Control of Arc Welding Processes	75,000
Multivariable Control of the Gas-Metal Arc Welding Processes	102,000
Modeling of GMA Weld Pool Geometry and Metal Transfer	88,000
Modeling and Analysis of Surface Cracks	200,000
Thermal Plasma Processing of Materials	142,000
Transport Properties of Disordered Porous Media from the Microstructure	90,000
Effects of Crack Geometry and Near-Crack Materials Behavior on Scattering of Ultrasonic Waves for QNDE Applications	65,000
Inelastic Deformation and Damage at High Temperature	120,000
Energy Changes in Transforming Solids	0
Nondestructive Testing	115,000
Effective Elastic Properties of Cracked Solids	107,000
Electrochemical Wear Mechanism and Deposit Formation in Lubricated Systems	93,000
Elastic-Plastic Fracture Analysis Emphasis on Surface Flaws	365,000
Continuous Damage Theory	44,000
Loss Characteristics of Cord-Rubber Composites	73,000
A Study of the Chemical Mechanism in Lubrication	86,000
Effects of Crack Geometry and Near-Crack Material Behavior on Scattering of Ultrasonic Waves for QNDE Applications	65,000
Mechanical Interactions of Rough Surfaces	135,294
Multiviewing Transducer System	241,000

OFFICE OF ENERGY RESEARCH (Continued)

		FY 1986
Office of Health and Environmental Research	$	650,000
Division of Physical and Technological Research	$	650,000
Materials Properties, Behavior, Characterizatiion or Testing	$	650,000
Semiconductor Radiation Detector Technology		390,000
Development of Advanced Internal Gain Radiation Detection Structures Based on Neutron Transmutation Doped Silicon		260,000
Office of Fusion Energy	$	19,350,000
Materials Properties, Behavior, Characterization or Testing	$	8,310,000
Alloy Development for Irradiation Performance (ADIP)		4,270,000
Damage Analysis and Fundamental Studies (DAFS)		1,990,000
Special Purpose Materials (SPM)		1,100,000
Tritium Breeding Materials		800,000
Analysis and Evaluation		150,000
Device or Component Fabrication, Behavior or Testing	$	5,140,000
Plasma Materials Interaction and High Heat Flux Component Development Programs		5,140,000
Instrumentation and Facilities	$	5,900,000
Radiation Facilities Operation		3,900,000
Operation of Oak Ridge Research Reactor		2,000,000

OFFICE OF ENERGY RESEARCH (Continued)

	FY 1986
Small Business Innovation Research Program*	$ 13,331,158*
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 4,363,109*
Phase I Projects:	
High Thermal Conductivity Dispersion-Strengthened Silicon Nitride	$ 49,848
Improved Silicon Germanium Thermoelectrics	50,000
Development of High-Temperature Amorphous Alloys	49,848
Processing Science: Understanding and Control of the Whisker Matrix Interface in Ceramic-Ceramic Composites	49,964
The Development of Nb_3Sn Superconductor with Micron-Size Filaments, High-Current Densities, and Low Magnetization	50,000
Mechanical Reliability of Superplastically Forged Silicon Nitride	50,000
Improved Brazing Techniques for Machinable Glass Ceramics	49,991
Neutron Irradiation Stable Carbon-Carbon Composites	49,991
Improvement of Copper/Epoxy Composites for Fusion Energy Magnet Applications	49,977
An Internal-External Bronze Process for the Manufacture of Large Filament Nb_3Sn	49,995
High-Current Density Nb_3Sn Superconductors with Electrically Uncoupled Fine NbTi Filaments and a High Current Density	49,989
A Search for Metal Oxide-Metal Nitride Eutectic Systems	30,953
Metallophilic Oxides in Copper for Fusion Reactors	50,000
TiC Infiltrated Graphite Fiber Structures for Fusion Reactors	49,948
Surface Modification by Ion Beams for Improved Corrosion Resistance	49,981

*Includes 33 new Phase I and 13 new Phase II awards made in FY 1986 and second-year incremental funding for 13 Phase II projects initiated in FY 1985; totals rounded to nearest $1000. Totals reflect the fact that Phase II funding levels are spread over a two-year period.

		FY 1986
Small Business Innovation Research Program* (Continued)		
Materials Preparation, Synthesis, Deposition, Growth, or Forming (Continued)		
Phase II Projects: (First Year)		
Fabrication and Characterization of Ceramic-Matrix-Ceramic Whisker Composites with Random Orientation of the Whiskers	$	498,816
Development of a Continuous Process to Clad Superconductors with High-Purity Aluminum		499,859
The Direct Production of Intermetallic Compound Powder		500,000
The Investigation of an Improved Processing Method for High Current Density, Fine-Filamentary Superconductors		499,994
The Development of a Process for Producing Aluminum Stabilized, Fine-Filamentary Superconducting Composites		499,992
Phase II Projects: (Second Year)		
Growth of BaF_2 Crystals by the Heat-Exchanger Method (HEM) with Enhanced Fast Component for Scintillator Applications	$	270,479
Brazing of Machineable Glass Ceramics and Other Ceramic Materials		368,495
Development of a New Process for the Production of Very Fine Filamentary Superconducting NbTi Composites		494,989
Materials Properties, Behavior, Characterization or Testing	$	1,186,900*
Phase I Projects:		
An Investigation of Fatigue Failure Initiation and Propagation in Wind-Turbine-Grade Wood/Epoxy Laminate Containing Several Veneer Joint Styles	$	50,000

*Totals reflect the fact that Phase II funding levels are spread over a two-year period.

		FY 1986
Materials Properties, Behavior, Characterization or Testing (Continued)		
Phase I Projects (Continued):		
Application of Direct Recoil Spectroscopy for Analysis of Li, H, and D on Fusion Materials	$	50,000
Nonorganic, Low-Pressure Solid Lubricants by Ion Beam Enhanced Deposition		50,000
A Novel Hybrid Lubrication Approach for Advanced Heat Engines		49,837
Phase II Projects: (Second Year)		
Processing and Characterization of SiCALON Ceramics	$	488,048
Reduction of Surface Recombination in Silicon Solar Cells		499,015
Device or Component Fabrication, Behavior or Testing	$	5,284,428*
Phase I Projects:		
An All-Metal, Demountable Cryogenic Seal	$	49,985
Development of High-Resolution Gratings Produced from Advanced Materials by Chemical Vapor Deposition Techniques		49,987
A Feasibility Assessment of the Thermotunnel Energy Converter		49,953
Study of Filament Instability in Multi-Filamentary NbTi/Cu Composites		50,000
A Differential Microalorimetric Biosensor Based on Pyroelectric Thin Polymer Films		49,843
Surface Figure Measurements of X-Ray Optics		49,867
A Real-Time, Nocontact Optical Surface Motion Monitor		48,905
A Fiber Optic Tactile Sensor for Robotics Applications		49,619

*Totals reflect the fact that Phase II funding levels are spread over a two-year period.

	FY 1986
Device or Component Fabrication, Behavior, or Testing (Continued)	
Phase I Projects (Continued):	
High-Temperature Thermionics for Burst Power Applications	$ 50,000
A Contactless Self-Scanning High-Temperature NDE Flaw Detector	49,765
An Improved Thermionic Conversion Device Using Oxide with Metallic or Metal Carbide Composites	49,925
Microlaminated Ferromagnetic Composites for Magnetic Switching	50,000
Phase II Projects: (First Year)	
The Design and Fabrication of Flat Panels with High Acoustic Transmissivity	$ 500,000
Highly Versatile Multilayer Tactile Sensor Arrays	50,000
Direct Energy Conversion with Pyroelectric Polymer	499,749
Reduction of Low-Level Radwaste Disposal in Water Clean-Up Systems by Use of Magnetite	499,667
Phase II Projects: (Second Year)	
Eddy-Current, Nondestructive Evaluation of Laser-Glazed Metallic Surfaces	$ 490,000
Fresnel-Lens Photovoltaic Concentrator Design Innovations	390,000
Development of Fe-Nd-B Metal-Matrix Magnets	284,615
Immuniodiagnostic Biosensor Device Based on Conductive Organic Polymers	483,124
Titanium Nitride Coating of High-Speed Steel and Carbide Metal Cutting Tools Using Fluid Bed Furnace Technology	495,040
Method and Device for Nondestructive Inspection of Niobium to Improve Superconductivity	494,424
Wear Resistant Ferrous Metal Matrix Composites for Municipal Solid Waste Processors	499,960

OFFICE OF ENERGY RESEARCH (Continued)

		FY 1986
Instrumentation and Facilities	$	2,496,721*
Phase I Projects:		
UV Holographic Mirrors With High Diffraction Efficiency	$	49,336
Phase II Projects: (First Year)		
The Construction of a Soft X-Ray Source Using Transition Radiation for Lithography	$	478,564
A New Two-Dimensional Position Encoder for Positron Emission Tomography (PET)		500,000
A High Efficiency Helium-3 Neutron Detector		499,667
An InP Semiconductor Neutrino Detector		499,970
Phase II Projects: (Second Year)		
Fiber-Optic Track Detector	$	469,184

*Totals reflect the fact that Phase II funding levels are spread over a two-year period

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 Health and Environmental Research: Division of Physical
  and Technologies Research

- Office of Fusion Energy

- Small Business Innovation Research Program

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 Iran Thomas, 301-353-3427. For specific detailed information, the reader is referred to DOE publication Materials Sciences Programs Fiscal Year 1986 (DOE/ER-0295 dated September 1986). 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

Bounds on Dynamic Plastic Deformation - DOE Contact Oscar P. Manley, Contact 301-353-5822; Argonne National Laboratory Contact C. K. Youngdahl, 312-972-6149

- o Devise load characterization parameters using weighted integrals of time-space distributions without requiring detailed numerical analysis.

Diffusion, Fluid Flow, and Sound Propagation in Disorders Media - DOE Contact Oscar P. Manley, 301-353-5822; Boston University Contact Thomas Keyes, 617-353-4730

- o Apply modern nonequilibrium statistical mechanics methods to transport with large disorder.
- o Calculate transport coefficients, correlation functions and lattice vibrations in several disordered systems.

In-Flight Measurement of the Temperature of Small, High Velocity Particles - DOE Contact Oscar P. Manley, 301-353-5822; Idaho National Engineering Laboratory Contact J. R. Fincke, 208-526-2031

- o Measure particle temperatures and sensitivities while electrodynamically suspended.
- o Develop analog and digital signal processing techniques for in-flight property evaluation.
- o Application of developed techniques to measure particle temperatures in a high-temperature plasma.

Experimental Measurement of the Plasma/Particle Interation- DOE Contact Oscar P. Manley, 301-353-5822; Idaho National Engineering Laboratory Contacts M. E. McIlwain, 208-526-8818, C. B. Shaw, 208-526-8818, S. C. Snyder, 208-526-1507, L. D. Reynolds, 208-526-8335

- o Describe, quantitatively, the heat, mass, and momentum transfer with metallic or oxide particles in thermal plasmas.
- o Use experimental results to validate and correct theoretical models for plasma processing and for optimal torch and fixture design.

Integrated Sensor/Model Development for Automated Welding- DOE Contact Oscar P. Manley, 301-353-5822; Idaho National Engineering Laboratory Contacts H. B. Smartt, 208-256-8333, J. A. Johnson, 208-526-9021, J. O. Bolstad, 208-526-1753

- Develop model of gas metal arc welding process suitable for real-time process control.

- Develop optical sensing capability to provide weld-bead geometry data.

- Develop ultrasonic sensing capability to directly sense weld bead site wall penetration and fusion.

Nondestructive Characterization of Fracture Dynamics and Crack Growth - DOE Contact Oscar P. Manley, 301-353-5822; Idaho National Engineering Laboratory Contacts J. A. Johnson, 208-526-9021, B. A. Barna, 208-526-6124, R. A. Allemeir, 208-526-9588

- Develop instrumentation and models to measure and predict interaction between ultrasound and gorwing cracks in engineering materials.

- Investigate methods of sensing properties of growing cracks.

Boiling of Aqueous Polymer Solutions - DOE Contact Oscar P. Manley, 301-353-5822; University of Illinois at Chicago Contact J. P. Hartnett, 312-996-4490

- Study pool boiling behavior of aqueous polymer solutions.

Plasma Reduction of Metallic Oxide Particles - DOE Contact Oscar P. Manley, 301-353-5822; MIT Contacts J. F. Eliott, 617-253-3305, J. Szekely, 617-253-3305, R. E. Spjut, 617-253-0252

- Characterize the reduction to metal of oxide particles into the tail flame of an arc plasma.

High-Temperature Gas-Particle Reactions - DOE Contact Oscar P. Manley, 301-353-5822; MIT Contacts J. F. Eliott, 617-253-3305, R. E. Spjut, 617-253-0252

- Examine the physicochemical behavior of industrial organic particles in conditions simulating exposure to arc plasmas.

Mathematical Modeling of Transport Phenomena in Plasma Systems - DOE Contact Oscar P. Manley, 301-353-5822; MIT Contact J. Szekely, 617-253-3305

- o Develop a comprehensive mathematical representation of the electromagnetic force field, velocity field, temperature field, and chemical composition of plasma flames, together with their interaction with solid particles.

In-Process Control of Residual Stresses and Distortion in Automatic Welding - DOE Contact Oscar P. Manley, 301-353-5822; MIT Contact Koichi Masubuchi, 617-253-6820

- o Develop technology of in-process control of residual stress and distortion in automatic welding.

Investigation of Visible and Near Visible Light Emissions as Sensors for Control of Arc Welding Processes - DOE Contact Oscar P. Manley, 301-353-5822; MIT Contact Thomas W. Edgar, 617-253-3229

- o Develop sensing and control methods to automate gas metal arc welding processes.

Multivariable Control of the Gas-Metal Arc Welding Process- DOE Contact Oscar P. Manley, 301-353-5822; MIT Contact David E. Hardt, 617-253-2429

- o Cast the GMAW process into its most general sense and examine the use of multivariable control methods.

Modeling of GMA Weld Pool Geometry and Metal Transfer - DOE Contact Oscar P. Manley, 301-353-5822; MIT Contact William Unkel, 617-253-2193

- o Develop physically-based, computationally-simple models of GMAW processes.
- o Use models to identify process modifications for more effective multivariable control.

Modeling and Analysis of Surface Cracks - DOE Contact Oscar P. Manley, 301-353-5822; MIT Contacts David M. Parks, 617-253-1630

- o Analyze ductile crack initiation, growth, and instability in part-through surface-cracked plates and shells.

Thermal Plasma Processing of Materials - DOE Contact Oscar P. Manley, 301-353-5822; University of Minnesota Contact E. Pfender, 612-625-6012

o Develop and diagnose a new plasma reactor to solve problems of particle injection, particle confinement, and particle dwell times.

Transport Properties of Disordered Porous Media from the Microstructure - DOE Contact Oscar P. Manley, 301-353-5822; North Carolina State University Contact S. Torquato, 919-737-2365

o Develop quantitative relationship between properties of a disordered porous medium and its microstructure.

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

o Apply the scattered field approach to the characterization and detection of cracklike flaws.

Inelastic Deformation and Damage at High Temperature - DOE Contact Oscar P. Manley, 301-353-5822; Rensselaer Polytechnic Institute Contact Erhard Krempl, 518-266-6432

o Characterize material behavior in mathematical forms for use in inelastic stress and life prediction.

o Develop a finite element program to calculate, directly, the life-to-crack initiation of a component under a given load history.

Energy Changes in Transforming Solids - DOE Contact Oscar P. Manley, 301-353-5822; Standord University Contacts George Herrmann, David M. Barnett, 514-723-4143

o Generalize configurational forces in deformable solids to characterize state changes accompanied by energy changes.

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

o Develop techniques for contactless nondestructive testing and range sensing in air.

Effective Elastic Properties of Cracked Solids - DOE Contact Oscar P. Manley, 301-353-5822; Tufts University Contact Mark Kachanov, 617-628-5000, ext. 2821

- Evaluate elastic properties of solids with cracks including effects of crack location and density.

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

- Measure and determine the importance of electrokinetic- or zeta- corrosion and deposit formation in lubricated rolling and sliding systems

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

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

- Improve design and analytical techniques for predicting the integrity of flawed structural components.

- Experimental research 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.

- Use of metallographic techniques 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

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

- 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

- 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 viscoelastic properties of the materials.

- Analysis of the rolling loss of a pneumatic tire 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.

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

- Study of the nature and 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.

- Calculation of micro-asperity temperatures and the wear film temperatures of the oil film 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.

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

- Application 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.

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

- Investigation of local anisotropy and inhomogeneity due to near-tip voids and the effect of a zone of plastic deformation near a crack tip.

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

- 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.

- Design and construct an apparatus designed and constructed 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.

- Develop guideline and techniques for the digital processing of surface roughness data generated in analog form by a stylus profile instrument.

Multiviewing Transducer System - 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. Material 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

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

- Study of semiconductor materials, primarily germanium and silicon, for use as radiation detectors. Research includes crystal growth and purification, measurement of materials properties, and signal processing.

Development of Advanced Internal Gain Radiation Detection Structures Based on Neutron Transmutation Doped Silicon - DOE Contact G. Goldstein, 301-353-5348; University of Southern California Contact G. Huth, 213-822-9184

- Silicon avalanche radiation detectors are developed using single crystal neutron transmission doped silicon. Research focuses on studies of the avalanche process and development of specific devices.

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, as 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 economics 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 (PIM) 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 fusion--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

- Research and development of structural alloys, focusing on neutron irradiation efforts.
- Development of variations of austenitic stainless, 9-12Cr ferritic/martensitic starts, vanadium alloys and reduced activation alloys.

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

- Establish the mechanistic basis to evaluate and project the effect of the fusion radiation environment from currently available irradiation facilities.
- Analyze Dosimetry and damage in order 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

- Investigate radiation effects on magnet system materials (super-conductor, 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

- o Establish 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

- o Provide a bridge between the materials and design communities.

- o Develop and publish 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; SNL Contact W. Gusster, 415-422-1648

- o Develop and maintain a basic long range technological capability which can be utilized by all confinement communities.

- o Development of specific component projects for present and future confinement facilities and experiments.

Instrumentation and Facilities

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

- o 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

- o Operating cost of the ORR for Energy Research users.

Small Business Innovation Research Program

The Small Business Innovation Research (SBIR) program was established in compliance with the Small Business Innovation Development Act of 1982, Public Law 97-219. 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 about 6 months and awards are limited to $50,000. Phase II is the principal research or research and development effort, and awards can be 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 to be 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 materials-related projects, like all other projects in the DOE SBIR program, were selected using the specific evaluation criteria listed in the program solicitation. Conclusions were reached on the basis of detailed reports returned by reviewers drawn from DOE laboratories, universities, private industry, and government. In the case of Phase II, if 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 supported in this program represents high-risk research, but the potential benefits are also high if the objectives are met. Brief descriptions of all DOE SBIR projects (not just those of interest in materials Research) are given in the following publications: Abstracts of Phase I Awards, 1986 (DOE/ER-0285), Abstracts of Phase II Awards, 1985 (DOE/ER-0209/1), and Abstracts of Phase II Awards, 1986 (DOE/ER-0286). Copies of these publications may be obtained by calling Mrs. Gerry Washington on 301-353-5867.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Phase I Projects:

High Thermal Conductivity Dispersion-Strengthened Silicon Nitride - DOE Contact Samuel J. Barish, 301-353-3054; CERAMATEC, Inc. Contact Mr. David W. Richerson, 801-486-5071

Improved Silicon Germanium Thermoelectrics - DOE Contact Bill Barnett, 301-353-3097; Electro Tech Corporation Contact Mr. Norbert B. Elsner, 619-459-1016

Development of High-Temperature Amorphous Alloys - DOE Contact Samuel J. Barish, 301-353-3054; Flow Research Company Contact Mr. Arthur C. Day, 206-872-7080

Processing Science: Understanding and Control of the Whisker Matrix Interface in Ceramic-Ceramic Composites - DOE Contact Samuel J. Barish, 301-353-3054; Flow Research Company Contact Mr. Birol Sonuparak, 206-872-7080

The Development of Nb_3Sn Superconductor with Micron-Size Filaments, High-Current Densities, and Low Magnetization - DOE Contact Victor Der, 301-353-5736; Intermagnetics General Corporation Contact Mr. Gennady Ozeryansky, 203-753-5215

Mechanical Reliability of Superplastically Forged Silicon Nitride - DOE Contact Samuel J. Barish, 301-353-3054; Jupiter Technologies, Inc. Contact Dr. Prakash C. Panda, 607-257-4514

Improved Brazing Techniques for Machinable Glass Ceramics- DOE Contact Marvin Cohen, 301-353-4253; Lintel Technology, Inc. Contact Dr. Chou H. Li, 516-484-1719

Neutron Irradiation Stable Carbon-Carbon Composites - DOE Contact Marvin Cohen, 301-353-4253; Nuclear and Aerospace Materials Corporation Contact Mr. Glen B. Engle, 619-487-0325

Improvement of Copper/Epoxy Composites for Fusion Energy Magnet Applications - DOE Contact Marvin Cohen, 301-353-4253; PDA Engineering Contact Mr. William H. Pfeifer, 714-556-2800

An Internal-External Bronze Process for the Manufacture of Large Filament Nb_3Sn - DOE Contact Victor Der, 301-353-5736; Supercon, Inc. Contact Dr. Eric Gregory, 617-842-0174

High-Current Density Nb_3Sn Superconductors Made by Powder Metallurgy - DOE Contact Victor Der, 301-353-5736; Supercon, Inc. Contact Dr. Eric Gregory, 617-842-0174

A Search for Metal Oxide-Metal Nitride Eutectic Systems- DOE Contact Samuel J. Barish, 301-353-3054; Syn Crys, Inc. Contact Dr. G. Wayne Clark, 615-482-3411

Metallophilic Oxides in Copper for Fusion Reactors - DOE Contact Ted Reuther, 301-353-4963; Technical Research Associates, Inc. Contact Mr. J. K. Weeks, 801-582-8080

TiC Infiltrated Graphite Fiber Structures for Fusion Reactors - DOE Contact Marvin Cohen, 301-353-4253; Ultramet Contact Mr. Richard B. Kaplan, 818-899-0236

Surface Modification by Ion Beams for Improved Corrosion Resistance - DOE Contact Samuel J. Barish, 301-353-3054; Universal Energy Systems Contact Dr. Rabi Bhattacharya, 513-426-6900

Phase II Projects: (First Year)

Fabrication and Characterization of Ceramic Matrix-Ceramic Whisker Composites with Random Orientation of the Whiskers - DOE Contact Iran Thomas, 301-353-3426; Ceramatec, Inc. Contact L. Viswanathan, 801-486-5071

Development of a Continuous Process to Clad Superconductors With High-Purity Aluminum - DOE Contact Earle Fowler, 301-353-4801; Intermagnetics General Corporation Contact Dr. Kanithi Hemachalam, 203-753-5215

The Direct Production of Intermetallic Compound Powder - DOE Contact Iran Thomas, 301-353-3426; Materials and Electrochemical Research Corporation Contact Dr. James C. Withers, 602-749-3257

The Investigation of an Improved Processing Method for High Current Density, Fine-Filamentary Superconductors - DOE Contact Earle Fowler, 301-353-4801; Supercon, Inc. Contact Dr. Eric Gregory, 617-842-0174

The Development of a Process for Producing Aluminum Stabilized, Fine-Filamentary Superconducting Composites - DOE Contact Earle Fowler, 301-353-4801; Supercon, Inc. Contact Dr. Eric Gregory, 617-842-0174

Phase II Projects: (Second Year)

Growth of BaF_2 Crystals by the Heat-Exchanger Method (HEM) with Enhanced Fast Component for Scintillator Applications - DOE Contact Stanley Whetstone, 301-353-3613; Crystal Systems, Inc. Contact Dr. Chandra P. Khattak, 617-745-0088

Brazing of Machineable Glass Ceramics and Other Ceramic Materials - DOE Contact Marvin Cohen, 301-353-4253; Hittman Materials & Medical Components, Inc. Contact Mr. Harold N. Barr, 301-730-7800

Development of a New Process for the Production of Very Fine Filamentary Superconducting NbTi Composites - DOE Contact Earle Fowler, 301-353-4801; Supercon, Inc. Contact Dr. Eric Gregory, 617-842-0174

Materials Properties, Behavior, Characterization, or Testing

Phase I Projects:

An Investigation of Fatigue Failure Initiation and Propagation in Wind-Tubine-Grade Wood/Epoxy Laminate Containing Several Veneer Joint Styles - DOE Contact Jeffrey Rumbaugh, 202-586-1696; Gougeon Brothers, Inc. Contact Mr. William D. Bertelsen, 517-684-7286

Applications of Direct Recoil Spectroscopy for Surface Analysis of Li, H, and D on Fusion Materials - DOE Contact Marvin Cohen, 301-353-4253; IONWERKS Contact Dr. J. Albert Schultz, 713-667-1691

Nonorganic, Low-Pressure Solid Lubricants by Ion Beam Enhanced Deposition - DOE Contact Marvin Cohen, 301-353-4253; Spire Corporation Contact Dr. James Hirvonen, 617-275-6000

A Novel Hybrid Lubrication Approach for Advanced Heat Engines - DOE Contact Terry Levinson, 202-586-5377; Technology Assessment & Transfer, Inc. Contact Dr. Larry L. Fehrenbacher, 301-858-0248

Phase II Projects: (Second Year)

Processing and Characterization of SiCALON Ceramics - DOE Contact Iran Thomas, 301-353-3426; Ceramatec, Inc. Contact Dr. Raymond A. Cutler, 801-487-5411

Reduction of Surface Recombination in Silicon Solar Cells- DOE Contact Richard King, 202-586-1693; Spire Corporation Contact Dr. Mark B. Spitzer, 617-275-6000

Device or Component Fabrication, Behavior, or Testing

Phase I Projects:

An All-Metal, Demountable Cryogenic Seal - DOE Contact Earle Fowler, 301-353-4801; Creare Inc. Contact Dr. Herbert Sixsmith, 603-643-3800

Development of High-Resolution Gratings Produced from Advanced Materials by Chemical Vapor Deposition Techniques - DOE Contact Donald Priester, 301-353-3421; CVD, Inc. Contact Dr. Parul Purohit, 617-933-9243

A Feasibility Assessment of the Thermotunnel Energy Converter - DOE Contact Bill Barnett, 301-353-3097; Energetics, Inc. Contact Mr. Thomas S. Bustard, 301-992-4000

Study of Filament Instability in Multifilamentary NbTi/Cu Composites - DOE Contact Earle Fowler, 301-353-4801; Intermagnetics General Corporation Contact Dr. Kanithi Hamachalam, 203-753-5215

A Differential Microcalorimetric Biosensor Based on Pyroelectric Thin Polymer Films - DOE Contact Janet Dorigan, 301-353-5778; Ohmicron Corporation Contact Mr. Mark K. Malmros, 609-737-9050

Surface Figure Measurements of X-Ray Optics - DOE Contact Samuel J. Barish, 301-353-3054; Optel Systems/Optel Bar Code Systems, Inc. Contact Dr. Thomas C. Bristow, 716-385-6760

A Real-Time, Noncontact Optical Surface Motion Monitor - DOE Contact Stan Sobczynski, 202-586-1878; OPTRA, Inc. Contact Mr. Geert Wyntjes, 617-535-7670

A Fiber Optic Tactile Sensor for Robotics Applications - DOE Contact Oscar Manley, 301-353-5822; Physical Optics Corporation Contact Dr. Joanna Jannson, 213-371-3909

High-Temperature Thermionics for Burst Power Applications- DOE Contact Ira Helms, 301-353-5845; Rasor Associates, Inc. Contact Mr. John McVey, 408-734-1622

A Contactless Self-Scanning High-Temperature NDE Flaw Detector - DOE Contact Phillip Hemmig, 301-353-3579; SONOQUEST/Advanced Ultrasonics Research Contact Mr. Jacques R. Chamuel, 617-239-0554

An Improved Thermionic Conversion Device Using Oxide with Metallic or Metal Carbide Composites - DOE Contact Bill Barnett, 301-353-3097; Technology for Energy Corporation Contact Dr. Francis E. LeVert, 615-966-5856

Microlaminated Ferromagnetic Composites for Magnetic Switching - DOE Contact David Bailey, 301-353-4078; Xi Magnetics, Inc. Contact Dr. John L. Wallace, 215-347-1768

Phase II Projects: (First Year)

The Design and Fabrication of Flat Panels with High Acoustic Transmissivity - DOE Contact Iran Thomas, 301-353-3426; Analysis Consultants Contact Dr. B. G. Martin, 714-380-1204

Highly Versatile Multilayer Tactile Sensor Arrays - DOE Contact Oscar Manley, 301-353-5822; Bonneville Scientific Contact Dr. Allen R. Grahn, 801-359-0402

Direct Energy Conversion with a Pryoelectric Polymer - DOE Contact Bill Barnett, 301-353-3097; Chronos Research Laboratories, Inc. Contact Dr. Randall B. Olsen, 619-756-1447

Reduction of Low-Level Radwaste Disposal in Water Clean-up Systems by Use of Magnetite - DOE Contact Scott Hinschberger, 208-526-1288; Nuclear Consulting Services, Inc. Contact Dr. Djordjiji R. Sain, 614-846-5710

Phase II Projects: (Second Year)

Eddy-Current, Nondestructive Evaluation of Laser-Glazed Metallic Surfaces - DOE Contact Iran Thomas, 301-353-3426; American Research Corporation of Virginia Contact Dr. Russell J. Churchill, 703-731-0836

Fresnel-Lens Photovoltaic Concentrator Design Innovations- DOE Contact Michael Pulscak, 202-586-6264; ENTECH, Inc. Contact Mr. Mark J. O'Neill, 214-456-0900

Development of Fe-Nd-B Metal-Matrix Magnets - DOE Contact Iran Thomas, 301-353-3426; KJS Associates Contact Mr. Reinhold M. W. Strnat, 513-879-0114

Immuniodiagnostic Biosensor Device Based on Conductive Organic Polymers - DOE Contact George Duda, 301-353-3651; MKM Research/Ohmicron Contact Mr. Mark K. Malmros, 609-737-9050

Titanium Nitride Coating of High-Speed Steel and Carbide Metal Cutting Tools Using Fluid Bed Furnace Technology - DOE Contact Raymond LaSala, 202-586-4198; Procedyne Corporation Contact Mr. Joseph E. Japka, 201-249-8347

Method and Device for Nondestructive Inspection of Niobium to Improve Superconductivity - DOE Contact David Sutter, 301-353-5228; Sonoscan, Inc. Contact Dr. Lawrence W. Kessler, 312-766-7088

Wear Resistant Ferrous Metal Matrix Composites for Municipal Solid Waste Processors - DOE Contact Donald Walter, 202-586-4679; Waste Energy Technology Corporation Contact Dr. David B. Spencer, 617-275-6400

Instrumentation and Facilities

Phase I Projects:

UV Holographic Mirrors with High Diffraction Efficiency- DOE Contact Samuel J. Barish, 301-353-3054; Physical Optics Corporation Contact Dr. Joanna Jannson, 213-371-3909

Phase II Projects: (First Year)

The Construction of a Soft X-Ray Source Using Transition Radiation for Lithography - DOE Contact Iron Thomas, 301-353-3426; Adelphi Technology Contact Dr. Melvin A. Piestrup, 415-861-0633

A New Two-Dimensional Position Encoder for Position Emission Tomography (PET) - DOE Contact Gerald Goldstein, 301-353-3426; Computer Technology and Imaging, Inc. Contact Dr. Ronald Nutt, 615-966-7539

A High Efficiency Helium-3 Neutron Detector - DOE Contact Stanley Whetstone, 301-353-3613; KMS Fusion, Inc. Contact Mr. Timothy M. Henderson, 313-769-8500

An InP Semiconductor Neutrino Detector - DOE Contact Stanley Whetstone, 301-353-3613; Radiation Monitoring Devices, Inc. Contact Dr. Gerald Entine, 617-926-1167

Phase II Projects: (Second Year)

Fiber-Optic Track Detector - DOE Contact Stanley Whetstone, 301-353-3613; Synergistic Detector Designs Contact Dr. Arthur H. Rogers, 415-964-4756

OFFICE OF NUCLEAR ENERGY

	FY 1986
Office of Nuclear Energy Grand Total	$129,294,000
Office of Reactor Systems Development and Technology	$ 6,180,000
Office of Advanced Reactor Programs	$ 6,180,000
High Temperature Gas Cooled Reactor Division	$ 6,180,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 690,000
Fuel Process Development	690,000
Materials Properties, Behavior, Characterization, or Testing	$ 5,490,000
Fuel Materials Development	940,000
Fuel Development and Testing	880,000
Graphite Development	580,000
Graphite Development and Testing	575,000
Metals Technology Development	840,000
Structural Materials Development	470,000
Advanced Gas Reactor Materials Development	1,205,000
Office of Terminal Waste Disposal and Remedial Action	$ 5,995,000
Division of Storage and Treatment Projects	$ 5,995,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 4,500,000
Technical Support to West Valley Demonstration Project	4,500,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,320,000
Materials Characterization Center Testing of West Valley Formulation Glass	520,000
Nuclear Waste Treatment	0
Test Development and Testing of West Valley Reference Formulation Glass Process	510,000
Process and Product Quality Optimization for West Valley Waste Form	290,000

		FY 1986
Device or Component Fabrication, Behavior, or Testing	$	175,000
Special Waste Form Lysimeter for Arid Regions		75,000
Special Waste Form Lysimeter for Humid Regions		100,000
Office of Uranium Enrichment	$	37,332,000
Device or Component Fabrication, Behavior, or Testing	$	37,332,000
Gaseous Diffusion: Barrier Quality		1,088,000
Gaseous Diffusion: Materials and Chemistry Support		3,080,000
AVLIS Separator Technology Development		33,164,000
Office of Reactor Systems, Development and Technology	$	2,305,000
Division of Special Applications	$	2,305,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$	1,730,000
Development of Improved Thermoelectric Materials for Space Nuclear Power Systems		850,000
Development of an Improved Process for the Manufacture of DOP-26 Iridium Alloy Blanks		525,000
Carbon Bonded Carbon Fiber Insulation Manufacturing Process Development and Product Characterization		355,000
Materials Properties, Behavior, Characterization, or Testing	$	575,000
Nondestructive Testing Methods Development and Application to Thermoelectric Materials and Devices		175,000
Characterization of State-of-the-Art Thermoelectric Device/Materials and Exploratory Studied of Rare Earth Sulfide Thermoelectric Materials		400,000

	FY 1986
Office of Space Reactor Projects	
Office of Breeder Technology Projects	$ 17,482,000
Fuels and Core Materials Division	$ 12,782,000
Materials Properties, Behavior, Characterization, or Testing	$ 12,782,000
Oxide Fuel Development - CDE	4,131,000
Technology Development Support for IFR	2,400,000
Qualification of 9 Cr-1 Mo Steel for LMF Applications	300,000
Absorber Development	384,000
Metallic Fuel Development	380,000
Mechanical Properties of Materials for LMR Applications	48,000
Structural Design/Life Technology	385,000
Integral Fast Reactor (IFR) Fuel Performance Demonstration	3,888,000
Oxide Fuel Development - Fuels and Materials Development	866,000
Clad/Duct Alloy Development	0
Materials and Structures Division	$ 4,700,000
Materials Properties, Behavior, Characterization, or Testing	$ 4,700,000
High Temperature Structural Design, Mechanical Property Design Data, Tribology Coolant Technology, Fabrication, Handbook, and Advanced Alloy Development	4,700,000
Office of Naval Reactors	$ 60,000,000*
Reactor Material Division	$ 60,000,000*

*Approximate

OFFICE OF NUCLEAR ENERGY

The Office of Nuclear Energy conducts research projects in the Division of High Temperature Gas-Cooled Reactors which includes 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 current research.

Division of High Temperature Gas-Cooled Reactors

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 Gas-Cooled Reactor (HTGR). The materials interests of this division include those required for the development of coated particle fuels, graphite moderator and reflector blocks, graphite core support blocks and posts, and heat exchanger tubing and tube sheets.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Fuel Process Development - DOE Contact J. E. Fox, 301-353-3985; GA Technologies Contact O. M. Stansfield, 619-455-2895

- o Production of depleted and enriched uranium oxycarbide microspheres.
- o Coating of microspheres with multiple ceramic layers of pyrolytic carbon and silicon carbide.
- o Consolidation of coated fissile and fertile fuel particles into fuel rods.

Materials Properties, Behavior, Characterization, or Testing

Fuel Materials Development - DOE Contact J. E. Fox, 301-353-3985; GA Technologies Contact O. M. Stansfield, 619-455-2895

- o Development of technology base required to design, qualify, and license fuel systems for near-term steam cycle and advanced process heat HTGRs.
- o Preparation and evaluation of irradiation experiments.
- o Performance of post-irradiation fission product release tests.

- o Development and verification of fuel performance models.

Fuel Development and Testing - DOE Contact J. E. Fox, 301-353-3985; ORNL Contact M. J. Kania, 615-576-4856

- o Fabrication, testing, and evaluation of irradiation experiments; development of post-irradiation examination equipment and methods.

- o Evaluation of fuel performance and development of fission product release mechanism and models.

Graphite Development - DOE Contact J. E. Fox, 301-353-3985; GA Technologies Contact R. Vollman, 615-455-3310

- o Selection, characterization, and qualification of graphite materials for application in HTRs.

- o Development of failure and design criteria.

Graphite Development and Testing - DOE Contact J. E. Fox 301-353-3985; ORNL Contact W. P. Eatherly, 615-574-5220

- o Selection, characterization, and qualification of graphite materials; evaluation of high temperature corrosion resistance and mechanical properties (tensile, creep, fatigue, fracture mechanics, etc.)

- o Fabrication, testing, and evaluation of irradiation experiments; development of high strength, oxidation resistant graphites with high resistance to irradiation damage.

Metals Technology Development - DOE Contact J. E. Fox, 301-353-3985; GA Technologies Contact D. I. Roberts, 619-455-2560

- o Characterize and qualify the metallic materials selected for application in the near-term steam cycle/cogeneration HTR system.

- o Develop base technology required for selection of alloys for advanced HTR systems.

Structural Materials Development - DOE Contact J. E. Fox, 301-353-3985; ORNL Contact P. L. Rittenhouse, 615-574-5103

- o Selection, characterization, and qualification of high temperature alloys; evaluation of effects of exposures in simulated environments on mechanical properties (creep, fatigue, fracture mechanics).

- o Development of the database and correlations required for qualification.

Advanced Gas Reactor Materials Development - DOE Contact J. E. Fox, 301-353-3985; GE Contact O. F. Kimball, 518-385-1086

- o Selection and evaluation of candidate high temperature alloys; evaluation of effects of exposures in simulated environments on mechanical properties (tensile, impact, creep, fatigue).

- o Generation of a database for development of design criteria and code qualification rules for temperatures above 760°C (1400°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 T. W. McIntosh, 301-353-3589; PNL Contact R. A. Brouns, 509-376-0731

- o 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

- o 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 R. B. Chitwood, 301-353-4728; PNL Contact R. A. Brouns, 509-376-0731

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

Test Development and Testing of West Valley Reference Formulation Glass - DOE Contact H. F. Walter, 301-353-5510; CUA Contact P. B. Macedo, 202-635-5327

- o Development of borosilicate glass waste form test methods.

- o Testing of nonradioactive reference West Valley Demonstration Project waste formulation glass.

Process and Product Quality Optimization for West Valley Waste Form - DOE Contact H. F. Walter, 301-353-5510; AU Contact L. D. Dye, 607-871-2432

- o Attempt to maximize optimum conditions for producing acceptable quality borosilicate glass waste form product.

- o Development of methods for control of product quality during routine manufacture of the West Valley Demonstration Project waste form.

Device or Component Fabrication, Behavior, or Testing

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

- o 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.

- o Identify the chemical and physical processes that control the concentrations of radionuclides in the surrounding soil.

- o 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

- o 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.

- o Identify the chemical and physical processes that control the concentration of radionuclides in the surrounding soil.

- o Compare radionuclide emigration from solidified commercial low-level waste in order to evaluate the benefits of solidification.

Office of Uranium Enrichment

The Department of Energy is authorized by the Atomic Energy Act, as amended, to provide toll uranium enrichment services to commercial customers. That is, customers deliver natural uranium to one of DOE's plants and for a fee, DOE returns material enriched to the desired level in the isotope uranium-235. 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, secure, and environmentally acceptable manner.

Until 1974, the United States held a virtual monopoly in the world enrichment market. Since that time, competition from foreign suppliers has reduced DOE's share of the world market to 46%. The ability of foreign suppliers to penetrate DOE's previously exclusive market was due principally to significant price differences and more favorable contract terms.

Recently, the Administration and Congress have reaffirmed that the United States must be a reliable and economic source of uranium enrichment services for domestic and military purposes. As a result, in early 1984, DOE announced that it was embarking on a major initiative to restore the competitive position of the United States in enrichment. The elements of the Department's initiative were: to stabilize DOE's market share through the issuance of a new more flexible enrichment contract; to reduce prices to competitive levels; to enhance DOE customer services and marketing activities; and to reduce program costs in all major areas, including diffusion operations and advanced technology research and development activities. The underlying philosophy of the DOE approach was to operate the program as much like a competitive business as possible keeping in mind that there will be an oversupply of world uranium enrichment services well into the 1990s.

One major element in the initiative to recapture the enrichment market was the selection in June 1985, after a lengthy evaluation, of the Atomic Vapor Laser Isotope Separation (AVLIS) process for having the best potential for providing the lowest cost uranium enrichment in the future. Because the enrichment market will be dynamic for at least the next decade, the timing and extent of integration of AVLIS into the enrichment enterprise is being carefully evaluated.

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 for use as nuclear fuel. To date, most nuclear reactors designed for producing electrical power require uranium 235 concentrations in the 2 to 4+ percent range. Presently uranium is enriched to the desired uranium 235 assay levels in gaseous diffusion plants located at Portsmouth, Ohio, and Paducah, Kentucky. The diffusion plant at Oak Ridge, Tennessee, used since World War II, recently was placed in standby operation.

The Office of the Deputy Assistant Secretary for Uranium Enrichment, reporting to the Assistant Secretary for Nuclear Energy, is responsible for the management of the uranium enrichment enterprise. Uranium enrichment is composed of four major offices: Marketing and Business Operations, Operations and Facility Reliability, Technology Deployment and Strategic Planning, and Advanced Technology Projects and Technology Transfer. The Office of Marketing and Business Operations is responsible for enrichment service sales, contracting, supply policy formulation, marketing, financial management, enterprise budgets, and enrichment demand/economic analyses. Operations and Facility Reliability is responsible for overseeing all aspects of the gaseous diffusion plants including the electrical power contracts which are a major cost element. The Technology Deployment and Strategic Planning Office is responsible for integrating production, business, marketing and technology development plans into a single strategic plan for the uranium enrichment enterprise. This includes working with the private sector to determine optimum means of financing new technology deployment. The Office of Advanced Technology Projects and Technology Transfer is responsible for all research/development/

demonstration and generation of production plant concepts for the AVLIS technology.

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 1986 were $855 million.

Materials R&D activities within the Office of Uranium Enrichment are varied and for the most part, especially the test results, classified Restricted Data. In FY 1986, approximately $37 million was used in these endeavors. The Appendix summarizes these activities for the purpose of this report. The DOE contact is A.P. Litman, (301) 353-5777.

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

<u>Gaseous Diffusion: Barrier Quality</u>

- 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.

<u>Gaseous Diffusion: Materials and Chemistry Support</u>

- Characterization of contaminant-process gas cascade reactions, physical/chemical properties of UF_6 substances, corrosion of materials, failure analyses, trapping technology, alternative materials replacement.

<u>Atomic Vapor Laser Isotope Separation Process Separator Development (AVLIS)</u>

- Utilizes the differences in the electronic spectra of atoms of uranium isotopes to induce the selective absorption required for isotopic separation. 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. Resulting plasma of uranium enriched in uranium 235 ions can then be removed from the vapor using electromagnetic methods.

- Development of process separator; coating development for various substrates to contain uranium and development/demonstration of engineering subcomponents.

Office of Reactor Systems: Division of Special Applications

The Division of Special Applications 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. D. Gorsuch, 215-354-5047

- Study of Si-Ge type thermoelectric alloys. 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 ^{o}C from 300 to 1000^{o} C.

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

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

- Development of a consumable arc melt/extrusion route process for the production of DOP-26 iridium alloy sheet.

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

- Improve 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.

Nondestructive Testing Methods Development and Application to Thermoelectric Materials and Devices - DOE Contact W. J. Barnett, 301-353-3097

o No submission received

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

o 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

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.

Fuels and Core Materials Division

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.

Oxide Fuel Development - CDE

o No submission received

Technology Development Support for IFR

o No submission received

Qualification of 9 Cr-1 Mo Steel for LMF Applications

o No submission received

Absorber Development

o No submission received

Metallic Fuel Development

o No submission received

Mechanical Properties of Materials for LMR Applications

- o No submission received

Structural Design/Life Technology

- o No submission received

Integral Fast Reactor (IFR) Fuel Performance Demonstration

- o No submission received

Oxide Fuel Development - Fuels and Materials Development

- o No submission received

Clad/Duct Alloy Development

- o No submission received

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.

High Temperature Structural Design, Mechanical Property Design Data, Tribology Coolant Technology, Fabrication, Handbook, and Advanced Alloy Development

- o No submission received

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 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 nondestructive 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 1986 including approximately $30 million as the cost for irradiation testing in the Advanced Test Reactor. The Naval Reactors contact is Robert H. Steele, (703) 557-5561.

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

	FY 1986
Office of Civilian Radioactive Waste Management Grand Total	$ 21,907,000
Office of Storage and Transportation Systems	$ 760,000
Materials Properties, Behavior, Characterization, or Testing	$ 760,000
Development of Criteria for Nuclear Spent Fuel Storage in Air	600,000
Development of Zircaloy Deformation and Creep Rupture Models for Predicting Cladding Behavior During Interim Dry Storage	80,000
Behavior of Water-Logged Spent Fuel During Interim Dry Storage	80,000
Basalt Waste Isolation Project Waste Package Materials Development	$ 6,230,000
Materials Properties, Behavior, Characterization or Testing	$ 5,910,000
Metal Barriers Development for Nuclear Waste Packages	1,780,000
Packing Materials development for Nuclear Waste Packages	1,280,000
Waste Package Materials Integrated Testing	2,850,000
Device or Component Fabrication or Testing	$ 170,000
Waste Package Container Welding and NDE Process Development	70,000
Waste Package Packing Fabrication Process Development	100,000
Instrumentation and Facilities	$ 150,000
High Temperature PH and EH Probe Development	150,000
Office of Geological Repositories - Nevada Nuclear Waste Storage Investigations Projects	$ 10,335,000
Materials Properties, Behavior, Characterization or Testing	$ 8,215,000
Waste Package Environment	970,000
Waste Form Testing	2,285,000

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT (Continued)

	FY 1986
Office of Geological Repositions - Nevada Nuclear Waste Storage Investigations Projects (Continued)	
Materials Properties, Behavior, Characterization or Testing (Continued)	
Metal Barrier Testing	$ 3,100,000
Other Engineered Barrier Waste Package Components	100,000
Integrated Testing	410,000
Waste Package - Performance Assessment	600,000
Research on Modeling of Radionuclide Migration in a Fractured Rock Matrix	530,000
Sealing Materials Evaluation	220,000
Device or Component Fabrication, Behavior or Testing	$ 2,120,000
Spent Fuel Storage in Crystalline Rock	800,000
Waste Package - Design, Fabrication, and Prototype Testing	655,000
Waste Package Environmental Field Tests	665,000
Salt Repository Project	$ 4,257,000
Materials Properties, Behavior, Characterization, or Testing	$ 4,257,000
Waste Form Evaluation Task	809,000
Waste Package Environment Studies	433,000
Metal Barrier Testing	1,693,000
Defense Glass Testing	400,000
Repository Seal Materials Development Task	664,000
Materials Characterization Center	258,000
Sandia National Laboratories: Brittle Fracture Technology Program	$ 325,000
Materials Structure and Composition	$ 50,000
Microstructure Investigations of Nodular Cast Iron	25,000
Composition Investigation of Nodular Cast Iron	25,000

		FY 1986
Sandia National Laboratories: Brittle Fracture Technology Program (Continued)		
Materials Properties, Characterization, Behavior, or Testing	$	145,000
Generate Material Property Database for Nodular Cast Iron		140,000
Investigate the Feasibility of Using Depleted Uranium as a Structural Component in Cask Construction		5,000
Instrumentation and Facilities	$	130,000
Evaluate Current NDE Methods for Applicability to Thick Section Nodular Cast Iron		130,000

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

Office of Storage and Transportation Systems

The objectives of the Commercial Spent Fuel Management (CSFM) Program are to encourage and expedite the implementation of existing and new spent nuclear fuel storage technologies; to accelerate the availability of dry storage and rod consolidation technologies through licensed cooperative demonstrations at reactor sites and unlicensed testing at Federal facilities; and to provide the planning for a Federal capability to store up to 1900 MT of spent fuel for those utilities that the NRC determines cannot reasonably provide increased at-reactor storage when needed.

Materials Properties, Behavior, Characterization, or Testing

Development of Criteria for Nuclear Spent Fuel Storage in Air - DOE Contact D. E. Shelor, 202-586-2836; PNL Contact E. R. Gilbert, 509-375-2533

- Testing spent fuel and unclad UO_2 in air to determine the temperature dependence of degradation by oxidation.
- Development of models to derive storage criteria to prevent degradation of spent fuel in air by oxidation.

Development of Zircaloy Deformation and Creep Rupture Models for Predicting Cladding Behavior During Interim Dry Storage - DOE Contact D. E. Shelor, 202-586-2836; PNL Contact E. R. Gilbert, 509-375-2533

- Analysis of existing data on deformation and creep rupture for nonirradiated Zircaloy.
- Development of theoretical models for deformation and creep rupture for spent fuel under dry storage conditions.
- Comparison of models with FRG deformation and creep rupture data on spent fuel and irradiated Zircaloy cladding.
- Prediction of spent fuel cladding behavior under dry storage conditions.

Behavior of Water-Logged Spent Fuel During Interim Dry Storage - DOE Contact D. E. Shelor, 202-586-2836; PNL Contact E. R. Gilbert, 509-375-2533

- o Perform tests with water-logged spent fuel to determine the behavior under dry storage conditions.

Basalt Waste Isolation Project Waste Package Materials Development

The objective of the Basalt Waste Isolation Project Waste Package Materials Development effort is to identify, characterize and evaluate the performance of potential waste package materials under the environmental conditions expected for a repository constructed in basalt. This information is used in developing design specifications for the waste package and in evaluating waste package design performance relative to regulatory requirements.

Materials Properties, Behavior, Characterization or Testing

Metal Barriers Development for Nuclear Waste Packages - DOE Contact P. E. Lamont, 509-376-6117; Rockwell Hanford Operations Contact T. B. McCall, 509-376-7114

- o Investigate iron and copper base metals for use as nuclear waste package container materials that will provide containment for 1000 years under conditions expected for a repository constructed in basalt.

Packing Materials Development for Nuclear Waste Packages- DOE Contact M. J. Furman, 509-376-7062; Rockwell Hanford Operations Contact P. F. Salter, 509-376-7207

- o Investigate crushed basalt and sodium bentonite clay composites for use as a packing material around nuclear waste containers which will retard/limit long term radionuclide release from the waste package under conditions expected for a repository constructed in basalt.

Waste Package Materials Integrated Testing - DOE Contact M. J. Furman, 509-376-7062; Rockwell Hanford Operations Contact P. F. Salter, 509-376-7207

- o Testing of Nuclear Waste/Engineered Barrier/Rock/Groundwater interactions over the range of conditions expected for waste packages emplaced in a repository in basalt in order to evaluate long term radionuclide releases from the waste package relative to regulatory criteria.

Device or Component Fabrication, Behavior or Testing

Waste Package Container Welding and NDE Process Development - DOE Contact P. E. Lamont, 509-376-6117; Rockwell Hanford Operations Contact T. B. McCall, 509-376-7114

- o Develop a remote welding and NDE process for waste package containers which will ensure the integrity of the welds is equal to the base metal.

Waste Package Packing Fabrication Process Development - DOE Contact P. E. Lamont, 509-376-6117; Rockwell Hanford Operations Contact T. B. McCall, 509-376-7115

- o Develop a fabrication and emplacement process for waste package packing which will ensure that the packing will meet its post-closure performance requirement to limit water flow around the waste package to that necessary to ensure mass transport is dominated by diffusion.

Instrumentation and Facilities

High Temperature pH and Eh Probe Development - DOE Contact M. J. Furman 509-376-7062; Rockwell Hanford Operations Contact P. F. Salter, 509-376-7207

- o High temperature (100-300^{o}C) pH and Eh probes are being developed for use in the waste package fully radioactive waste release hydrothermal interactions testing program.

Office of Geological Repositories Nevada Nuclear Waste Storage Investigations Project (OGR/NNWSI)

The primary goal of the OGR/NNWSI materials program is the development of Tuff specific waste packages that meet the performance requirements of the 10 CFR 60, 10 CFR 960, and 40 CFR 191 and are cost effective. This goal requires the definition of physical and chemical conditions of the site, selection of package materials, waste package design activity, prototype waste package fabrication, and performance testing.

Materials Properties, Characterization or Testing

Waste Package Environment - DOE Contact D. L. Vieth, 702-295-3662; LLNL Contacts J. Yow, V. Oversby, 213-423-2228; and William Glassley, 415-422-6499

- o Characterize the time-dependent behavior of the hydrogeologic environment in which the waste packages will reside in order to establish the envelope of conditions that define package design parameters, materials testing conditions, and boundary conditions for performance analysis.

Waste Form Testing - DOE Contact D.L. Vieth, 702-295-3662; LLNL Contacts J. Yow, V. Oversby, 213-423-2228; and Roger Aines, 415-423-7184

- o Perform the testing and evaluation necessasry to identify the waste package components required by specific host rock and to select the materials for those components.

- o Characterize the behavior of and determine the radionuclide release rates for the various waste forms in the geological tuff environment and as modified by corrosion products in the Metal Barrier Testing.

Metal Barrier Testing - DOE Contact D. L. Vieth, 702-295-3662; LLNL Contacts J. Yow, V. Oversby, 415-423-2228; R. D. McCright, 415-423-7051

- o Characterize the behavior of the metal barrier and determine corrosion rates and corrosion mechanisms, including the interaction between the metal barriers and its surrounding environment.

- o Work is being performed to evaluate austenitic stainless steels and copper/copper-based alloys.

Other Engineered Barrier Waste Package Components - DOE Contact D. L. Vieth, 702-295-3662; LLNL Contacts J. Yow and V. Oversby, 415-423-2228

- o Characterize the properties and behavior of other engineered barrier waste package components that may be present in a repository.

Integrated Testing - DOE Contact D. L. Vieth, 702-295-3662; LLNL Contact J. Yow, and V. Oversby, 415-423-2228

- o Characterize the integrated behavior of the waste form, barrier materials, and surrounding environment.

Waste Package - Performance Assessment - DOE Contact D. L. Vieth, 702-295-3662; LLNL Contact J. Yow; K. Eggert, 415-423-6779

- o Provide a quantitative prediction of long-term waste package performance.

Research on Geochemical Modeling of Radionuclide Interaction with a Fractured Rock Matrix - DOE Contact D. L. Vieth, 702-295-3662; LLNL Contact J. Yow; K. Eggert, 415-423-6779; D. Emerson, 415-422-6504

- o Further develop the geochemical modeling code EQ3/6 for use in long-term predictions for site suitability and radionuclide release from a nuclear waste repository.

Sealing Materials Evaluation - DOE Contact D. L. Vieth, 702-295-3662; Penn State University; LANL Contacts D. M. Roy, C. Duffy, 505-843-5154

- o Evaluate materials for use in various sealing components and to obtain confidence in performance capabilities of geochemical and geomechanical properties.

Device or Component Fabrication, Behavior, or Testing

Spent Fuel Storage in Crystalline Rock - DOE Contact D.L. Vieth, 702-295-3662; LLNL Contact J. Yow, 415-423-3521

- o Demonstrate the feasibility of short-term storage and retrieval of spent, unreprocessed fuel.
- o To measure the response of a crystalline rock mass to simulated repository conditions and use these data to validate thermal and thermomechanical models.
- o To compare the effects of heat alone and heat in combination with intense ionizing radiation on a crystalline rock mass.

Waste Package - Design, Fabrication and Prototype Testing- DOE Contact D. L. Vieth, 702-295-3662; LLNL Contacts J. Yow, L. Ballou, 415-422-4911; T. Nelson, 415-422-0306

- o Develop, analyze, fabricate, and test waste package designs that incorporate qualified materials and that are fully compatible with the repository design.
- o Supports license application by demonstrating conformance with requirements for safe handling, emplacement, possible retrieval, and credible accident conditions per NRC 10 CFR 60 and 40 CFR 191 in a cost-effective manner.

Waste Package Environmental Field Tests - DOE Contact D. L. Vieth, 702-295-3662; LLNL Contact J. Yow, L. Ballou, 415-422-4911; Dale Wilder, 415-422-6908

- o Develop and conduct field experiments designed to determine and evaluate the thermal, mechanical, thermomechanical, hydrothermal and chemical phenomena for welded tuff.

- o Determine the responses of tuff to excavation of an underground facility in order to evaluate effects of the heat released by the waste on the hydrologic behavior and effects on components of the engineered barrier system.

<u>Salt Repository Project</u>

The Salt Repository Project has sponsored a Waste Package Program at PNL that has the objective of conducting nuclear waste package component development and interactions testing, and applying the resulting database to the development of predictive models describing waste package degradation and radionuclide release.

<u>Materials Properties, Behavior, Characterization, or Testing</u>

<u>Waste Form Evaluation Task</u> - DOE Contact K. K. Wu, FTS 976-5916; PNL Contact D. J. Bradley, 509-375-2587

- o The radioactive release from unreprocessed spent fuel in a simulated salt repository environment is being evaluated.

<u>Waste Package Environment Studies</u> - DOE Contact K. K. Wu, FTS 976-5916; PNL Contact D. J. Bradley, 509-375-2587

- o The most probable range of environments to be expected in a salt repository are being defined, and the solubilities of radionuclides in these environments are being determined.

<u>Metal Barrier Testing</u> - DOE Contact K. K. Wu, FTS 976-5916; PNL Contact D. J. Bradley, 509-375-2587

- o The resistance of candidate waste package container materials to general corrosion and various non-general corrosion, such as stress corrosion cracking, pitting, etc., in brine environments is being determined.

<u>Defense Glass Testing</u> - DOE Contact K. K. Wu, FTS 976-5916; Pacific Northwest Laboratory Contact L. G. Morgan, 509-375-3874

- o The release of radionuclides from defense glass in environments expected in a salt repository is being evaluated.

The Salt Repository Project is sponsoring a Repository Seal Materials Performance Program at Science Applications International Corporation that has the objective of developing materials formulations and models to support repository seal system design.

Repository Seal Materials Development Task - DOE Contact D. K. Robinette, FTS 976-5916; Science Applications International Corporation Contact M. B. Gross, 415-351-7807

- o Laboratory experiments to identify compositions for sealing materials for a salt repository are to be conducted.

Materials Characterization Center - DOE Contact K. K. Wu, FTS 976-5916

- o No submission received

Sandia National Laboratories: Brittle Fracture Technology Program

The objective of this program is to qualify alternate materials (other than stainless steel) for use in nuclear spent fuel cask construction. Candidate materials include nodular cast iron and ferritic steel. The main technical issue which must be addressed is the application of fracture mechanics to cask analysis and design. Materials, such as nodular cast iron, exhibit a ductile/brittle failure mode transition. Hence, a cask constructed out of this material may be susceptible to brittle fracture under certain environmental and loading conditions. The application of fracture mechanics can provide the cask analyst/designer the ability to guarantee ductile cask material response to design loadings.

Materials Structure and Composition

Microstructure Investigations of Nodular Cast Iron - DOE Contact F. Falci, 301-353-3595; SNL Contact K. B. Sorenson, 505-844-5360

- o Investigation of the effect of microstructure on material properties.

- o Study of the effect of graphite nodule size and spacing on fracture toughness.

Composition Investigation of Nodular Cast Iron - DOE Contact F. Falci, 301-353-3595; SNL Contact K. B. Sorenson, 505-844-5360

- o Investigation of the effect of material composition on material properties.

- o Study of the effect of material composition on fracture toughness and tensile properties.

Materials Properties, Behavior, Characterization, or Testing

Generate Material Property Database for Nodular Cast Iron- DOE Contact F. Falci, 301-353-3595; SNL Contact K. B. Sorenson, 505-844-5360

- o Generate a database for nodular cast iron which includes material properties pertinent to fracture mechanics.

Investigate the Feasibility of Using Depleted Uranium as a Structural Component in Cask Construction - DOE Contact F. Falci, 301-353-3595; SNL Contact K. B. Sorenson, 505-844-5360

- o Investigate the feasibility of using depleted uranium (DU) as a structural component in cask body construction.

Instrumentation and Facilities

Evaluate Current NDE Methods for Applicability to Thick Section Nodular Cast Iron - DOE Contact F. Falci, 301-353-3595; SNL Contact K. B. Sorenson, 505-844-5360

- o Evaluate state-of-the-art NDE methods for specific application to thick-walled nodular cast iron.

OFFICE OF DEFENSE PROGRAMS

	FY 1986
Office of Defense Programs Grand Total	$ 44,962,000
Office of Inertial Fusion	$ 3,000,000
Fusion Research Division	$ 3,000,000
Device or Component Fabrication, Behavior, or Testing	$ 3,000,000
Target Fabrication	1,500,000
Laser Materials and Optical Components	1,500,000
Office of Military Applications	$ 41,962,000
Sandia National Laboratories - Albuquerque	$ 17,735,000
Solid State Sciences Directorate, 1100	$ 3,750,000
Ion Implantation and Radiation Physics Research Department, 1110	$ 1,300,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,300,000
Ion Implantation Studies for Friction and Wear	250,000
Silicon-Based Radiation Hardened Microelectronics	550,000
New Concepts in Microsensors	500,000
Condensed Matter and Surface Science Department, 1130	$ 1,250,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,250,000
Shock Chemistry	500,000
Initiation of Granular Explosives	350,000
Surface Science	400,000

	FY 1986
Compound Semiconductor and Device Research Department, 1140	$ 1,200,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 1,200,000
Materials Growth by Molecular Beam Epitaxy (MBE)	150,000
Materials Growth by MOCVD	300,000
Strained Layer Superlattices for IR Detectors	300,000
Novel Processing Technology for Semiconductor Technologies	300,000
Materials Processing for Sensors	150,000
Organic and Electronic Materials Department, 1810	$ 1,660,000
Chemistry of Organic Materials Division, 1811	$ 400,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 250,000
Dyed Antireflective Photoresist Material	150,000
Sulfonated Aromatic Polysulfones	100,000
Materials Properties, Behavior, Characterization, or Testing	$ 150,000
Radiation Hardened Dielectrics	150,000
Physical Chemistry and Mechanical Properties of Polymers Division, 1812	$ 720,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 250,000
Effects of Material and Processing Variables on the Mechanical and Thermal Expansion Behavior of Graphite/Epoxy and Kevlar/Epoxy Composites	250,000

		FY 1986
Physical Chemistry and Mechanical Properties of Polymers Division, 1812 (Continued)		
Materials Structure and Composition	$	470,000
Polysilanes, Photoresists, Photoconductors, and Non-Charring Dielectrics		150,000
Plasma Deposition of Inorganic Materials		150,000
Electron and Photon Stimulated Desorption From Organic Surfaces		100,000
Materials Structure and Properties by NMR Spectroscopy		70,000
Physical Properties of Polymers Division, 1813	$	240,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$	150,000
Carbon Foam Development		150,000
Materials Properties, Behavior, Characterization, or Testing	$	90,000
Mechanical Properties of Encapsulants		20,000
The Strength of Kevlar Narrow Fabrics		70,000
Electronic Property Materials Division, 1815	$	300,000
Materials Properties, Behavior, Characterization, or Testing	$	300,000
High Electric Field Varistors		100,000
Highly Polarizable Dielectrics		100,000
High Resistivity Thin Film Polycrystalline Silicon		100,000
Materials Characterization Department, 1820	$	950,000
Analytical Chemistry Division, 1821	$	200,000
Instrumentation and Facilities	$	200,000
Development of Automated Methods for Chemical Analysis		200,000

		FY 1986
Electron Optics and X-Ray Analysis Division, 1822	$	280,000
Materials Properties, Behavior, Characterization, or Testing	$	80,000
Thermomechanical Treatment of U Alloys		80,000
Instrumentation and Facilities	$	200,000
Advanced Methods for Electron Optical X-Ray, and Image Analysis		200,000
Surface Chemistry and Analysis Division, 1823	$	200,000
Instrumentation and Facilities	$	200,000
Advanced Methods for Surface and Optical Analysis		200,000
Thermophysical Properties Division, 1824	$	270,000
Instrumentation and Facilities	$	270,000
Design and Fabrication of a Multi-Source X-Ray Gauge		150,000
Infrared Reflectometer Development		120,000
Metallurgy Department, 1830	$	4,445,000
Coating Technology Division, 1831	$	1,390,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$	450,000
Plasma Deposition of Amorphous Metal Alloys		70,000
Electrophoretically-Deposited Coatings		150,000
Near-Net-Shape Processing of Nickel-Based Alloys		150,000
High Temperature Semiconductors		80,000

	FY 1986
Materials Properties, Behavior, Characterization, or Testing	$ 440,000
Optical Diagnostics for Metallurgical Processing	440,000
Device or Component Fabrication, Behavior, havior, or Testing	$ 500,000
Development of Materials for Magnetic Fusion Reactors	500,000
Physical Metallurgy Division, 1832	$ 1,040,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,040,000
Toughness of Ductile Alloys	330,000
Properties of Ni-B Alloys	50,000
Analytical Electron Microscopy of Engineering Alloys	130,000
Friction and Wear of Modified Surfaces	230,000
Alloy Deformation Response and Constitutive Modeling	300,000
Process Metallurgy Division, 1833	$ 1,115,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 120,000
Vacuum Arc Remelting	120,000
Materials Properties, Behavior, Characterization, or Testing	$ 10,000
Toughness of Inertia Welds	10,000
Device or Component Fabrication, Behavior, or Testing	$ 835,000
Aluminum Laser Welding	40,000
Low Temperature, Solid State Welds of Copper	20,000
Dissimilar Metal Welds	200,000
Welding of Nickel-Based Alloys	225,000
Plasma Arc Welding	175,000
Laser Welding	175,000

OFFICE OF DEFENSE PROGRAMS (Continued)

		FY 1986
Instrumentation and Facilities	$	150,000
Electrode Gap Controller		150,000
Surface and Interface Technology Division, 1834	$	900,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$	80,000
Deposition of Amorphous Materials with a Dual Beam Ion System		80,000
Materials Properties, Behavior, Characterization, or Testing	$	25,000
Modification of Mechanical Properties by Ion Implantation		25,000
Device or Component Fabrication, Behavior, or Testing	$	615,000
Development of Materials for Magnetic Fusion Reactors		500,000
Solder Flux Removal Studies		115,000
Instrumentation and Facilities	$	180,000
Ion Beam Reactive Deposition System		100,000
In-Situ Friction, Wear, and Electrical Contact Resistance System		80,000
Chemistry and Ceramics Department, 1840	$	6,930,000
Ceramics Development Division, 1845	$	3,280,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$	2,600,000
Ceramic Processing		2,600,000

	FY 1986
<u>Materials Properties, Behavior, Characterization, or Testing</u>	$ 680,000
Fracture of Ceramics	680,000
<u>Inorganic Materials Chemistry Division, 1846</u>	$ 2,500,000
<u>Materials Preparation, Synthesis, Deposition, Growth, or Forming</u>	$ 2,500,000
Glass and Glass-Ceramic Development	2,500,000
<u>Corrosion Division, 1847</u>	$ 1,150,000
<u>Materials Properties, Behavior, Characterization, or Testing</u>	$ 1,150,000
Corrosion	1,150,000
<u>Sandia National Laboratories - Livermore</u>	$ 2,700,000
<u>Materials Preparation, Synthesis, Deposition, Growth, or Forming</u>	$ 800,000
Powder Metallurgy	200,000
Advanced Electrodeposition Studies	150,000
Metal Forming	200,000
Advanced Organic Materials	250,000
<u>Materials Properties, Behavior, Characterization, or Testing</u>	$ 1,350,000
Helium Induced Crack Growth in Metals and Alloys	650,000
Joining Science and Technology	450,000
Composites: Characterization and Joining	150,000
Compatibility, Corrosion, and Cleaning of Materials	100,000
<u>Instrumentation and Facilities</u>	$ 550,000
New Surface and X-Ray Spectroscopy	150,000
Tritium Facility Upgrade for Materials Characterization and Testing	400,000

	FY 1986
Lawrence Livermore National Laboratory	$ 5,446,000
Materials Properties, Behavior, Characterization, or Testing	$ 2,746,000
Materials Modification by Ion Beams	229,000
Synchrotron Radiation Studies	335,000
Metal Deformation Modeling	90,000
Rapid Solidification Processing of Alloys	270,000
Microstructure of Stainless Steel Welds	70,000
Coating Adhesion	30,000
Dislocation Structures and Reversed Strains	89,000
Weld Library Generation	40,000
Deformation of Aluminum to Large Strains	90,000
Microstructure Research	300,000
Pu Metallurgy	180,000
Pu Alloy Characterization	220,000
Pu Sputtering	180,000
Directed Energy Surface Processing	180,000
Homogeneity of Dry-Powder Substrates for Generating Low-Density Carbon Networks	30,000
Formation of Metastable Surface Alloys	193,000
Mechanics of Low Density Materials	100,000
Polymeric Materials Computer Modeling	60,000
Lifetime Prediction Theory for Polymeric Materials	60,000
Instrumentation and Facilities	$ 2,700,000
Weapons Database Development	200,000
Tritium Facility Upgrade	2,500,000
Los Alamos National Laboratory	$ 16,081,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 13,720,000
Fluidized Bed Coatings	200,000
Materials Synthesis by Solid State Combustion	250,000
Powder Preparation by Plasma Chemical Synthesis	350,000
Precision Tungsten Tubes	170,000
Superhard Materials	38,000
Glass Fabrication Technology	50,000
Slip Casting of Ceramics	150,000
Whisker Growth Technology	785,000
Development of Ceramic Matrix Whisker-Reinforced Composites	250,000

	FY 1986
Los Alamos National Laboratory (Continued)	
Materials Preparation, Synthesis, Deposition, Growth, or Forming (Continued)	
New Hot Processing Technology	$ 210,000
Glass and Ceramic Coatings	10,000
Cold Pressing, Cold Isostatic Pressing and Sintering	175,000
Plasma-Flame Spraying Technology	170,000
Electroplating Low Atomic Number Materials	120,000
Superhard Parylene Coating Development	80,000
Three New Conducting Polymers	50,000
New Highly Conductive Doped Polyacetylene	200,000
Liquid Crystal Polymer Development	200,000
Surface Property Modified Plastic Components	130,000
High-Z Loaded Parylene Polymer Coatings	50,000
Low Density, Microcellular Plastic Foams	400,000
Radiochemistry Detector Coatings	250,000
Target Coatings	600,000
Physical Vapor Deposition and Surface Analysis	700,000
High Energy Density Joining Process Development	410,000
Arc Welding Process Development	150,000
Superplastic Forming	150,000
Actinide Alloy Development	1,350,000
Metallic Glasses	160,000
Structural Ceramics	887,000
Surface Studies	500,000
Tritiated Materials	730,000
Actinide Surface Properties	700,000
Mechanical Properties and Alloy Development, Plutonium	500,000
Mechanical Properties of Uranium	60,000
Low Temperature Electronic Properties	1,060,000
Phase Transformations in Pu and Pu Alloys	505,000
High Strain Rate Testing	510,000
Neutron Diffraction of Pu and Pu Alloys	160,000
Powder Characterization	90,000
Dielectric Loss Measurements in Ceramics	210,000
Device or Component Fabrication, Behavior, or Testing	$ 2,361,000
Polymers and Adhesives	700,000
Salt Fabrication	426,000
Ceramic Technology	60,000
Glass and Ceramic Sealing, Metallizing Technology	65,000

		FY 1986
Los Alamos National Laboratory (Continued)		
Device or Component Fabrication, Behavior, or Testing (Continued)		
Microwave Sintering/Processing	$	200,000
Injection Mold Process for Making Snap-On Fittings		50,000
Composite Spring Support Structures		300,000
Solid State Bonding		110,000
Nondestructive Evaluation		450,000

ASSISTANT SECRETARY FOR 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; LANL Contact Richard Mah, 505-667-3238; KMS Fusion, Inc. Contact Timothy Henderson, 313-769-8500, ext. 302; LLNL Contact W. Hatcher, 415-422-1100

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

Laser Materials and Optical Components - DOE Contact Carl B. Hilland, 301-353-3687; LLNL Contact E. Storm, 415-422-0400; KMS Fusion, Inc. Contact A. Glass, 313-769-8500; University of Rochester Contact R. McCrory, 716-275-5286

- Development of Nd:glass amplifier discs and optical components for kilojoule-class laser systems.

Office of Military Applications

Sandia National Laboratories, Albuquerque

Solid State Sciences Directorate, 1100

Ion Implantation and Microsensors 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, microsensors, 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. Fundamental understanding of physical and chemical principles, materials properties and microfabrication technologies are combined to develop new approaches to sensing such parameters as radiation, hydrogen and other gases, pressure, magnetic fields, liquid viscosity, optical signals and corrosion. A major aspect of the work is thus to develop an underlying understanding and control of defects, alloying processes, sensing functions, 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 A. E. Evans, 301-353-3098; SNL Contacts D.M. Follstaedt, 505-844-2102; S. M. Myers, 505-844-6076; L. E. Pope, 505-844-5041

- o 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 A. E. Evans, 301-353-3098; SNL Contacts H. J. Stein, 505-844-6279; K. L. Brower, 505-844-6131; J. A. Knapp, 505-844-2305

- o Optical, electrical and compositional 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.

New Concepts in Microsensors - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts R. C. Hughes, 505-844-8172; A. J. Ricco, 505-844-4947; M. A. Butler, 505-844-6897

- New concepts in microsensors are being developed for a variety of stimuli, including radiation, magnetic fields, chemical species and viscosity, using principles of semiconductor device operation and fabrication, surface acoustic wave propagation, and optical properties of solids.

Condensed Matter and Surface Science Department, 1130

The mission of Department 1130 is to provide fundamental understanding and strong technology bases in two main areas: (1) shock wave and explosives physics and chemistry; and (2) surface science of materials. Current areas of emphasis include shock-induced solid state chemistry, shock initiation of heterogeneous explosives, shock-activated thermal battery, PVE stress gauge, phase transitions in ferroelectrics, modification and control of surface properties, the early stages of oxidation and corrosion, adhesion of metals to polymers, and the mechanism of operation of metal-insulator-semiconductor (MIS) electronic gas sensors.

Materials Properties, Behavior, Characterization, or Testing

Shock Chemistry - DOE Contact A. E. Evans, 301-353-3098, 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.

- Studies of the mechanisms and materials parameters which determine the electrical output of shock-activated thermal batteries are also being carried out.

Initiation of Granular Explosives - DOE Contact A. E. Evans, 301-353-3098; 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.

Surface Science - DOE Contact A. E. Evans, 301-353-3098, SNLA Contact D. W. Goodman, 505-844-5435

- Field ion microscopy, Auger electron spectroscopy, UV photoemission spectroscopy, and thermal desorption are being used to understand at an atomic level the early stages of oxidation and corrosion of metals, the nature of the adhesion of polymers to metals and how to improve it, and the mechanisms by which gaseous species are dissociated at the surface and transported to the insulator-semiconductor interface in MIS gas sensors.

Compound Semiconductor and Device Research Department, 1140

Department 1140 conducts fundamental theoretical and experimental research on compound semiconductors and solid state devices. Projects include growth and characterization of bulk semiconductors and of artificially structured materials not available in nature, as well as extensive modeling of electronic, optical and structural properties important to a wide range of device applications in weapons and energy initiatives.

Materials Growth by Molecular Beam Epitaxy (MBE) - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; Sandia Contact L. R. Dawson, 505-846-3451

- Growth of AlGaAs/GaAs, InAsSb/InAs and InGaAs/GaAs strained layer superlattice (SLS) and strained quantum well (SQW) structures for electronic and optoelectronic applications.

Materials Growth by MOCVD - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; Sandia Contact R. M. Biefield, 505-844-1556

- Growth of GaP/GaAsP and InAsSb/InSb SLS's for high temperature radiation-hard electronic devices and for long wavelength IR detectors, respectively. Another major effort centers on the AlGaAs/GaAs and InGaAs/GaAs systems for detailed studies of the electrical and optical properties. This work has led to a variety of devices, including bistable optical switches, photon-hard photodectectors and high speed p-channel modulation doped FET;s.

Strained Layer Superlattices for IR Detectors - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; Sandia Contact G. C. Osbourn, 505-844-8850

o Strained layer superlattices based on the InAsSb/InSb and InAsSb/InSb/AlSb systems are being investigated for use as attractive alternatives to the unstable HgCdTe alloys for IR detector applications in the 8-12 um range. These IR materials are being grown by both MBE and MOCVD techniques.

Novel Processing Technology for Semiconductor Technologies- DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; Sandia Contact D. S. Ginley, 505-844-8863.

o This program involves studies of new technologies for formation of diffusion barriers for improved epitaxial growth, novel metallurgies for Shottky barrier and Ohmic contact formation, and development of new metallurgical techniques for deposition of reactive alloys.

Materials Processing for Sensors - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; Sandia Contacts D. S. Ginley, 505-844-8863 and R. J. Baughman, 505-844-6337

o Growth of high quality semimagnetic semiconductors for magnetic field sensors, development of processing technologies for fabricating fiber-optic based strain and chemical sensors, and thin dielectric and organic films for chemical sensors.

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

Dyed Antireflective Photoresist Material - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact C. Renschler, 505-844-8151

- A new antireflective photoresist material has been developed which allows dramatic improvement in line resolution for microelectronic applications.

Sulfonated Aromatic Polysulfones - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts R. L. Clough, 505-844-3492, C. Arnold, Jr., 505-844-8728 and R. A. Assink, 505-844-6372

- Sulfonated aromatic polysulfones have been developed as stable ionic battery membranes and are now in testing in prototype batteries.

Materials Properties, Behavior, Characterization, or Testing

Radiation Hardened Dielectrics - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts R. L. Clough, 505-844-3492, S. R. Kurtz, 505-844-5436 and C. Arnold, 505-844-8728

- Polymer dielectrics have been 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

Division 1812 develops new organic materials, structurally and chemically characterize organic materials, and studies their mechanical properties. 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 Kevlar/Epoxy Composites - DOE Contact A .E. Evans, 301-353-3098; Sandia Contacts J. M. Zeigler, 505-844-0324 and 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

Polysilane Photoresists, Photoconductors, and Non-Charring Dielectrics - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact J. M. Zeigler, 505-844-0324

- Alkyl-substituted polysilanes and related materials are currently being developed as improved self-developing photoresists for use in microelectronic circuit manufacture.

- Different polysilane structures are under investigation as high temperature, non-charring dielectrics.

Plasma Deposition of Inorganic Materials - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts J. M. Zeigler, 505-844-0324 and R. J. Buss, 505-844-7494

- Procedures for preparation of fine particles of ceramic materials such as Si_3N_4 in plasmas are under development.

Electron and Photon Stimulated Desorption from Organic Surfaces - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts J. M. Zeigler, 505-844-0324 and J. A. Kelber, 505-844-3408

- Electronc and photon stimulated desorption from organic surfaces are being used to examine both the structure of surfaces and the fundamental mechanisms of radiation damage.

o These studies are being applied to problems in polymer adhesion and bulk radiation damage.

Materials Structure and Properties by NMR Spectroscopy - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact J. M. Zeigler, 505-844-0324 and R. A. Assink, 505-844-6372

o NMR studies are being used to characterize the microstructure and reaction kinetics of polymers and the transport characteristics of polymeric membranes.

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

Carbon Foam Development - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts J. H. Aubert, 505-844-5604 or P. B. Rand, 505-844-7953

o We have discovered a new way to produce carbon foams of low density and small cell size. The process involves the production of polyacrylonitrile (PAM) by a solution-gelation technique followed by CO_2 solvent extraction. The resulting PAN foam is then carbonized by exposure to elevated temperatures. These foams are of potential use in several weapons applications.

Materials Properties, Behavior, Characterization, or Testing

Mechanical Properties of Encapsulants - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact D. Adolf, 505-844-4773

o The bulk modulus of polymeric encapsulants is essential for predicting internal stresses from thermal cycling. Up to now, only estimated values of the bulk modulus have been used since it is a difficult quantity to evaluate. Recently, we have demonstrated that the bulk modulus can be obtained by using the tri-axial testing facility. Preliminary measurements indicate significant departures from previous estimates of the bulk modulus for polymeric encapsulants.

The Strength of Kevlar Narrow Fabrics - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact R. H. Ericksen, 505-844-8333

- The influence of variables important for parachute applications of Kevlar was studied and tests to determine the fabric deformation mechanisms are underway.

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 A. E. Evans, 301-353-3098; SNL Contacts R. G. Kepler, 505-844-7520 and G. E. Pike, 505-844-7562

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

Highly Polarizable Dielectrics - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts R. G. Kepler, 505-844-7520 and R. A. Anderson, 505-844-7676

- Thin organic dielectric films with high dielectric constants are being developed and characterized for use in high energy density capacitors. The susceptibility of these materials to bulk dielectric breakdown is being determined.

High Resistivity Thin Film Polycrystalline Silicon - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts R. G. Kepler, 505-844-7520 and 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, polymers, 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 A. E. Evans, 301-353-3912; Sandia Contact S. H. Weissman, 505-846-0820

- New, highly automated methods and software for artificial intelligence for search/match routines are being developed for the identification and quantitative analysis of a broad range of materials.

Electron Optics and X-Ray Analysis Division, 1822

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Thermomechanical Treatment of U Alloys - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact K. H. Eckelmeyer, 505-844-7775

- Thermomechanical treatments of uranium alloys 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 for Electron Optical, X-Ray, and Image Analysis - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact W. F. Chambers, 505-844-6163

- Advanced methods of automated electron and x-ray instrumental analysis to improve resolution, accuracy, and efficiency. Improvements in in-situ electronic diffraction analysis are a recent accomplishment. A new system in advanced centralized image analysis interfaces 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 A. E. Evans, 301-353-3098; 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 improvmed software for automated data acquisition and reduction for the laser Raman microprobe system. Also, a combined gas chromatography/Fourier transform infrared spectrometer has been constructed for use in reaction studies on organic materials.

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 Multi-Source X-Ray Gauge - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact W. D. Drotning, 505-844-7934

- o A new system is being constructed based on attenuation of monochromatic gamma rays from a radioactive isotopic source to analyze special materials for a strategic defense initiative program. This is a nondestructive method that yields quantitative elemental analysis. More complex systems using multi-isotopic sources are being constructed and tested for complex materials.

Infrared Reflectometer Development - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact H. L. Tardy, 505-846-6548

- o A new infrared reflectometer has been designed and construction is almost completed. 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.

Coating Technology Division, 1831

The Coating Technology Division conducts basic and applied research in two areas: (1) coatings and (2) optical diagnostics for processes. 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 coatings.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Plasma Deposition of Amorphous Metal Alloys - DOE Contact A. E. Evans, 301-353-3098; 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 time-temperature transformation and electron transport properties of these materials have been studied. The diffusion of H_2 through these films is under investigation.

Electrophoretically-Deposited Coatings - DOE Contact A. E. Evans, 301-353-3099; Sandia Contact D. J. Sharp, 505-844-8604

- Electrophoretic deposition technology is being developed for three applications: (1) to apply electrically insulating coatings on large, irregularly shaped objects; (2) to apply IEMP hardeners on electronic component packages; and (3) to apply nuclear fuel (UO_2) to metal substrates to produce unique energy sources.

Near-Net-Shape Processing of Nickel-Based Alloys - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact A. W. Mullendore, 505-844-6833

- High hardness Ni-B alloys have been produced from the chemical vapor deposition of $Ni(CO)_4$ and B_2H_6. Injection moldings for fiber optic connectors have been produced to near-net-shape.

High Temperature Semiconductors - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact A. W. Mullendore, 505-844-6833

- Single crystals of boron carbide 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 Properties, Behavior, Characterization, or Testing

Optical Diagnostics for Metallurgical Processing - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact H. C. Peebles, 505-846-3454

- Emission spectroscopy has been used to investigate laser light absorption during plume formation that occurs during a laser welding process. Similar techniques are being developed to obtain species concentration and temperature profiles in a vacuum arc remelter.

Device or Component Fabrication, Behavior, or Testing

Development of Materials for Magnetic Fusion Reactors - DOE Contact A. E. Evans, 301-353-3098; 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.

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 thermomechanical 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 A. E. Evans, 301-353-3098; Sandia Contacts R. J. Salzbrenner, 505-844-5041 and 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 at high loading rates 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.

Properties of Ni-B Alloys - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact A. N. Campbell, 505-844-7452

- The mechanical response of a Ni-B alloys produced by chemical vapor deposition is being characterized. Microstructural examination is being performed to explain and model the deformation processes for this material.

Analytical Electron Microscopy of Engineering Alloys - DOE Contact A. E. Evans, 301-353-3098; 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, stainless steels, and refractory alloys are currently under study.

Friction and Wear of Modified Surfaces - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts R. J. Bourcier, 505-844-6638 and 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 A. E. Evans, 301-353-3098; Sandia Contacts W. B. Jones, 505-844-4026 and 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 investment casting.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Vacuum Arc Remelting - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact F. J. Zanner, 505-844-7073

- o 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 A. E. Evans, 301-353-3098; Sandia Contact G. A. Knorovsky, 505-844-1109

- o 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.

Device or Component Fabrication, Behavior, or Testing

Aluminum Laser Welding - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact M. J. Cieslak, 505-846-7500

- o The role of the laser plume in defocusing the laser beam is being studied. Also, the effect of alloying elements, such as magnesium, on laser energy absorption is being characterized.

Low-Temperature, Solid State Welds of Copper - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact F. M. Hosking, 505-844-8401

- o Solid state welding and solid-liquid interdiffusion techniques have been evaluated for joining copper flex circuits in the 373-450^{o}K range. High quality welds were produced with the use of indium and indium-silver alloy interlayers.

Dissimilar Metal Welds - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts M. J. Cieslak, 505-846-7500 and G. A. Knorovsky, 505-844-1109

- o Fusion welding procedures for dissimilar-metal 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 A. E. Evans, 301-353-3098; Sandia Contacts M. J. Cieslak, 505-846--7500 and G. A. Knorovsky, 505-844-1109

o Mechanisms of hot-cracking during the fusion welding of both solid solution strengthened and precipitation-strengthened nickel-based alloys are 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. The roles of C, S, and Nb in Inconel 625 hot-cracking are under study.

Plasma Arc Welding - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts P. W. Fuerschbach, 505-846-2464 and J. L. Jellison, 505-844-6397

o 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 A. E. Evans, 301-353-3098; Sandia Contact J. L. Jellison, 505-844-6397

o 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 convention, are being incorporated into models of the processes. Thermal blooming of the beam as it passes through the plume and weld pool convection are under study.

Instrumentation and Facilities

Electrode Gap Controller - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact F. J. Zanner, 505-844-7073

o 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

The 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 A. E. Evans, 301-353-3098; 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 A. E. Evans, 301-353-3098; 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 A. E. Evans, 301-353-3098; SNL Contact M. F. Smith, 505-846-4270

- Tests are continuing to evaluate materials used in magnetically confined fusion energy devices. The two materials developed for these applications are a beryllium limiter assembly and a low-pressure chamber plasma spray process.

Solder Flux Removal Studies - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact R. R. Sowell, 505-844-1038

- Fluorocarbon plasmas have been used to remove metal oxide films from the surface of Inconel 718 that are formed during an S-glass-to-Inconel metal sealing process.

Instrumentation and Facilities

Ion Beam Reactive Deposition System - DOE Contact A. E. Evans, 301-353-3098; 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 A. E. Evans, 301-353-3098; Sandia Contacts L. E. Pope, 505-844-5041 and 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 perform 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 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), in bedded salt environments as nuclear waste containers.

Electronic Ceramics Division, 1842

The Electronic Ceramics Division studies powder preparation processes to make improved, better characterized ceramics, primarily for electronic applications. Research in this Division is aimed at high temperature semiconductors, preparation and consolidation of difficult-to-sinter powders, and transport mechanisms in glasses. Typical areas supported by this division include active ceramic devices, e.g., capacitors, ferrites, ferroelectric powder supplies, Beta"Al_2O_3-containing powder supplies, and components using Al_2O_3 such as vacuum tubes and thermal batteries.

Materials Preparation, Synthesis, Deposition, Growth, or Forming

High Temperature Semiconductor/Thermoelectric Development- DOE Contact A. E. Evans, 301-353-3098; Sandia Contact T. L. Aselage, 505-844-0949

- Boron rich solids containing carbon are being prepared by CVD and growth from melts to make P and N doped semiconductors.

Ferroelectric Ceramic Processing - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts B. C. Bunker, 505-844-8940 and W. F. Hammetter, 505-844-8302

- Stable suspensions of lead zirconate titanate ferroelectric powders are are prepared using lead carbonate and pH control to prepare ceramics with uniform grains.

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

Ceramic Processing - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact B. C. Bunker, 505-844-8940

- 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.

Materials Properties, Behavior, Characterization, or Testing

Fracture of Ceramics - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact F. P. Gerstle, Jr., 505-844-4304

- Basic research to better understand fracture processes and to develop tougher ceramics based on this understanding.

Inorganic Materials Chemistry Division, 1846

Division 1846 has responsibility for relating the chemical properties of inorganic materials to their application in a variety of Sandia 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, 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 A. E. Evans, 301-353-3098, FTS 233-3098; Sandia Contact D. H. Doughty, 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.

Corrosion Division, 1847

Division 1847 personnel perform 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 Properties, Behavior, Characterization, or Testing

Corrosion - DOE Contact A. E. Evans, 301-353-3098; Sandia Contact R. B. Diegle, 505-846-3450

- Determination of how certain glassy alloys derive corrosion resistance to corrosion and why they require less alloyed chromium than conventional stainless steels.

Sandia National Laboratories - Livermore

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Powder Metallurgy - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts J. A. Brooks, 415-422-2051, J. E. Smugeresky, 415-422-2910 and J. W. Zindel, 415-422-2051

- Inert gas atomization and spark erosion processes are being used to advance development of the powder metallurgy and rapid solidication processing of a variety of alloy systems. Advanced techniques are being developed and applied to powder characterization.

Advanced Electrodeposition Studies - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts L. R. Thorne, 415-422-2636; J. C. Farmer, 415-422-3418 and H. R. Johnson, 415-422-2822

- Engineering applications, electroanalytical development, and fundamental investigations are being pursued in the area of electrodeposition of metals from both aqueous and non-aqueous media.

Metal Forming - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts J. Lipkin, 415-422-2417 and T. C. Lowe, 415-422-3187

- Nonelastic deformation is being examined through crystal plasticity modeling and experimentation. Results are used to guide design of phenomenological models for use in finite element simulations of forming and of failure of anisotropic materials.

Advanced Organic Materials - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts D. L. Lindner, 415-422-3306; J. G. Curro, 505-844-3963; W. R. Even, 415-422-3217 and C. B. Frost, 415-422-2048

- An understanding of methods for producing microstructural modifications in organic foams has enabled the production of polymeric foams with unique physical properties.

Helium Induced Crack Growth in Metals and Alloys - DOE Contact A. E. Evans, 301-353-3098; 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 theoreticalloy and experimentally. Tritium decay is used to introduce helium into metals without inducing radiation damage.

Joining Science and Technology - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts J. A. Brooks, 415-422-2051; K. W. Mahin, 415-422-2051 and J.R. Spingarn, 415-422-3307

- This program is developing a science-based methodology for improving the fundamental understanding of the behavior of welded structures and modeling of the complex fusion weld process. Advanced joining techniques using brazing, solid state welding, and adhesives are being developed for advanced structural materials.

<u>Composites: Characterization and Joining</u> - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts J. B. Woodard, 415-422-3115; B. C. Odegard, 415-422-2789; J. R. Spingarn, 415-422-3307

- The stability, compatibility, and joining of polymer matrix composite materials are under investigation. Focus is upon graphite fiber reinforced materials. Identification of moisture adsorption sites in thermosetting resins is underway. Coatings to increase stability for special designs are being studied. Joining studies include adhesives, mechanical fasteners and the welding of thermoplastics.

<u>Compatibility, Corrosion, and Cleaning of Materials</u> - DOE Contact, A. E. Evans, 301-353-3098; Sandia Contacts L. R. Thorne, 415-422-2636; H. R. Johnson, 415-422-2822 and D. K. Ottesen, 415-422-2787

- Sophisticated electroanalytical and spectroscopic techniques are being used to examine surfaces to assess compatibility, corrosion, and cleanliness.

<u>New Spectroscopy</u> - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts L. R. Thorne, 415-422-2636; D. L. Lindner, 415-422-3306; M. C. Nichols, 415-422-2906 and B. E. Mills, 415-422-3230

- New spectroscopic techniques are being developed for special applications. For example, micro-fluorescence spectroscopy, high resolution energy loss spectroscopy (HREELS), and x-ray photoelectron spectroscopy (XPS) are being implemented.

<u>Tritium Facility Upgrade for Materials Characterization and Testing</u> - DOE Contact A. E. Evans, 301-353-3098; Sandia Contacts S. H. Goods, 415-422-3274 and S. L. Robinson, 415-422-2209

- New laboratory capabilities within the Tritium Research Laboratory include the development of equipment for quantitative helium analysis and a high pressure, high temperature apparatus for T_2 exposure of test specimens.

Lawrence Livermore National Laboratory

Materials Properties, Behavior, Characterization, or Testing

Materials Modification by Ion Beams - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact R. G. Musket, 415-422-0483

- Research on the applications of ion implantation and ion-beam mixing for the modification of the surface properties of materials.

Synchrotron Radiation Studies - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contacts J. H. Kinney and Q. C. Johnson, 415-422-6669

- Study of high-resolution three-dimensional elemental and chemical phase mapping in small samples using the fine structure in the x-ray absorption coefficient.

- Development of a high spatial resolution array detector for applications in computed x-ray tomography.

Metal Deformation Modeling - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact E. C. Flower, 415-423-1572

- Develop LLNL existing finite element methods (FEM) codes (NIKE/DYNA) to accurately predict metal deformation during a forming operation.

- Extend efforts to include modeling of two-phase alloy systems and predictions of residual stresses.

Rapid Solidification Processing of Alloys - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact L. E. Tanner, 415-423-2653

- Elucidate mechanisms of high-rate solidification of alloys leading to microdisperse two-phase microstructures. Materials under investigation include Al-Be, Bi-B, Fe-Mn-S, and Fe-Al-O. Solid state vitrification is also being studied.

Microstructure of Stainless Steel Welds - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact J. W. Elmer, 617-253-6474 (MIT)

- Identify and model variables which affect the welding behavior of stainless steels.

Coating Adhesion - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact R. S. Rosen, 415-422-9559

- Study of the effect of substrate temperature on coating interface.

Dislocation Structures and Reversed Strains - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact G. F. Gallegos, 415-422-7002

- Study of deformation mechanisms in stainless steel at elevated temperatures and biaxial stress conditions.

- Determine effects of prestraining on deformation behavior under multiaxial loading.

Weld Library Generation - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact E. N. Kaufmann, 415-423-2640

- Compilation of a weld library database from existing weld information at DOE facilities for the purpose of generating trends in weld process parameters for various materials.

Deformation of Aluminum to Large Strains - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact M. E. Kassner, 415-423-2329

- Identification of deformation mechanism over a large temperature range for aluminum subjected to large strains.

Microstructure Research - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact H. R. Leider, 415-423-1884

- Project focuses on a basic research effort and a feasibility demonstration effort run in parallel.

- Study of the effects of size scale on physiochemical and engineering processes to create guidelines for work in the micro domain.

Pu Metallurgy - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact P. H. Adler, 415-423-4417

- Theoretical study of the kinematics of the alpha to delta martensitic transformation in Pu alloys leading to an understanding of the basic mechanisms and crystallographic features of this important phase change.

- Enhance the ductility and fracture toughness of brittle alpha-Pu by means of a deformation-induced alpha to delta transformation.

Pu Alloy Characterization - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact P. H. Adler, 415-423-4417

- Elucidation of a technically important region of the Pu-Ga-Fe phase diagram at temperatures in the range 425-600° using a combination of theoretical calculations and experimental measurements.

- Improved understanding of the effect of small Fe additions on alloy homogenization which, in turn, is likely to lead to a change in the heat-treating temperature currently used in a process line at Rocky Flats.

Pu Sputtering - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact H. F. Rizzo, 415-422-6369

- Exploration of the glass forming ability of various elements with plutonium by sputtering. Binary alloys of Fe, Ta, V, Os, Re, Co, and Si with plutonium have been prepared which show strong evidence for the formation of glassy phases. The formation of amorphous phases observed with the various systems studied can be directly related to the atomic size mismatch between the elements.

- Predict the glass forming ability of various Pu alloys.

Directed Energy Surface Processing - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact E. N. Kaufmann, 415-423-2640

- Study of the mechanisms of formation of metastable surface alloys using laser, electron and ion beams applied to metallic surfaces.

- Identify new methods to improve surface resistance to hostile environments.

Homogeneity of Dry-Powder Substrates for Generating Low-Density Carbon/ Polymer Networks - DOE Contact A. E. Evans; Lawrence Livermore Contact James Carley, 415-422-6601

- o Porosity variations in pressed salt bars have been studied with the goal of producing more uniformly dense porous polymeric structures.

Formation of Metastable Surface Alloys - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact E. N. Kaufmann, 415-423-2640

- o Study of the fundamental mechanisms involved in the formation of metastable structures by rapid solidification of surface melts by extracting quantitative data on the kinetics of nucleation and growth in a variety of alloys.

Mechanics of Low Density Materials - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact Richard Christensen, 415-422-7136

- o Investigation of the mechanics of open cell and closed cell low density materials in order to design improved materials.

Polymeric Materials Computer Modeling - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact Robert Cook, 415-422-6993

- o Computer simulation studies of the deformation and failure of polymeric materials.

Lifetime Prediction Theory for Polymeric Materials - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact Robert Cook, 415-422-6993

- o Development of polymeric material failure theory based on activated rate process concepts encompassing both stress induced and environmentally induced failure.
- o Application of theory to lifetime behavior of Kevlar strands under load, including median lifetimes and the dispersion of lifetime.

Instrumentation and Facilities

Weapons Database Development - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contact D. D. Jackson, 415-422-8054

o 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.

Tritium Facility Upgrade - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LLNL Contacts G. M. Morris, 415-423-1770 and M. Holda, 415-423-7240

o Upgrade of the Tritium Facility Upgrade to include a clean-up system and an office/mechanical technician shop addition.

Los Alamos National Laboratory

Materials Synthesis, Deposition, Growth, or Forming

Fluidized Bed Coatings - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098;LANL Contact D. W. Carroll, 505-667-2145, FTS 843-2145

o Development of techniques for low temperature deposition of tungsten, molybdenum, rhenium, and nickel on hollow substrates of spherical and cylindrical shapes.

o Fabrication of ultra-thin, free-standing shapes.

Materials Synthesis by Solid State Combustion - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact R. G. Behrens, 505-667-8327, FTS 843-8327

o Investigation of solid state combustion as a viable technology for rapid, high-temperature synthesis of alloys, ceramics, ceramic composites, and metals either as powders or as near-net-shape forms.

Powder Preparation by Plasma Chemical Synthesis - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact G. J. Vogt, 505-667-5813, FTS 843-5813

o Development of plasma-assisted chemical vapor deposition for the production of ultrafine, ultrapure ceramic powders.

Precision Tungsten Tubes - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. W. Carroll, 505-667-2145, FTS 843-2145

- o Development of a technique for producing precision tungsten tubes of various wall thicknesses in substantial lengths by chemical vapor deposition.

Superhard Materials - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Addition of B_4C to conventional W-Ni-Fe alloys to improve hardness, wear resistance, and resistance to deformation.

- o Investigation of optimum composition and processing to attain uniform microstructure, and characterization of fracture toughness and hardness.

Glass Fabrication Technology - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365; R. Mah, 505-667-3238, FTS 843-3238

- o Casting and hot forming into hemispheres, disks, plates, sheets, and rods.

- o Composition control to yield good strength, hardness, nuclear requirements, or chemical durability.

- o Optimize forming process to yield precise shapes, for example by glass-blowing in a gravity-free environment.

- o Investigate silica, sodalime, and pyrex glasses.

- o Investigate perfection of shape by surface forces in a high temperature microgravity experiment in the space shuttle.

Slip Casting of Ceramics - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Slip casting of many ceramics including alumina, magnesia, and thoria.

- o Use colloidal chemistry and powder characterization theory along with materials engineering.

Whisker Growth Technology - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Growth of silicon carbide whiskers by a vapor-liquid-solid process which produces very long fibers.

- o Improving control over the process itself to obtain mono-sized whiskers of regular morphology; processing whiskers to remove detritus and impurities; characterizing the whiskers and relating their properties to structural features; and growth of Si_3N_4 whiskers by same process.

Development of Ceramic Matrix Whisker-Reinforced Composites - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Fabrication by hot pressing of structural ceramic materials, borosilicate glass, $MoSi_2$, and Si_3N_4-matrix composites reinforced with SiC whiskers.

- o Achieve uniform microstructures of dispersed whiskers with low porosity which result in high fracture toughness.

New Hot Processing Technology - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Use of hot pressing techniques to consolidate bodies of materials such as Al_2O_3, ZrO_2, UO_2, B_4C, copper, aluminum, and carbon for application such as armor, ceramic components for nuclear reactor meltdown experiments, nuclear shielding, and filters.

Glass and Ceramic Coatings - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Develop vitreous enamels and general ceramic coatings to provide radiation-hardened, electrical-insulating components for accelerator technolgogy.

Cold Pressing, Cold Isostatic Pressing and Sintering - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Use of cold pressing and cold isostatic pressing to consolidate ceramic and metal powders to support laboratory program.

Plasma-Flame Spraying Technology - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Fabrication of free-standing shapes, and metallic and ceramic coatings by plasma spraying.

Electroplating Low Atomic Number Materials - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Investigation of electroplating low atomic number metals (aluminum and beryllium) by using non-aqueous plating baths.

Superhard Parylene Coating Development - DOE Contact A. E. Evans, 301-353-3099, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Use of a unique plasma cross-linking technique during the deposition of thermally pyrolyzed p-xylylene monomer in an inert atmosphere to yield a highly cross-linked, hard, polymer product.

Three New Conducting Polymers - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Synthesis of one polyphenylguinoxaline and two polypyrrones showing unique electrically conductive properties when treated with appropriate doping agents.

New Highly Conductive Doped Polyacetylene - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Use of new cesium electride to induce a high level of electrical conductivity and to improve the stability in polyacetylene films.

Liquid Crystal Polymer Development - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact R. May, 505-667-3238, FTS 843-3238

- o Synthesis of a liquid crystal polymer with strength in three dimensions.

Surface Property Modified Plastic Components - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Modification of surface properties of plastic components by a solvent infusion process.

- o Use of process to improve the biocompatibility properties of such plastics as acrylics and silicones.

High-Z Loaded Parylene Polymer Coatings - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Infusion of high-Z metals such as gold into parylene coatings using organometallic-solvent systems.

- o Preparation of uniformly loaded and graded Z coatings.

Low Density, Microcellular Plastic Foams - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Manufacture of microstructural polyolefin foams with densities between 0.01 g/cc and 0.2 g/cc by a nonconventional foaming process.

Radiochemistry Detector Coatings - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Physical vapor deposition of coatings for radiochemical detectors.

Target Coatings - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3912; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Development of single and multilayer metallic and nonmetallic thin film coatings, smooth and uniform in thickness.

Physical Vapor Deposition and Surface Analysis - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Physical vapor deposition and sputtering to produce materials for structural applications, corrosion resistance, optical properties, and thin film transducers.

- Doped, in-situ laminates of aluminum and Al_xO_y for high strength and smooth surface finish.

- Ion plating of aluminum and rare earth oxides, onto various substrates for corrosion resistance to gases and liquid plutonium.

- Deposition of oriented AlN onto various substrates to enable nondestructive evaluation of materials.

- Reflective and anti-reflective coatings for infrared, visible, ultra-violet, and x-ray wavelengths.

High Energy Density Joining Process Development - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- Development of microcomputer technology and signal analysis for process control and multiaxis, programmable component manipulation for high-voltage electron beam welding.

- Operation of a high-voltage electron beam welder for fabrication of products in the fissile material area.

- Investigation of real time diagnostics of laser welding efficiency.

- Study of plasma effects on laser welding efficiency.

- Correlate photodiode, acoustic, light-spectral and electron current measurements with high speed cinematography and resultant weld geometry.

Arc Welding Process Development - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- Video monitoring and Varistraint testing established as techniques to investigate crack susceptibility of gas-tungsten-arc welds.

Superplastic Forming - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- Investigation of superplastic forming of titanium and uranium alloys.

- Evaluation of fine grained U-6 wt% Nb (2m grain size) in biaxial forming.

Actinide Alloy Development - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. C. Christensen, 505-667-2556, FTS 843-2556

- o Development of new alloys of plutonium, including casting, thermo-mechanical working, sputtering, and stability studies.

- o Measurements of resistivity, thermal expansion and bend ductility to evaluate fabrication processes and alloy stability.

Metallic Glasses - DOE Contact Louis Ianiello, 301-353-3427, FTS 233-3427; LANL Contact S. E. Bronisz, 505-667-4665, FTS 843-4665

- o Experimental and calculational modeling studies of atomic mobility phenomena and irradiation effects in metallic glasses ($Fe_{40}Ni_{40}$ $P_{14}B_6$ and $Pd_{80}Ge_{20}$).

- o Development of radiation resistant, amorphous metal magnetic materials.

Structural Ceramics - DOE Contact Robert Gottschall, 301-353-3428, FTS 233-3428; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Development of ceramic materials based on SiC or Si_3N_4 to improve fracture toughness and strength through controlled processing.

- o Colloidal processing of plasma-produced powders.

Surface Studies - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3912; LANL Contact H. K. McDowell, 505-667-4686, FTS 843-4686

- o Studies of surface structures and atomic and electronic properties of uranium alloys and intermetallics, UO_2 and ThO_2 single crystals, heavy fermion system, and palladium/hydrogen systems.

- o Develop essential atomic-level understanding of surface properties of materials and physical and chemical processes.

- o Investigate and study surface modification, synchrotron radiation of uranium, UPt_3 surface properties, valence bands of UO_2, residues on electropolished/oxidized uranium, and use of MeV ion beams to probe surface structure.

- o Use of techniques such as Low Energy Electron Diffraction (LEED), Auger and Loss Spectroscopies, Ion-Scattering Spectroscopy (ISS), Ultraviolet Photoelectron Spectroscopy (UPS), Synchrotron Radiation, and MeV-ion-beam scattering.

<u>Tritiated Materials</u> - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. H. W. Carstens, 505-667-5849, FTS 843-5849

- o Advanced R&D on low-Z, tritiated materials with the emphasis on Li(D,T) (salt) and other metal tritides.

- o Studies of new methods for preparing, fabricating, and containing such compounds.

<u>Actinide Surface Properties</u> - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D.C. Christensen, 505-667-2556, FTS 843-2556

- o Characterization of actinide metal, alloy and compound surfaces using the techniques of x-ray photoelectron spectroscopy, Auger analysis, ellipsometry and Fourier-transform infrared spectroscopy.

- o Studies of surface reactions, chemisorption, attack by hydrogen, nature of associated catalytic processes.

<u>Mechanical Properties and Alloy Development</u> - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact S.E. Bronisz, 505-667-4665, FTS 843-4665

- o Develop thermomechanical processing of plutonium alloys to optimize mechanical properties.

- o Study of complex microstructures, grain refinement, and deformation-induced transformations.

<u>Mechanical Properties of Uranium</u> - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact S.E. Bronisz, 505-667-4665, FTS 843-4665

- o Investigation of mechanical properties of U-6 wt% nB and pure U at high strain rates.

- o Study of the effects of crystallographic texture on high rate (shock regime) uranium deformation.

Low Temperature Electronic Properties - DOE Contact Louis Ianiello, 301-353-3427, FTS 233-3427; LANL Contact S. E. Bronisz, 505-667-4665, FTS 843-4665 and R. H. Heffner, 505-667-4838, FTS 843-4838

- Understanding electronic properties of materials through their superconducting and magnetic behavior. Emphasis on actinide elements and their alloys.

Phase Transformations in Pu and Pu Alloys - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact S. E. Bronisz, 505-667-4665, FTS 843-4665

- Investigation of mechanisms, crystallography, and kinetics of transformations in plutonium and alloys using pressure and temperature dilatometry, optical metallography, and x-ray diffraction.

High Strain Rate Testing - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact P. S. Follansbee, 505-667-8021, FTS 843-8021

- Testing of metals at rates up to, but not including the shock-wave regime to elicit fundamental understanding of changes in mechanism as a function of deformation rate.

Neutron Diffraction of Pu and Pu Alloys - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact S. E. Bronisz, 505-667-4665, FTS 843-4665

- Neutron diffraction studies of plutonium and its alloys conducted at the Los Alamos WNR pulsed neutron source.

- Time-of-flight technique used to measure diffraction at elevated temperatures and pressures.

Powder Characterization - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- Characterization of starting powders (RF plasma SiC, commercial powders of ThO_2, tungsten, copper, Si_3N_4, MgO and Al_2O_3).

- Determination of particle size and distribution, morphology, state of agglomeration, zeta potential, and surface area.

Dielectric Loss Measurement in Ceramics - DOE Contact Marion Cohen, 301=353-4253; LANL Contact F. W. Clinard, 505-667-5102, FTS 843-5102

- Loss tangent measurements in ceramics at very high frequencies to evaluate effects of neutron damage for magnetic fusion energy applications.

- Evaluation of microwave sintering properties of ceramics for fabrication purposes.

Device or Component Fabrication or Testing

Polymers and Adhesives - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact W. A. May, Jr., 505-667-6362; FTS 843-6362

- Development of fabrication processes, and evaluation and testing of commercial plastic materials for weapons programs.

- Development of plastic-bonded composites, cushioning materials, and compatible adhesives.

- Applications of commercial and developmental plastics fabrication techniques to specific weapons-related materials and components for the purpose of improving efficiency and economy of weapons design.

Salt Fabrication - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact J. E. Nasise, 505-667-1459, FTS 843-1459

- Development and evaluation of fabrication processes for lithium tritide.

- Use of hot pressing and hot isostatic pressing to near net shape to improve part shape versatility, density, and surface quality.

- Conduct component integrity studies involving radiation induced growth and outgassing.

Ceramic Technology - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- Fabrication castable ceramics for energy technologies.

Glass and Ceramic Sealing, and Metallizing Technology - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Design of sealing techniques to join ceramic and metal components which are used in experimental devices for energy technologies.

- o Development of an alumina assembly consisting of a large number of oval tubes joined together to form an arc of accelerator path.

Microwave Sintering/Processing - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Investigating techniques of bonding and sintering ceramics such as Al_2O_3 and glass.

- o Use of very high frequency microwaves which suscept directly to the area in which the heat is needed.

- o Investigation of the control of the heating and its effect on microstructure.

Injection Mold Process for Making Snap-On Fittings - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Use of injection molding to create high-strength snap-on tube fittings made from carbon-fiber reinforced polyether ether ketone, polycarbonate and nylon.

Composite Spring Support Structures - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact D. V. Duchane, 505-667-3238, FTS 843-3238

- o Fabrication of composite spring support structures from filament-wound, carbon-fiber epoxy composites.

Solid State Bonding - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact H. Casey, 505-667-4365, FTS 843-4365

- o Evaluating aluminum solid state bonding for seamless ICF targets.

- o Evaluation of bond load modulation and ion bombardment cleaning.

- o Investigation of bonding technique optimization.

<u>Nondestructive Evaluation</u> - DOE Contact A. E. Evans, 301-353-3098, FTS 233-3098; LANL Contact A. Wilson, 505-667-6404, FTS 843-6404

- o Development of nondestructive evaluation techniques that produce quantitative estimates of material properties.

- o Application of multivariate analysis to welding processes. Use tomographic techniques to extend radiographic inspections.

OFFICE OF FOSSIL ENERGY

	FY 1986
Office of Fossil Energy Grand Total	$ 7,328,000
Office of Technical Coordination	$ 5,628,000
Advanced Research and Technology Development Program	$ 5,628,000
Materials Preparation, Synthesis, Deposition, Growth, or Forming	$ 1,209,000
Evaluation of the Feasibility of Pressure Quenching to Produce Hard Metastable Materials	0*
Consolidation of Rapidly Solidified Aluminide Metal Powders	238,000
Investigation of Electrospark Deposited Coatings for Protection of Materials in Sulfidizing Atmospheres	48,000
Short Fiber Reinforced Structural Ceramics	229,000
Fabrication of Fiber-Reinforced Composites by CVD Infiltration	324,000
Transfer of CVD Infiltration Technology to Industry	100,000
Development of Advanced Fiber Reinforced Ceramics	180,000
Development and Microstructural Evaluation of Austenitic Alloys	90,000
Materials Properties, Behavior, Characterization, or Testing	$ 3,146,000
Technical Monitoring of Coal Gasification Subcontracted Materials Projects for the AR&TD Fossil Energy Materials Program	29,000
Study of Damage Mechanisms in Coal Conversion Atmospheres Affecting the Fatigue and Creep Rupture Properties of Cr-Mo Steels	150,000
Mechanical Properties and Microstructural Stability of Advanced Steam Cycle Materials	140,000
Transformation, Metallurgical Response and Behavior of the Weld Fusion and Heat Affected Zone in Cr-Mo Steels for Fossil Energy Applications	0**

*Prefunded in FY 1984.

**Prefunded in FY 1985.

FY 1986

Office of Technical Coordination (Continued)

Advanced Research and Technology Development Program (Continued)

Materials Properties, Behavior, Characterization, or Testing (Continued)

Investigation of Correlation of Carbide Size and Percentage with Mechanical Properties of High-Strength, Low Alloy Steels	$ 0
Analysis of Hydrogen Attack on Pressure Vessel Steels	95,000
Evaluation of 3 Cr-1.5 Mo Steel in a Simulated Coal Conversion Environment	0*
Investigation of the Weldability of Ductile Alumindes	50,000
Development of Iron and Nickel Aluminides	143,000
Joining of Advanced Aluminides	238,000
Corrosion of Alloys for Internal and Heat Exchangers in Mixed-Gas Environments	215,000
Corrosion of Alloys in FBC Systems	105,000
A Mechanistic Study of Low-Temperature Corrosion on Materials in the Coal Combustion Environment	0*
Investigation of Corrosion Mechanisms of Coal Combustion Products in Alloys and Coatings	80,000
Investigation of the Mechanisms of Molten Salt Corrosion of Candidate Materials for Molten Carbonate Fuel Cells	100,000
Erosion in Dual-Phase Microstructures	0*
Evaluation of Advanced Materials for Slurry Erosion Service	0**
Mechanisms of Erosion-Corrosion in Coal Combustion Environments	180,000
Study of Particle Rebound Characteristics and Material Erosion at High Temperature	80,000
Development of Nondestructive Evaluation Techniques for Structural Ceramics	197,000
Effect of Flaws on the Fracture Behavior of Structural Ceramics	128,000
Joining of Silicon Carbide Reinforced Ceramics	238,000

*Prefunded in FY 1984.

**Prefunded in FY 1985.

	FY 1986
Office of Technical Coordination (Continued)	
Advanced Research and Technology Development Program (Continued)	
Materials Properties, Behavior, Characterization, or Testing (Continued)	
Nondestructive Evaluation of Advanced Ceramic Composite Materials	$ 238,000
Investigation of the Mechanisms of Failure of Ceramic Materials for Hot Gas Filtration	0*
High Temperature Creep Behavior of Refractory Bricks	60,000
Investigation of the Effect of Slag Penetration on the Mechanical Properties of Refractories	0*
Weldability Studies of Advanced Austenitic Alloys	60,000
Investigation of Corrosion-Resistant Oxide Scales on Iron-Based Alloys in Mixed Gas Environments	150,000
Solid Particle Erosion in Turbulent Flows Past Tube Banks	50,000
Modeling of Fibrous Preforms for CVD Infiltration	40,000
Structural Reliability and Damage Tolerance of Ceramic Composites	240,000
Evaluation of Mechanical Properties of Advanced Austenitic Alloys	140,000
Device or Component Fabrication, Behavior, or Testing	$ 883,000
"Materials and Components in Fossil Energy Applications" Newsletter	105,000
Membrane Separation of Gases from Coal Combustion and Coal Conversion Processes	30,000
Three-Dimensional Residual Stress Characterization of Thick Plate Weldments with Advanced Instrumentation and Methodologies	0*
Studies of Materials Erosion in Coal Conversion and Utilization Systems	286,000
Mechanisms of Galling and Abrasive Wear	75,000

*Prefunded in FY 1985.

		FY 1986
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	$	0*
Alkalai Attack of Coal Gasifier Refractory Linings		0*
Thermodynamic Properties and Phase Relations for Refractory-Slag Reactions in Slagging Coal Gasifiers		40,000
Assessment of the Causes of Failure of Ceramic Filters for Hot-Gas Cleanup		56,000
Oxide Electrodes for High-Temperature Fuel Fuel Cells		191,000
Development of a Design Methodology for High-Temperature Cyclic Application of Materials Which Experience Cyclic Softening		100,000
Instrumentation and Facilities	$	390,000
Management of the AR&TD Fossil Energy Materials Program		350,000
Coal Conversion and Utilization Plant Support Services		40,000
Office of Surface Coal Gasification	$	580,000
Materials Preparation, Synthesis, Deposition, Growth or Forming	$	580,000
Electroslag Component Casting		96,000
Protective Coatings and Claddings: Application/Evaluation		181,000
Development of Iron Aluminides for Coal Gasification Systems		205,000
Ceramic Fiber-Ceramic Matrix Hot-Gas Filters		98,000

		FY 1986
<u>Office of Surface Coal Gasification (Continued)</u>		
<u>Materials Properties, Behavior, Characterization or Testing</u>	$	0
Corrosion of Structural Ceramics in Coal Gasification Environments		0*
<u>Office of Oil, Gas, Shale, and Coal Liquids</u>	$	0
<u>Materials Preparation, Synthesis, Deposition Growth, or Forming</u>	$	0
Coating Studies for Coal Conversion		0
<u>Materials Properties, Behavior, Characterization or Testing</u>	$	0
Assessment of Materials Selection and Performance for Coal Liquefaction Plants		0
Materials Review and Support for the SRC-I Liquefaction Project		0
Coal Liquefaction Pilot Plant Materials Testing and Failure Analysis		0
Elastomer Test Program		0
<u>Office of Coal Utilization</u>	$	1,120,000
<u>Fuel Cells Program</u>	$	0
<u>Materials Properties, Behavior, Characterization, or Testing</u>	$	0
Molten Carbonate Fuel Cell and Stack Technology Development		0
Molten Carbonate Fuel Cell Component Technology Development		0
Alternative Molten Carbonate Fuel Cell Cathodes		0

*Prefunded in FY 1985.

	FY 1986
Office of Coal Utilization (Continued)	
Device or Component Fabrication, Behavior or Testing	$ 0
High Temperature Solid Oxide Electrolyte Fuel Cell Power Generation System	0
Magnetohydrodynamics Program	$ 1,120,000
Materials Properties, Behavior, Characterization, or Testing	$ 1,100,000
MHD Materials Development, Testing, and Evaluation	250,000
UTSI MHD Development Testing	800,000
Superconducting Magnet High Current Conductor Development and Testing	50,000
Instrumentation and Facilities	$ 20,000
Autoclave Testing	20,000

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:

- o Provide a capability to convert coal to liquid and gaseous fuels;
- o Increase domestic production of coal, oil, and gas;
- o Ensure that current and new facilities that burn coal can do so in an economically viable and environmentally acceptable manner; and
- o 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 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 ongoing 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 E. E. Hoffman, 615-576-0735; R&D Associates Contact H. L. Weisberg, 213-822-1715

- o Design, build and test a high-pressure press system to evaluate "pressure quenching" of materials.

Consolidation of Rapidly Solidified Aluminide Metal Powders - DOE Contact E. E. Hoffman, 615-576-0735; Idaho National Engineering Laboratory Contacts A. D. Donaldson, J. E. Flinn, R. N. Wright, FTS 583-2627

- o Determination of the most effective means of, and associated parameters for, consolidating rapidly solidified nickel-iron aluminide powders.

Investigation of Electrospark Deposited Coatings for Protection of Materials in Sulfidizing Atmospheres - DOE Contact E. E. Hoffman, 615-576-0735; Hanford Engineering Development Laboratory Contact R. N. Johnson, 509-376-0715

- o Examination of the use of the electrospark deposition coating process for the application of corrosion-, erosion-, and wear-resistant coatings to candidate superheater alloys.

Short Fiber Reinforced Structural Ceramics - DOE Contact E. E. Hoffman, 615-576-0735; LANL Contacts F. D. Gac, 505-647-9498

- o Investigate the utility of whisker reinforcement technology for producing structural ceramic composites of improved strength and fracture toughness.

Fabrication of Fiber-Reinforced Composites by CVD Infiltration - DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact D. P. Stinton, 615-574-4556

- o Develop a ceramic composite having higher than normal toughness and strength yet retaining the typical ceramic attributes of refractories and high resistance to abrasion and corrosion.

Transfer of CVD Infiltration Technology to Industry - DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact D. P. Stinton, 615-574-4556

- o Transfer AR&TD-developed CVD infiltration technology to Babcock and Wilcox as part of a joint R&D program with Babcock and Wilcox Research Laboratories.

Development of Advanced Fiber Reinforced Ceramics - DOE Contact E. E. Hoffman, 615-576-0735; Georgia Institute of Technology, Georgia Tech Research Institute Contact T. L. Starr, 404-894-3678

- o 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.

Development and Microstructural Evaluation of Austenitic Alloys - DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact R. W. Swindeman, 615-574-5108

- o Alloys will be developed on the basis of attributes required for advanced steam cycle superheater service.

Materials Properties, Behavior, Characterization, or Testing

Technical Monitoring of Coal Gasification Subcontracted Materials Projects for the AR&TD Fossil Energy Materials Program - DOE Contact E. E. Hoffman, 615-576-0735; ANL Contact W. A. Ellingson, 312-972-5068

- o Assist with the 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.

Study of Damage Mechanisms in Coal Conversion Atmospheres Affecting the Fatigue and Creep Rupture Properties in Cr-Mo Steels - DOE Contact E. E. Hoffman, 615-576-0735; University of California Contacts E. R. Parker, R. O. Ritchie, 415-642-0863

- o Evaluate the effects of high-temperature service in adverse environments on the metallurgical properties of weld metal and heat affected zone (HAZ) regions in thick section weldments of 3 Cr-Mo steels.

Mechanical Properties and Microstructural Stability of Advanced Steam Cycle Materials - DOE Contact E. E. Hoffman, 615-576-0735; Cornell University Contact Che-Yu Li, 607-256-4349

- o Mechanical testing and ranking of the strengths and metallurgical stabilities of advanced steam cycle superheater alloys at temperatures ranging from 650 to 760^{o}C.

Transformation, Metallurgical Response and Behavior of the Weld Fusion and Heat Affected Zone in Cr-Mo Steels for Fossil Energy Applications - DOE Contact E. E. Hoffman, 615-576-0735; University of Tennessee Contact C. D. Lundin, 615-974-5310

- o Develop fundamental information on the metallurgical behavior of the heat affected zone of welds in chromium-molybdenum alloys.

Investigation of Correlation of Carbide Size and Percentage with Mechanical Properties of High-Strength, Low Alloy Steels - DOE Contact E. E. Hoffman, 615-576-0735; Westinghouse Contact B. J. Shaw, 412-256-1201

- o Examine the correlation between the size and percentage of carbides in high-strength Cr-Mo steels and their mechanical properties.

Analysis of Hydrogen Attack on Pressure Vessel Steels - DOE Contact E. E. Hoffman, 615-576-0735 ; University of California at Santa Barbara Contact G. R. Odette, 805-961-3525

- o Refine previous analyses and confirm the adequacy of the basic thermodynamic information available in the literature.

Evaluation of 3 Cr-1.5 Mo Steel in a Simulated Coal Conversion Environment - DOE Contact E. E. Hoffman, 615-576-0735; Westinghouse Contact B. J. Shaw, 412-256-1201

- o Develop a fracture mechanics characterization of candidate materials for coal gasification pressure vessels.

Investigation of the Weldability of Ductile Aluminides - DOE Contact E. E. Hoffman, 615-576-0735; Colorado School of Mines Contact G. R. Edwards, 303-273-3773

- o Determine the role of microstructure in the intergranular cracking of alumindes, with special emphasis on weld cracking susceptibility.

Development of Iron and Nickel Aluminides - DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact C. T. Liu, 615-574-4459

- o Design and test 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.

Joining of Advanced Aluminides - DOE Contact E. E. Hoffman, 615-576-0735; Idaho National Engineering Laboratory Contacts A. D. Donaldson, D. E. Clark, FTS 583-0746

- o Investigate weldability problems limiting the use of aluminides in welded structures.

Corrosion of Alloys for Internal and Heat Exchangers in Mixed-Gas Environments - DOE Contact E. E. Hoffman, 615-576-0735; ANL Contacts W. A. Ellingson and K. Natesan, 312-972-5068

- o Provide a basic understanding of the corrosion behavior of commercial and model alloys after exposure to multi-component gas mixtures.

Corrosion of Alloys in FBC Systems - DOE Contact E. E. Hoffman, 615-576-0735; ANL Contacts W. A. Ellingson and K. Natesan, 312-972-5068

- o Experimentally evaluate the corrosive behavior of alloys in various gas environments and evaluate deposit-induced corrosion behavior of heat-exchanger and gas-turbine materials after exposure to such environments.

A Mechanistic Study of Low-Temperature Corrosion on Materials in the Coal Combustion Environment - DOE Contact E. E. Hoffman, 615-576-0735; General Electric Contact R. W. Haskell, 518-385-4226

- Develop a mechanistic understanding of the low-temperature corrosion phenomena observed in the Long-Term Materials Test, focusing on corrosion morphology and interface chemistry of selected specimens, thermochemical calculations and laboratory test to correlate experimental results with the calculations.

Investigation of Corrosion Mechanisms of Coal Combustion Products on Alloys and Coatings - DOE Contact E. E. Hoffman, 615-576-0735; University of Pittsburgh Contact G. H. Meier, 412-624-5316

- Investigate the formation and breakdown of protective oxide scales in mixed oxidant gases.

Investigation of the Mechanisms of Molten Salt Corrosion of Candidate Materials for Molten Carbonate Fuel Cells - DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact H. S. Hsu, 615-576-4810

- Investigation of the corrosion mechanisms of the anode and cathode current collectors in molten carbonate fuel cells.

Erosion in Dual-Phase Microstructures - DOE Contact E. E. Hoffman, 615-576-0735; University of Notre Dame Contact T. H. Kosel, 219- 239-5642

- Systematically investigate the effects of microstructural variables in dual-phase metallic alloys containing large second-phase particles on erosion by solid particle impact.

Evaluation of Advanced Materials for Slurry Erosion Service - DOE Contact E. E. Hoffman, 615-576-0735; Battelle-Columbus Laboratories Contacts I. G. Wright, A. H. Clauer, 614-424-4377

- Obtain erosion data on candidate valve trim materials under varied wear conditions.

- Explore and characterize behavior of the new erosion-resistant materials.

- Develop a substitute erodent and liquid carrier combination to reduce health risks in the laboratory.

<u>Mechanisms of Erosion-Corrosion in Coal Combustion Environments</u> - DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact J. R. Keiser, 615-574-4453

- Microscopically evaluate erosion-corrosion of alloys before and after being subjected to a flowing gas stream of erodent particles.

<u>Study of Particle Rebound Characteristics and Material Erosion at High Temperature</u> - DOE Contact E. E. Hoffman, 615-576-0735; University of Cincinnati Contact W. Tabakoff, 513-475-2849

- Investigate the erosion processes and fluid mechanics phenomena that occur in coal combustion systems.

<u>Development of Nondestructive Evaluation Techniques for Structural Ceramics</u> - DOE Contact E. E. Hoffman, 615-576-0735; ANL Contact W. A. Ellingson, 312-972-5068

- Study and develop acoustic and radiographic techniques as well as possible novel techniques to characterize structural ceramics with regard to various properties and flaws.

<u>Effect of Flaws on the Fracture Behavior of Structural Ceramics</u> - DOE Contact E. E. Hoffman, 615-576-0735; ANL Contact J. P. Singh, 312-972-5123

- Establish correlations between the composition, microstructure, and mechanical properties of structural ceramics with well-defined flaws.
- Provide information to relate mechanical properties to nondestructive evaluation results.

<u>Joining of Silicon Carbide Reinforced Ceramics</u> - DOE Contact E. E. Hoffman, 615-576-0735; Idaho National Engineering Laboratory Contacts A. D. Donaldson, R. M. Nielson, FTS 583-8274

- Identify and develop techniques for joining silicon carbide fiber-reinforced composite materials.

Nondestructive Evaluation of Advanced Ceramic Composite Materials - DOE Contact E. E. Hoffman, 615-576-0735; Idaho National Engineering Laboratory Contacts A. D. Donaldson, J. B. Walter, FTS 583-0033

- Develop an effective capability for nondestructive evaluation of ceramic fiber reinforced ceramic composites focusing on ultrasonic and radiographic techniques.

Investigation of the Mechanisms of Failure of Ceramic Materials for Hot Gas Filtration - DOE Contact E. E. Hoffman, 615-576-0735; United Kingdom Coal Research Establishment/Oak Ridge National Laboratory Contact R. R. Judkins, 615-574-4572

- Investigate the mechanisms of failure of high temperature ceramic filters used for removing particulates from gas streams and apply the results to similar rigid ceramic filters.

High Temperature Creep Behavior of Refractory Bricks - DOE Contact E. E. Hoffman, 615-576-0735; Iowa State University Contact T. D. McGee, 515-294-9619

- Study of the creep behavior of high-chromia refractories suitable for lining the hot section of slagging gasifiers.

Investigation of the Effect of Slag Penetration on the Mechanical Properties of Refractories - DOE Contact E. E. Hoffman, 615-576-0735; National Bureau of Standards Contact S. M. Wiederhorn, 301-921-2901

- Evaluate the effect of slag and microstructure on the fracture and deformation behavior of refractory materials, and model refractory degradation caused by slag penetration.

Weldability Studies of Advanced Austenitic Alloys - DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact R. W. Swindeman, 615-574-5108

- Evaluation of the weldability of alloys including use of a special technique which evaluates the hot cracking tendency of the weldments.

- Development of a suitable filler metal.

Investigation of Corrosion-Resistant Oxide Scales on Iron-Based Alloys in Mixed Gas Environments - DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact H. S. Hsu, 615-576-4810

- o Development of protective oxide scales on iron-based alloys in mixed oxidant environments for coal-related applications at 600 to 800^{o}C.

Solid Particle Erosion in Turbulent Flows Past Tube Banks - DOE Contact E. E. Hoffman, 615-576-0735; University of California, Berkeley, Contact J. A. C. Humphrey, 415-642-6460

- o Investigation to improve the understanding of erosion processes in gas streams.

Modeling of Fibrous Preforms for CVD Infiltration - Doe Contact E. E. Hoffman, 615-576-0735; Georgia Institute of Technology Contact T. L. Starr, 404-894-3678

- o Development of an analytical model for the fabrication and infiltration of fibrous preforms.

- o The proposed analytical model will (1) predict preform structure (density, porosity, fiber orientation, etc.) based on fabrication technique and fundamental fiber parameters (diameter, aspect ratio, etc.) and (2) predict permeation and heat conduction through the preform structure and, thus, predict the CVD infiltration performance. Initially, the model will be developed for preforms containing only one type of fiber, but extension to mixed fiber and fiber-particle blends is planned.

Structural Reliability and Damage Tolerance of Ceramic Composites - DOE Contact E. E. Hoffman, 615-576-0735; NBS Contacts E. R. Fuller and S. J. Schneider, 301-921-2901

- o Characterization of the high temperature failure mechanisms of structural ceramics, especially silicon carbide and silicon nitride based materials, for use in coal conversion applications.

Evaluation of Mechanical Properties of Advanced Austenitic Alloys - DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact R. W. Swindeman, 615-576-5108

- o Creep-rupture data on alloys developed in an earlier task will be gathered in the temperature range 600 to 760°C for times from 10 to 10,000 h.

Device or Component Fabrication, Behavior, or Testing

"Materials and Components in Fossil Energy Applications" Newsletter - DOE Contact E. E. Hoffman, 615-576-0735; Battelle-Columbus Laboratories Contact I.G. Wright, 614-424-4377

- o Publish a periodic newsletter to address current developments in materials and components in fossil energy applications.

Membrane Separation of Gases from Coal Combustion and Coal Conversion Processes - DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact B. Z. Egan, 615-574-6868

- o Assessment of the applications of membrane technology for separating and recovering gases encountered in coal combustion and coal conversion processes.

Three-Dimensional Residual Stress Characterization of Thick Plate Weldments with Advanced Instrumentation and Methodologies - DOE Contact E. E. Hoffman, 615-576-0735; Pennsylvania State University Contact C. O. Rudd, 814-863-2843

- o Characterization of the three-dimensional residual stress field in an approximately 30cm thick V-groove weldment of 2 1/4 Cr-1 Mo steel.
- o Evaluate various postweld heat treatment techniques.

Studies of Materials Erosion in Coal Conversion and Utilization Systems - DOE Contact E. E. Hoffman, 615-576-0735; LBL Contact A. V. Levy, 415-486-5822

- o Determine 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 E. E. Hoffman, 615-576-0735; National Bureau of Standards Contact L. K. Ives, 301-921-2943

o Study of the wear mechanisms of materials associated with valves in coal conversion systems.

Thermomechanical Modeling of Refractory Brick Linings for Slagging Gasifiers - DOE Contact E. E. Hoffman, 615-576-0735; Massachusetts Institute of Technology Contact Oral Breyukozturk, 617-253-7186

o 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 E. E. Hoffman, 615-576-0735; Virginia Polytechnic Institute and State University Contact J. J. Brown, Jr., 703-961-6777

o Investigate 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 Gasifiers - DOE Contact E. E. Hoffman, 615-576-0735; Pennsylvania State University Contact Arnulf Muan, 814-865-7659

o Determine the chemical constraints affecting the performance of refractory material under experimental conditions corresponding to those prevailing in slagging gasifiers.

Assessment of the Causes of Failure of Ceramic Filters for Hot-Gas Cleanup in Fossil Energy Systems and Determination of Materials Research and Development Needs - DOE Contact E. E. Hoffman, 615-576-0735; Acurex Corporation R. L. S. Chang, 415-961-5700

o Determination of the principal causes of failure of ceramic filters used in coal conversion and utilization systems.

Oxide Electrodes for High-Temperature Fuel Cells - DOE Contact E. E. Hoffman, 615-576-0735; PNL Contact J. L. Bates, 509-375-2579

o Find and develop highly electronically conducting oxides for use as cathodes in SOFC's.

Development of a Design Methodology for High-Temperature Cyclic Application of Materials Which Experience Cyclic Softening - DOE Contact E. E. Hoffman, 615-576-0735; University of Illinois Contact D. L. Marriott, 217-333-7237

- Investigation into the general behavior of components subject to the cyclic softening phenomenon.

Instrumentation and Facilities

Management of the AR&TD Fossil Energy Materials Program- DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contacts R.A. Bradley, P. T. Carlson, 615-574-6094

- Management of the AR&TD Fossil Energy Materials Program under DOE approved guidelines.

Coal Conversion and Utilization Plant Support Services- DOE Contact E. E. Hoffman, 615-576-0735; ORNL Contact J. R. Keiser, 615-574-4453

- Provide screening data on the susceptibility to corrosion and stress-corrosion cracking of potential materials of construction for coal conversion and utilization plants.

- Provide failure analyses and on-site examination for the Wilsonville, Alabama, Advanced Coal Liquefaction Research and Development Facility and other coal conversion plants as needed.

Office of Surface Coal Gasification

Materials Preparation, Synthesis, Deposition, Growth, or Forming

Electroslag Component Casting - DOE Contact J. P. Carr, 301-353-5985; ORNL Contact V. K. Sikka, 615-574-5112

- Development of electroslag casting technology for use in coal conversion components such as valve bodies, pump housings, and pipe fittings.

Protective Coatings and Cladding: Application/Evaluation - DOE Contact J. P. Carr, 301-353-5985; ANL Contact D. J. Baxter, 312-972-5117

- Experimental evaluation and thermodynamic analysis of metallic protective coatings for coal gasifier waste heat steam generators and superheaters.

- o Development of coating inspection methods.

Development of Iron Aluminides for Coal Gasification Systems - DOE Contacts J. P. Carr, 301-353-5985 and D. Dubis, 304-291-4399; ORNL Contact C. T. Liu, 615-574-5120

- o Development of low cost, low density intermetallic alloys for use as components in advanced fossil energy conversion and utilization systems.

Ceramic Fiber-Ceramic Matrix Hot-Gas Filters - DOE Contacts J. P. Carr, 301-353-5985 and D. Dubis; ORNL Contact D. P. Stinton, 615-574-4556

- o Development of a ceramic fiber-ceramic matrix composite that will be suitable as a high-temperature particulate filter for use in hot-gas cleanup systems.

Materials Properties, Characterization, Behavior, or Testing

Corrosion of Structural Ceramics in Coal Gasification Environments - DOE Contact J. P. Carr, 301-353-5985; ANL Contact T. E. Easler, 312-972-4250

- o Provide experimental data for SiC when exposed to coal gasification heat exchanger environments.

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

- o Development of chemically vapor deposited coatings which offer the hope of extending the life of valve trim materials in coal conversion applications.

- o Determination of erosion rates 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

- o 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

- o Provide assistance in the review of contractor documents for materials selection.
- o Review and provide input to materials testing and failure analysis plans
- o 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

- o Provide alloy screening data on the susceptibility to corrosion and stress-corrosion cracking of potential materials of construction for coal liquefaction plants. Project will be completed this year.

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

- o 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. Project will be completed this year.

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 Properties, Behavior, Characterization, or Testing

Molten Carbonate Fuel Cell and Stack Technology Development - DOE Contact J. E. Copley, 304-291-4747; International Fuel Cells Contact W. Johnson, 203-727-2215

- Evaluation of materials which maintain springiness under molten carbonate fuel cells (MCFC) operating conditions with temperatures up to about 700 degrees C for use in the construction of flexible flanges which maintain sealing pressures against electrolyte-filled ceramic matrices.

- Evaluation of ZrO_2 materials as gasket materials between gas manifolds and the MCFC stack.

Molten Carbonate Fuel Cell Component Technology Development - DOE Contact J. E. Copley, 304-291-4747; Energy Research Corporation Contact L. Paetsch, 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 W. J. Huber, 304-291-4663; ANL Contact R. D. Pierce, 312-972-4450

- Evaluation of ceramic materials (e.g., Li_2MnO_3, $LiFeO_2$) 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 A. Jones, 412-256-1903

- Diffusion studies to determine potential life limiting factors are underway.

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 DOE Materials Program for MHD is the development of materials applicable to the unique operating environment of coal-fired MHD systems. Program effort is primarily in the area of applied engineering development of MHD component materials.

Materials Properties, Behavior, Characterization, or Testing

MHD Materials Development, Testing, and Evaluation - DOE Contact L. Makovsky, 412-675-5814; Avco Contact S. Petty, 617-381-4354

- Development of electrode, sidewall and insulator materials applicable to the MHD environment.

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.

Superconducting High Current Conductor Development and Testing - DOE Contact L. Makovsky, 412-675-5814; Massachusetts Institute of Technology Contact P. Marston, 617-253-5722

o Developing and testing a high-current conductor for large scale MHD magnets based on the concept of the internally cooled cabled superconductor (ICCS).

Instrumentation and Facilities

Autoclave Testing - DOE Contact C. A. Thomas, 412-675-5814; Argonne National Laboratory Contact W. Swift, 312-972-5964

o Construction of an autoclave test facility for long-term testing and MHD bottoming cycle materials.

PARAGRAPH DESCRIPTIONS

OFFICE OF ENERGY UTILIZATION 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.

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 in two projects, the Materials Project and the Tribology Project. The DOE contacts are Jim Eberhardt (202-586-5377; FTS 896-5377) for the Materials Project and Terry Levinson (202-586-5377; FTS 896-5377) for the Tribology Project. The Oak Ridge National Laboratory (ORNL) technical manager of the Materials Project is Joe Carpenter (615-574-4571; FTS 624-4571). The Tribology Project is managed by Argonne National Laboratory (ANL), technical manager is Fred Nichols (312-972-8292; 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.

1. Lubricant Qualities of the Constituents of Base Stock Oil

	FY 1986
$	490,000

DOE Contact - Terry Levinson, 202-586-1484
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 micro-oxidation test.

chemical species produced during both tests are identified. The mechanisms for additive effectiveness are also investigated. New analytical and mechanical tests are developed.

Keywords: Metals, Oils, Friction, Wear, Engines

2. Friction and Wear of Ceramics at Elevated Temperatures

FY 1986
$ 377,500

DOE Contact - Terry Levinson, 202-586-5377
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. 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^{o}, and 800^{o}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

3. Observations of "Hot Spots" on Ceramics and Development of Theory

FY 1986
$ 125,000

DOE Contact - Terry Levinson, 202-586-5377
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 on 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, ultimately leading to improvements in the wear resistances of ceramics.

Keywords: Ceramics, Erosion and Wear

4. <u>Assessment of X-ray Methods for Investigations of Ceramic Wear Surfaces</u> FY 1986
$ 37,500

DOE Contact - J. Eberhardt, 202-586-5377
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

5. <u>Solid Lubricants Deposited From the Gas Phase</u> FY 1986
$ 50,000

DOE Contact - Terry Levinson, 202-586-5377
The Pennsylvania State University (IAA No. DE-AI02-83OR21350) Contact - E. E. Klaus, 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^{o}F.

Keywords: Coatings and Films, Chemical Vapor Deposition

6. <u>Tribological Surface Modifications and Coatings</u> FY 1986
$ 847,000

DOE Contact - Terry Levinson, 202-586-5377
ANL (Contract No. W-31-109-ENG-38) Contact - Fred Nichols, 312-972-8292,
Borg-Warner (ANL Subcontract No. 432024C1) Contact - William Sproul, 312-827-3131

This program will provide quantitative experimental and theoretical information on improving tribological properties of solid materials for use under extreme conditions. Program emphasis will be on developing wear resistant surfaces for tribological systems operating under extreme conditions, such as high temperature (>600°C), high speed, high stress, and high chemical activity. This project will commence with two tasks: (1) the development of hard coatings for high speed steel cutting tools to improve tool life and performance; and (2) the development of novel coatings and surfaces for tribological systems operating under extreme environments. The initial process to be explored is ion implantation. This will also include a modeling effort.

Keywords: Surface Modification, Coatings, Tribology

7. Modeling of Hard Coatings for Tribological Systems Operating Under Extreme Conditions — FY 1986: $ 80,000

DOE Contact - Terry Levinson, 202-586-5377
George Washington University (Contract No. DE-AC02-84CE90225)
Contact - Bruce Kramer, 202-676-8237

A specific model of the wear behavior of hard wear coatings has been developed that includes the effects of chemical dissolution of mechanical abrasion on the wear rate. Inputs to the model include the free energy of formation on the potential coating material, the excess free energies of solution of the constituent elements of the coating in the workpiece, the hardness of the coating and the cutting temperature. An algorithm has been written to search the available literature database and estimate the wear performance of candidate materials. Preliminary results indicate that significant improvements in wear resistance relative to conventional TiN coatings may be possible by employing new coating compositions. Coatings are being prepared and tested to experimentally evaluate the predictions of the theory and calibrate the wear model.

Keywords: Coatings, Friction, Wear, Metals, Machining

8. Tribological Studies on Coated High Speed Steel Cutting Tools — FY 1986: $ 80,000

DOE Contact - Terry Levinson, 202-586-5377
LLNL (Contract No. W-7405-ENG-48) Contact - William Steele, 415-423-2949

This project is developing innovative wear resistant coatings constructed by anchoring a high density mat of very fine, hard filaments or "hairs" into the surface of a bulk matrix, which is to be protected from abrasion and wear. These filaments form an intertwined, compliant mat which effectively resists impacts. Tests have been conducted in a sandblaster with controlled air flow, and controlled sand size and flow. Initial tests were conducted on carbon fibers imbedded in an epoxy matrix. These tests have established that a dense mat of 2 to 5 micron carbon fibers can provide complete protection to the epoxy matrix. Unprotected epoxy specimens were completely destroyed. Future tests will focus on metal matrices, and on C, B, SiC, Al_2O_3, and ZrO fibers.

Keywords: Coatings, Wear, Friction, Fibers, Metals, Polymers

9. Mechanical Interactions of Rough Surfaces — FY 1986 $ 75,000

DOE Contact - Terry Levinson, 202-586-5377
SKF Industries, Inc. (Contract No. DE-AC02-84ER13163) Contact-John McCool, 215-265-1900, Ext. 267

This project is a joint effort with the Office of Basic Energy Sciences. The project is exploring the behavior of lubricated concentrated contacts involving microscopically rough surfaces under conditions of combined rolling, sliding and spinning, with and without the presence of contaminating particles. It also is developing processing principles and techniques for the analysis of digitized rough surface profiles to yield surface descriptors that are predictive of functional performance and which have acceptable systematic and random error. It consists of both experimental and analytical work.

Keywords: Friction, Wear, Surface Roughness

10. Energy Efficient Gears — FY 1986 $ 50,000

DOE Contact - Terry Levinson, 202-586-5377
Northwestern University (NBS Subcontract No. 60NANBD0547) Contact - Herbert Cheng, 312-491-7062

This project is developing a friction model in partial-elastohydrodynamic and boundary lubrication for prediction of power loss in spur gears due to rolling and sliding. A new two-disk friction testing machine has been designed and constructed and experiments will be conducted to validate the model.

Keywords: Gears, Oils, Frictions, Wear, Engines

11. <u>Ordered Metallic Alloys for High Temperature Applications</u>

FY 1986
$ 895,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract DE-AC05-84OR21400) Contact - Chain Liu, 615-574-4459,
NC State (ORNL Subcontract 19X-43368C) Contact - Carl Koch, 215-861-4235 Columbia (ORNL Subcontract 19X-58664C) Contact - John Tien, 212-280-5192
University of Tennessee (ORNL Subcontract S7685-S91) Contact - Ben Oliver, 615-974-5326

Ordered metallic alloys based mainly on nickel and titanium aluminides and nickel and titanium silicides are being developed and assessed for 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. ORNL is also assessing the weldability of the ductile aluminides, their potential for use in steam turbines, and leading efforts to transfer the technologies of the alloys to industry as rapidly as possible. At NC State, alloys based on mechanical alloying approaches are prepared and investigated. Directionally solidified alloys are prepared and evaluated at Columbia. Single crystals of TiAl are prepared at the University of Tennessee.

Keywords: Alloys, Ordered, Intermetallics

12. <u>Development of Tests for Ceramic-Ceramic and Ceramic-Metal Joints</u>

FY 1986
$ 150,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact - Artie Moorhead, 615-574-5153

Test specimens and procedures are being developed for measurement of the strength and fracture toughness of ceramic-ceramic and ceramic-metal joints. Specimens are tested to provide experimental data that can be compared with the theoretical predictions generated by the finite element models of joints being developed at the Norton Company.

Keywords: Ceramic, Joining, Tests

13. <u>Modeling of Solid Ceramic Joints</u>

FY 1986
$ 175,000

DOE Contact - James Eberhardt, 202-586-5377
The Norton Company (ORNL Subcontract 86X-00208C) Contact - Pierre Charreyron, 617-393-5962

Generalized finite element models are being developed by Norton to predict the stress states existing in and near solid ceramic-ceramic and ceramic-metal joints of simple geometries. Butt-on-butt joints of rectangular cross sections and cylindrical cross sections were modeled first and attempts are now being made to experimentally verify the models before proceeding to develop models for more complex geometries. The purpose of the effort is to provide guidance concerning compatible ceramic joints and applications.

Keywords: Ceramics, Metals, Joining, Models

14. <u>Electromagnetic Joining of Ceramics - Laboratory Proof of Concept</u>

FY 1986
$ 0
($350,000 in FY 85)

DOE Contact - James Eberhardt, 202-586-5377
DHR, Incorporated (ORNL Subcontract 86X-00217C) Contact - Richard Silberglitt, 703-883-0833
NRL (Interagency Agreement DE-AI05-86OR21655 through ORO) Contact - Dave Lewis, 202-767-2131

The objective of this effort is to develop methods for joining ceramic materials to one another by means of microwave-induced heating of the joint interface. A device has been made for heating the joint region while holding the sample pieces under compression and nondestructively determining by acoustic methods when the bonding is complete. All work to date has been on mullite, alumina, and silicon nitride joined to themselves.

Keywords: Ceramics, Joining

15. <u>Nondestructive Evaluation (NDE) of Ceramic Joints</u>

FY 1986
$ 100,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact - Bob McClung, 615-574-4466

This task is exploring the development of nondestructive evaluation (NDE) techniques for ceramic-ceramic and ceramic-metal joints. Various NDE techniques are being tried on joints with known defects in sample attachments and attempts were made to correlate the signals with performance of the attachments. Selected specimens are nondestructively evaluated using radiography and ultrasound prior to destructive testing in order to try to develop a correlation between "indications" found by NDE and the mechanical behavior of the brazements. A high-frequency ultrasound system has been assembled and used to demonstrate resolution commensurate with the thickness scale of the braze components in a typical ceramic joint and with the critical flaw size in the ceramic itself. Elastic moduli of the ceramic materials available have also been determined ultrasonically.

Keywords: Ceramics, Joining, Testing

16. <u>Mechanisms of Adherence at Ceramic Joints</u> <u>FY 1986</u>
$ 156,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact Mike Santella, 615-574-4805

This task investigates the fundamental physical and chemical parameters controlling the adhesion of ceramics to ceramics and metals in order to increase the understanding of the problems and limitations inherent in such attachments if they are to be used in future heat engines and high temperature industrial heat exchangers.

Keywords: Ceramics, Joining, Adherence

17. <u>Ion Implantation of Ceramics</u> <u>FY 1986</u>
$ 385,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact - Carl McHargue, 615-574-4344
Georgia Institute of Technology (ORNL Subcontract 19B-07802C) Contact - Joseph Cochran, Jr., 404-894-2851
Universal Energy Systems (ORNL Subcontract 86X-22015C) Contact - Peter Pronko, 513-426-6900, ext. 113

The objective of these efforts is to explore the effects of ion implantation on certain properties of ceramics. Properties measured include strength, strength reliability (Weibull modulus), hardness, fracture toughness, coefficient of friction, and wear rates. Work at ORNL is concentrated on implantation into TiB_2; at Georgia Tech, into Al_2O_3 and ZrO2; and at UES, on SiC and Si_3N_4.

Keywords: Ceramics, Ion Implantation

18. Laser Surface Modifications of Ceramics FY 1986
$ 100,000

DOE Contact - James Eberhardt, 202-586-5377
North Carolina State University (ORNL Subcontract 19X-43377C)
Contact - Jagdish Narayan, 919-248-1902 and 919-737-7874

The objective of this effort is to investigate the nature and implications of surface modifications induced by driving or diffusing 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 alpha- or beta-SiC, Si_3N_4, or Al_2O_3 and then irradiated by pulsed lasers. Fracture strength and toughness, friction and wear behavior, fatigue resistance, and microstructural and compositional variations are determined and related to the wavelength of the laser radiation, the pulse duration, and the energy density.

Keywords: Ceramics, Coatings and Films, Diffusion, Erosion and Wear, Surface Characterization and Treatment

19. Injection Molding of Electrosterically-Stabilized Oxide Suspensions in an Aqueous Medium FY 1986
$ 60,000

DOE Contact - James Eberhardt, 202-586-5377
University of Washington (ORNL Subcontract 19X-27458C) Contact - Ilhan Aksay, 206-543-2625

A method of preparing highly concentrated but fluid colloidal aqueous suspensions of ceramic particles is being studied. The objective is to produce an injection-moldable aqueous slurry with little or no organic binders by adsorbing organic polyelectrolytes onto the surfaces of the powder particles in order to minimize the particle agglomeration usually encountered in aqueous-based slurries. Model experiments with submicron size alumina have been designed to determine the guidelines for the selection of the proper molecular weight polyelectrolytes used to stabilize the suspensions.

Keywords: Ceramics, Injection Molding, Polymers

20. High Density Sol-Gel FY 1986
$ 150,000

DOE Contact - James Eberhardt, 202-586-5377
LBL (Contract DE-AC03-76SF00090) Contact - Arlon Hunt, 415-486-5370

A process is under development to produce controlled porosity materials with tailored thermal, optical, and physical characteristics. This effort is a combined program of analytical studies and experimental measurement of the particle creation and assembly process. In addition, the properties of the finished material will be determined and related to the preparation technique.

Keywords: Ceramics, Fabrication, Sol-Gel

21. Thin-Wall Hollow Ceramic Spheres from Slurries FY 1986
$ 150,000

DOE Contact - James Eberhardt, 202-586-5377
Georgia Institute of Technology (ORNL Subcontract 86X-22043C)
Contact - A. T. Chapman, 404-894-4815

This effort is investigating the development of processes for economically fabricating hollow thin wall spheres from conventional ceramic powders using dispersions. Currently, hollow thin wall spheres can only be made of ceramics that are easily melted or can be formed from solutions; the ability to produce them from conventional slurries would open the technique to ceramics such as SiC or Si_3N_4. Ceramic spheres of small (.1-5 mm) diameter might have numerous novel applications as high temperature insulations or even lightweight structural materials. A collection system will be developed to dry the spheres in free fall, the drying to be completed after the spheres have separated from the connecting fibers and surface tension has provided near perfect spheres. Approaches include the use of microwave heating in the free-fall stage to accelerate the removal of the slurry water or the substitution of a highly volatile liquid such as acetone as the slurry medium. Process variables using a standard Al_2O_3-based dispersion will then be characterized. Spheres of a variety of compositions will be formed and the properties of the spheres, individually and collectively, in the form of both loose fills and bonded monoliths will be measured. Prototype quantities of microspheres of several compositions will be available for testing by government agencies and commercial companies.

Keywords: Ceramics, Fabrication

22. Synthesis of SiC Whisker - $MoSi_2$ Matrix Composites for Elevated Temperature Applications FY 1986
$ 50,000

DOE Contact - James Eberhardt, 202-586-5377
LANL (Contract W-7405-Eng-36) Contact - John Petrovic, 505-667-5452

SiC whisker-$MoSi_2$ matrix composites are being examined for potential elevated temperature structural applications in oxidizing environments. A composite approach will be employed to improve the mechanical properties of $MoSi_2$. Initial room temperature mechanical property measurements indicate a composite strength nearly twice that of the pure $MoSi_2$, and a composite fracture toughness 30% higher than that of the pure $MOSi_2$.

Keywords: Physical Properties, Ceramics, Composites, Whiskers

23. <u>Assessment of the State of the Art in Machining and Surface Preparation of Ceramics</u> <u>FY 1986</u>
$ 0
($25,000 in FY 85)

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact - Dave Stinton, 615-574-4556 and Ted Besmann

This task is an assessment of current machining and surface preparation methods on the performance of ceramic materials developed for use in high-temperature engineering systems. These new materials, which include fiber-reinforced ceramics, high strength aluminas, and transformation toughened zirconia, exhibit high-temperature strengths comparable to conventional ceramics but also possess improved fracture toughness. The machining and surface preparation of these materials has a significant effect on the mechanical properties and cost of the materials, but has received little attention.

Keywords: Machining, Surface Preparation, Ceramics

24. <u>Chemical Vapor Deposition of Ceramic Composites</u> <u>FY 1986</u>
$ 145,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact - Dave Stinton, 615-574-4556

The objective of this effort is to produce toughened ceramic matrix composite coatings by simultaneous chemical vapor deposition (CVD) of a dispersoid phase and a matrix phase. The basic mechanisms which control the toughness, strength, thermal expansion, and thermal conductivity of the composite coatings are investigated by varying the quantity, composition, and morphologies of the two phases.

Keywords: Coatings, Ceramics, Chemical Vapor Deposition, Composites

25. <u>Plasma-Assisted Sintering of Ceramics</u> <u>FY 1986</u>
$ 145,000

DOE Contact - James Eberhardt, 202-586-5377
Northwestern (ORNL Subcontract 19X-55900C) Contact - D. Lynn Johnson, 312-492-3537

The objective of this effort is to investigate sintering of ceramic materials in furnaces filled with low pressure gas plasmas. Previous work (supported by DoD and NSF) has shown that some ceramics can be sintered to high densities quite rapidly by means of plasmas and microwaves by means of (1) simple heating and (2) activation of mass transport properties (e.g., grain boundary diffusion) important to sintering. In the present work, attempts are being made to decouple the two mechanisms, i.e., the specimen is heated by conventional means such as resistance heating while in a low-pressure, non-equilibrium plasma.

Keywords: Ceramics, Sintering, Plasma

26. <u>NMR of Green State Ceramics</u> <u>FY 1986</u>
$ 75,000

DOE Contact - James Eberhardt, 202-586-5377
ANL (Contract W-31-109-Eng-30) Contact - Bill Ellingson, 312-972-5068

This work explores the use of advanced nuclear magnetic resonance (NMR) imaging methods to characterize green-state ceramic materials, particularly the detection and mapping of binder/plasticizer distribution and porosity. An existing NMR imaging system has been highly modified and a set of well-defined ceramic test specimens will be used.

Keywords: Ceramics, Fabrication, NDE, Green State

27. <u>Compositionally Modified Ceramics</u> <u>FY 1986</u>
$ 150,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract DE-AC05-84OR21400) Contact - Rodney Mckee, 615-574-5144

This research task contains three elements: (1) materials synthesis and characterization, (2) mechanics and mechanical behavior studies, and (3) electrical and optical properties measurements. The ceramic system under investigation will be layered structures of aluminum oxide and titanium oxides. The mechanical property characterization techniques that will be used include (1) dynamic resonance for studying the elastic-inelastic behavior, (2) ultra-low load microindentation for quantitative measurements of plastic deformation, and (3) conventional materials testing for strength and ductility studies.

Keywords: Ceramics, Fabrication, Molecular Beam Epitaxy, Layers

28. Coordination of ECUT Plastics Recycling and Reuse Efforts

FY 1986
$ 57,000

DOE Contact - James Eberhardt, 202-586-5377
Plastics Institute of America (ORNL Subcontract 19X-09100C)
Contact - Mike Curry or Al Spaak, 201-420-5552

The PIA is coordinating efforts to assess the potential of recycling or reusing post-consumer plastic scrap via various approaches. Previous work concentrated on techniques involving bonding and/or separations of mixed plastic scrap. Currently, work is being planned 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 products such 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.

Keywords: Plastics, Recycle

29. Assessment of the Economic Potential of Plastics Reuse

FY 1986
$ 40,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact - Randall Curlee, 615-576-4864

The objective of this work is to assess the general economic potential of plastics reuse. The work focuses on projections of particular types of plastic waste in different waste streams and on the various economic and institutional incentives and barriers that impact the market acceptance of different recycle technologies.

Keywords: Plastics, Recycle, Economics

30. Reactive Polymer Processing Assessment

FY 1986
$ 65,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact - Joseph Carpenter, 615-574-4571 and Paul Phillips, 615-974-5304

In order for polymeric materials to be used cost effectively to a greater extent in structural components of ground transportation vehicles, it is necessary that the speed of processing be increased. The purpose of this assessment is to determine technology research and development needs that could eventually facilitate the greater use of lightweight polymer-based structural components in energy-conserving applications in ground transportation vehicles.

Keywords: Polymers, Curing, Lightweight Materials

31. <u>Biobased Polymers</u> <u>FY 1986</u>
$ 50,000

DOE Contact - James Eberhardt, 202-586-5377
SERI (Contract DE-AC02-83CH10093) Contact - Helena Chum 303-231-7249

The objective of this work is to explore the potential of innovative polymers from biomass, as well as biobased materials in general, for the production of inexpensive materials at a substantial overall energy savings. The initial focus has been on the formulation of a research program for the development of biobased materials. Three main components have been identified: (1) biomass-derived plastics, (2) innovative bioprocessing, and (3) biotechnology-produced lightweight materials.

Keywords: Polymers, Biomass

32. <u>Liquid Crystalline Polymers Assessment</u> <u>FY 1986</u>
$ 0
($25,000 in FY 85)

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact - Paul Phillips, 615-974-5304

This project assesses the potential of emerging liquid crystal technologies for producing polymeric materials for structural applications. Liquid crystal polymers are curious materials which retain a degree of molecular regularity and orientation even in the melt stage. A possibility exists that such materials may be capable of forming a self-reinforcing composite in which the solid part of the melt stage acts as a reinforcement for the remainder after solidification. A unique advantage of such material would be that it could be melted and shaped like any thermoplastic.

Keywords: Polymers, Liquid Crystals

33. <u>Inorganic Polymers Assessment</u> <u>FY 1986</u>
$ 15,000
($+45,000 from FY 85)

DOE Contact - James Eberhardt, 202-586-5377
Pennsylvania State University (ORNL Consultant) Contact - Harry Allcock, 814-865-3527

The objective of this effort is to determine if there is a potential role for ECUT in supporting long-term, high-risk, base technology research and development that could result in the greater use of inorganic polymers. These materials are attractive for energy conservation as they do not require a petroleum-based feedstock and they may have properties superior to the usual carbon-based polymers.

Keywords: Polymers, Inorganic, Lightweight Materials

34. <u>Thermosetting Resins with Reversible Crosslink</u> <u>FY 1986</u>
$ 100,000

DOE Contact - James Eberhardt, 202-586-5377
Polytechnic of New York (ORNL Subcontract 19X-55935C) Contact Guiliana Tesoro 718-643-5244

The objective of this effort is to determine if it is possible to develop thermosetting resins with "reversible crosslinks." If so, it may be possible to produce plastics with the strengths, toughnesses, temperature capabilities, and corrosion resistances typical of thermoset resins but which can be easily reprocessed like a thermoplastic. This process would allow easier recycling, thereby reducing the need for virgin plastics made from natural oil or gas as well as easing the repair of lightweight automotive structural parts.

Keywords: Polymers, Thermosets, Resins, Crosslinks

35. <u>Ordered Metallic Alloys for Lightweight Applications</u>
<u>FY 1986</u>
$ 160,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact - Wally Porter, 615-574-5143
Dartmouth (ORNL Subcontract 19X-55918C) 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. Alloys based on Mg-Si, Mg-Li, and Mg-Al were identified as candidates for initial development.

Keywords: Metals, Intermetallics, Magnesium

36. <u>Modeling of Boron-Effect in Ni_3Al</u> <u>FY 1986</u>
$
920,000

DOE Contact - James Eberhardt, 202-586-5377
LANL (Contract W-7405-Eng-36) Contact - Jeff Hay, 505-667-2097
Virginia Polytechnic Institute and State University (ORNL Contract 19x-58678V) Contact - Diana Farkas, 703-961-4742

The ECUT Materials by Design effort is currently developing models to predict the interfacial properties of Ni_3Al and the role of solute atoms such as B in preventing brittle fracture at grain boundaries. A hierarchy of models has been implemented which encompass electronic properties, interatomic potentials, atomistic simulation, and phenomenological models of crack propagation. In addition to the main efforts at Los Alamos, there are collaborations with investigators at Virginia Polytechnic Institute and State University and others (mostly funded by the DOE Office of Basic Energy Sciences) working on experimental investigations of the B-effect-in-Ni_3Al.

Keywords: Modeling, Grain Boundary, Structure, Polymers

37. <u>Predictions of Cubic Ordered Intermetallics</u> <u>FY 1986</u>
$ 85,000

DOE Contact - James Eberhardt, 202-586-5377
Imperial College of London (ORNL Subcontract 19X-55992V) Contact - David Pettifor, 1-589-5111, ext. 5756 (England)
ORNL (Contract DE-AC05-84OR21400) Contact - Don Nicholson, 615-575-5873

The objective of this task is to develop and experimentally verify models for predicting ordered intermetallic alloys with cubic ordered crystal structures which would be expected to be the most likely candidates for further development as useful structural materials. The expected results are a model, or models, which can predict the possible existence of such materials which could not otherwise be identified by more classical approaches.

Keywords: Modeling, Ordered, Intermetallics

38. <u>Predictions of Super-Strong Liquid Crystal Polymers</u>
<u>FY 1986</u>
$ 100,000

DOE Contact - James Eberhardt, 202-586-5377
LANL (Contract W-7405-Eng-36) Contact - Flonnie Dowell

Advanced, first-principles, microscopic, molecular statistical-physics theories will be originated and developed into mathematical models to predict (with the aid of computer-based modeling) new molecular structures most likely to form liquid crystal polymers. These candidate molecules will then be chemically synthesized and experimentally characterized.

Keywords: Modeling, Polymers, Liquid Crystals

39. <u>Predictions of Polymer Decompositions</u> <u>FY 1986</u> $ 75,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract DE-AC05-84OR21400) Contact - Bill Thiessen, 615-574-4973

The objective of this task is to develop computer models at the atomic/molecular level to guide the development and optimization of polymers. The initial thrust will be to learn how to tailor polymers to allow recovery of value from waste plastics by approaches based on molecular decomposition and/or rearrangements.

Keywords: Modeling, Polymers, Decomposition

40. <u>Influence of Electronic Structure on Ordered Intermetallics</u> <u>FY 1986</u> $ 50,000

DOE Contact - James Eberhardt, 202-586-5377
Carnegie-Mellon (ORNL Subcontract 19X-58672C) Contact T. B. Massalski, 412-578-2708

This work seeks to identify phenomenological correlations between the electronic structure and the ordering temperature and stacking arrangement in ordered intermetallics. Available data were analyzed and apparent correlations were identified among the electron-to-atom ratio, average electron energy for valence electrons and the atomic plane stacking characteristics for two ordered pseudo-binary alloys. Electronic-level calculations were initiated to explain the correlations in terms of valence electronic energies as functions of the atomic arrangements in various stacking sequences.

Keywords: Modeling, Electronic Structure, Intermetallics

41. <u>Assessment of DoD/NASA Thermal Insulation Technology</u> <u>FY 1986</u> $ 30,000

DOE Contact - James Eberhardt, 202-586-5377
University of Kentucky (ORNL Subcontract 19X-55951V) Contact Alan Fine, 606-257-3713

This task focuses on the possibilities of technology transfer of specialized concepts from aerospace and other government programs to energy conservation applications in the civilian sector.

Keywords: Thermal Insulations, Aerospace

42. Thin Film Thermocouples for Heat Engines — FY 1986 $ 100,000

DOE Contact - James Eberhardt, 202-586-5377
National Bureau of Standards - Gaithersburg (Interagency Agreement OR-21375) Contact - Ken Kreider, 301-921-3281

The goal of the project is to demonstrate the feasibility of a materials system and fabrication technique for measuring temperature inside the combustion chamber of ceramic insulated engines using thin film thermocouples. The ceramic insulating materials under investigation include partially stabilized zirconia (PSZ) in both monolithic and plasma sprayed forms and alumina. The thermocouple systems have included type E (chromel-constantan); type N (nisil-nicrosil); and platinum-platinum 6% rhodium. Scanning electron microscopy and electron microprobe analysis have indicated that the sputtered films were produced with the same composition as the target alloys and continuous, strong, pore-free deposits can be sputtered 1-4 mm thick.

Keywords: Engines, High Temperature Service, Ceramics, Thermocouples, Adhesion

43. Novel Technique for Particulate Removal from Molten Metals — FY 1986 $ 100,000

DOE Contact - James Eberhardt, 202-586-5377
ORNL (Contract No. DE-AC05-84OR21400) Contact - D. O. Hobson, 615-574-5109

This research is directed toward development of a device to remove particulates from a flowing molten metal stream just before it solidifies. Such removal is very important because of the recent trend toward near-net-shape castings. The device is electromagnetic and creates differential forces in the particles, causing them to migrate through the liquid stream.

Keywords: Removal, Particulates, Molten Metal

44. Abrasion and Impact Resistant Coatings — FY 1986 $ 150,000

DOE Contact - Terry Levinson, 202-252-5377
LLNL Contact - William Steele, 415-423-2949

This project is developing innovative wear resistant coatings constructed by anchoring a high density mat of very fine, hard filaments or "hairs" into the surface of a bulk matrix, which is to be protected from abrasion and wear. These filaments form an intertwined, compliant mat which effectively resists impacts. Tests have been conducted in a sandblaster with controlled air flow, and controlled sand size and flow. Initial tests were conducted on carbon fibers imbedded in an epoxy matrix. These texts have established that a dense mat of 2 to 5 micron carbon fibers can provide complete protection to the epoxy matrix. Unprotected epoxy specimens were completely destroyed. Future tests will focus on metal matrices, and on C, B, SiC, Al_2O_3, and ZrO fibers.

Keywords: Coatings, Wear, Friction, Fibers, Metals, Polymers

OFFICE OF BUILDINGS AND COMMUNITY SYSTEMS

The Office of Buildings and Community Systems 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, and residential conservation service, and Federal energy management program. Specific objectives include providing the technology to:

- o reduce energy consumption in existing buildings, and in new buildings;
- o increase the energy efficiency of oil and gas combustion heating systems and of oil- and gas-fired heat pump systems;
- o improve the energy efficiency of advanced electric heat pump and refrigeration systems, and of light systems; and
- o 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 accompolish 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 thermal energy performance effectiveness, durability, safety, and health impacts; to develop and verify analytical models that are useful to building designers and researchers for predicting the thermal performance characteristics of materials; to develop methods for measuring the thermal performance characteristics of materials; and to provide technical assistance, advice and data to organizations that develop consensus standards for the performance characteristics of materials. The DOE contact is Bill Gerken, 202-586-9193.

45. <u>Unguarded Flat Insulation Nichrome Wire Screen Tester</u>

FY 1986
$ 100,000

DOE Contact - Bill Gerken, 202-586-9193
ORNL Contact - David McElroy, 615-574-5976

Materials under investigation include mineral fiberboard, and powered 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

46. <u>Settled Density Studies of Loose-Fill Insulation</u> FY 1986
$ 70,000

DOE Contact - Bill Gerken, 202-586-9193
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

47. <u>Heat Flow Modeling</u>

FY 1986
$ 50,000

DOE Contact - Bill Gerken, 202-586-9193
ORNL Contact - David McElroy, 615-574-5976

There are two aspects in this effort. The first is the mathematical modeling of heat transfer along longitudinal and radial coordinates. One dimensional heat flow studies in various materials are being undertaken and calculation of errors associated with edge heat loss effects are also considered.

The second component involves the physical description of heat transfers in a material with respect to "apparent" thermal conductivity. The factors that contribute to heat transfer phenomena are being studied in detail.

Keywords: Building Insulation, Heat Transfer, Mathematical Modeling

48. Improved Standard Reference Materials FY 1986
$ 50,000

DOE Contact - Bill Gerken, 202-586-9193
National Bureau of Standards Contact - Hunter Fanney, 301-975-5864

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

49. Gas Diffusion and Effective Conductivity of Foam Insulation Versus Age FY 1986
$ 40,000

DOE Contact - Bill Gerken, 202-586-9193
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 theormal 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

50. <u>Corrosiveness of Thermal Insulating Materials</u> <u>FY 1986</u>
$ 8,000

DOE Contact - Bill Gerken, 202-586-9193
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 the effect 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

51. <u>High Temperature Insulation Standard Reference Materials</u>
<u>FY 1986</u>
$ 50,000

DOE Contact - Bill Gerken, 202-586-9193
National Bureau of Standards Contact - Jerome Hust, 303-497-3733

Ceraboard and a high temperature loose-fill insulation are candidates to be investigated for use as new Standard Reference Materials (SRM), using a new 800^{o}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 1987.

Keywords: Industrial Insulation, Heat Transfer, Nondestructive Evaluation

52. <u>Theory of Radiative Heat Transport in Low-Density Insulations</u> <u>FY 1986</u>
$ 0

DOE Contact - Bill Gerken, 202-586-9193
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 a radiation transmission properties study reported in 1985, and will result in technical reports and papers describing the work.

Keywords: Building Insulation, Radiative Heat Transfer, Mathematical Analysis

53. Dynamic Latent Heat Storage Effects of Building Construction Materials

FY 1986
$ 0

DOE Contact - Bill Gerken, 202-586-9193
Manville Corporation Contact - Jack Verschoor, 303-972-2262

Latent heat considerations are important in developing optimum energy conservation strategies in the operation of air conditioning systems for both commercial and residential buildings. Comprehensive data is needed, but is not now available, on the time rate of moisture adsorption and desorption in building construction materials and furnishings as temperature and humidity conditions changes. The data will be obtained by exposing various materials in a programmable climatic chamber using conditions simulating several air conditioning/ventilation strategies.

Keywords: Latent Heat Storage

54. Assessment of the Physical and Thermal Properties of Masonry Block Products

FY 1986
$ 0

DOE Contact - Bill Gerken, 202-586-9193
Steven Winter Associates Contact - Deane Evans, 212-564-5800

A data bank is needed on the thermal properties of concrete and masonry units covering the range of raw materials, densities and moisture contents typically encountered in building practice. Presently available handbook data on thermal properties used for concrete and clay masonry are not sufficiently comprehensive to cover all of the variables. This precursor activity is a survey and technical assessment of the present available physical and thermal property data for concrete and clay masonry block products commonly used in building wall construction. The assessment will also identify gaps in known information on these products and will recommend approaches for filling those gaps.

Keywords: Thermal Properties

55. Assessment of Spray-Applied Urethane Foam Materials

FY 1986
$ 15,183

DOE Contact - Bill Gerken, 202-586-9193
Dynatech Contact - Ronald Tye, 617-868-8050

A technical assessment is being conducted of spray-applied urethane foam materials used in buildings. The assessment will identify material types used, production and installation procedures, application areas in buildings, properties that influence performance, new developments, and technical information gaps.

Keywords: Building Insulation, Plastic Foam, Rapid Solidification, NDE

56. Assessment of Low Density Concretes and Cement Insulation

FY 1986
$ 50,000

DOE Contact - Bill Gerken, 202-586-9193
NBS Contact - Walter Rossiter, 301-975-6719

A study is being conducted to review existing information and building practices concerning the use of lightweight concrete in construction and foamed cement insulation in wall cavities. The review focuses on the properties and composition of the materials, test methods used for evaluating the materials, the effect of the materials on other building components, types of applications and constructions for which they are used, and installation techniques. Gaps in technical knowledge regarding the use and characterization of these materials will be identified and used to define subsequent research in this area.

Keywords: Building Insulation, Cements and Concrete, Foam Generation, Autoclaving, Conventional Solidification

57. Radiative Properties of Insulating Materials

FY 1986
$ 50,322

DOE Contact - Bill Gerken, 202-586-9193
University of Mississippi Contact - Jeffery Roux, 601-232-5375

Laboratory reflectance measurements are being conducted in the 3 to 50 micron wavelength range for several types of thermal insulation at different thicknesses to determine their spectral absorption and scattering coefficients. The resulting data will be analyzed to determine where in the total heat transfer the effects of scattering are important.

Keywords: Building Insulation, Radiative Heat Transfer, Mathematical Analysis, Fibers, NDE, Non-Metallic Glasses

58. Acoustic Measurement of Attic Insulation — FY 1986 $ 60,000

DOE Contact - Bill Gerken, 202-586-9193
NBS Contact - Daniel Flynn, 301-975-6634

A laboratory feasibility study is being conducted to determine the value of using acoustical techniques to evaluate the density, thickness and thermal resistance of installed loose fill thermal insulations. Sound transmission through insulation samples is being measured and related to the independently known density, thickness and thermal conductivity of the specimens. The results will indicate whether a follow-on effort should be mounted to expand the sound transmission data base for a wider range of materials, densities, temperatures and humidities, and to develop a proof-of-concept test apparatus.

Keywords: Building Insulation, Fibers, NDE, Non-Metallic Glasses

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 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.

59. Materials for Condensing Heat Exchangers — FY 1986 $ 120,000

DOE Contact - Danny C. Lim, 202-586-9130
Battelle Contact - George Stickford, 614-424-4810
BNL 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 techniques 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

60. <u>Non-Azeotropic Refrigerant Mixtures</u> FY 1986 $ 521,000

DOE Contact - Terry G. Statt, 202-586-9130
ORNL Contact - Phil Fairchild, 615-574-2020

The objective of this project is to improve system efficiency of refrigeration equipment and heat pumps through the application of non-azeotropic refrigerant mixtures. Basic research on properties is focused on conducting thermodynamic and transport properties measurements, developing an Equation-of-State, and conducting heat capacity measurements. Applied research in developing analytical tools and in laboratory testing of breadboard systems are made to investigate and evaluate novel refrigeration cycles which, conceptually, exploit the full potential of non-azeotropic refrigerant mixtures for saving energy.

Keywords: Refrigerants, Refrigeration Systems

61. <u>Mercury Isotope Enrichment</u> FY 1986 $ 175,000

DOE Contact - John Ryan, 202-586-9130
LBL 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 dischange 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

62. <u>Zeeman Effect on Lamp Gas Plasma</u> FY 1986 $ 175,000

DOE Contact - John Ryan, 202-586-9130
LBL 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

63. <u>Absorption Fluid Pairs Research</u> FY 1986 $ 100,000

DOE Contact - Ronald Fiskum, 202-586-9130
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 absorption heat pumps. A methodology for screening characterizing and selecting novel fluid pairs and ternary mixtures for advanced absorption cycles is being developed. Selected materials for corrosion effects and compatibility with existing and novel fluid pairs are under investigation.

Keywords: Absorption, Fluid Pairs, Corrosion, Heat Pump

64. <u>New Gases/Diagnostics for High and Low Pressure Discharge Lamps</u> FY 1986 $ 25,000

DOE Contact - John Ryan, 202-586-9130
GTE Products Corporation (Contract No. DE-AC03-84SF12235) Contact - Dr. Jakob Maya, 617-777-2309

The object of this project is to establish Laser Induced Fluorescence (LIF) as a novel nonintrusive diagnostic technique for light sources—and explore new gases that might hold potential for a high efficiency practical illumination source using the LIF technique. The project seeks to establish the viability of LIF technique for measuring radial excited state distributions in low pressure as well as high pressure discharges. Using the LIF technique, the excited state radial distributions in novel discharges such as isotopically enriched and magnetic field enhanced fluorescent lamps will then be studied. Promising new molecular field enhanced fluorescent lamps will then be studied. Promising new molecular radiators will be determined by calculations. Performance of the promising systems found in three in electroded discharges will be studied experimentally. The performance of promising systems that are incompatible with electrodes in electrodeless Radio Frequency (RF) excited discharged will also be studied. Reports on the utility of the LIF method for characterizing the radial Hg excited and ground state distributions in the low pressure Hg-rare gas plasma will be issued. The impact of such measurements will be analyzed and future research directions that may yield greater understanding toward more efficient fluorescent lamps will be pointed out.

Keywords: New Gases Diagnostics, Discharge Lamps

65. <u>Explore Performance of New Ingredients in High Intensity Discharge Lamps</u> <u>FY 1986</u>
$ 25,000

DOE (San Francisco Operations Office) Contact - Michael Lopez, 415-273-4264
GE Contact - Dr. V. D. Roberts, 518-385-8983

The objective is to examine the performance (efficacy, electrical properties) of new ingredients in high intensity discharge lamps. The approach is to provide excitation of HID lamps through electrodeless discharges operating at 13.56 MHz. This permits use of ingredients which might otherwise attack conventional electrodes. Power input is in the range of 100-1000 watts. The expected results are higher efficacy than conventional electroded lamps, along with good color.

Keywords: Discharge Lamps

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. It also encourages the private sector to implement and deploy such technologies as they are developed. Materials research is done in support of the technologies under development, to develop materials with lower embodied energy and to provide materials for use in equipment/ systems which can improve energy efficiency.

Improved Energy Productivity Division

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

66. Corrosion Resistant Amorphous Metallic Films FY 1986
$ 200,000

DOE Contact - Robert Massey, 202-586-8668
JPL Contact - Edward Cuddihy, 818-354-3188

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 MoCrB and TiCrPC. The objective is to provide a construction material that will reduce the impact of corrosion on heat transfer, equipment maintenance and capital cost.

Keywords: Coatings and Films, Sputtering, Corrosion, Metallic Glasses

67. Investigation of Material for Inert Electrodes in Aluminum Electrodeposition Cells FY 1986
$ 200,000

DOE Contact - M. J. McMonigle, 202-586-2087
MIT Contact - J. S. Haggarty, 617-253-3300

Materials being tested are ceramics ($NiO-NiFe_2O_4$). 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

68. Diagnostic Sources of Current Inefficiency in Industrial Molten Salt Electrolytic Cells by Raman Spectroscopy

FY 1986
$ 180,000

DOE Contact - M. J. McMonigle, 202-586-2087
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

69. Expand and Control Inert Electrode Cell Operating Conditions

FY 1986
$ 1,105,000

DOE Contact - M. J. McMonigle, 202-586-2087
PNL Contact - Pat Hart, 509-375-2906

Cermets of Ni-Fe spinels with copper additions are to be tested. Raman spectroscopy techniques will be used to identify surface reactions. Experimental design tests of bath and material composition and fabrication techniques will be run. Cathode materials and attachment have been investigated. MIT initiated a program to identify more stable ceramics for inert electrodes.

Cathode work will center on TiB_2 failure mechanisms and attachment techniques.

Keywords: Ceramics, Cryolite, Material Science, Aluminum

70. Rapid In-Situ Analysis of Molten Metal

FY 1986
$ 265,000

DOE Contact - W. E. Eckhart, 202-586-9549
LANL Contact - L. Blair, 505-667-6250

A laser-based system for spectrographic analysis of liquid steel in the refining vessel was developed for possible use in steel refining. The research and development were brought to a successful conclusion and the report will be distributed on an unrestricted basis to those interested in the technology. Development of a commercial unit will be left to industry.

Keywords: Chemical Analysis, Liquid Steel, Laser, Spectrographic Analysis

71. <u>Direct Measurement of Thermal State of Solids</u> <u>FY 1986</u>
$ 175,300

DOE Contact - W. E. Eckhart, 202-586-9549
PNL Contact - Douglas Lemon, 509-375-2306

Materials tested are steels. A non-contact ultrasonic 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 ultrasonic signal. Development of a second-generation sensor has been achieved. Total system integration is being pursued.

Keywords: Temperature Distribution, Ultrasonics, Physics, Heat Transfer, Metallurgy, Steel, EMAT, Electromagnetic Acoustic Transducers

<u>Waste Energy Reduction Division</u>

Waste Energy Reduction is concerned with the efficient conversion of fuel to a more useful energy form and with the utilization of energy embodied in waste products--solids, liquids, and gases. This division conducts research to develop advanced waste energy recovery technologies for the industrial sector.

72. <u>Advanced Heat Exchanger Material Technology Development</u>
<u>FY 1986</u>
$ 600,000

DOE Contact - S. Richlen, 202-586-2078
ORNL Contact - E. Long, 615-574,5172

This project conducts research to develop improved materials and fabrication processes and to expand the materials data base for advanced ceramic heat exchangers. Currently the project is studying the effects of corrosive waste stream constituents on candidate ceramic materials through coupon tests and exposure to synthetic exhaust streams, assessing commercially available surface coatings for ability to protect ceramic surfaces from corrosive elements, and developing techniques for extrusion of toughened oxide ceramic heat exchanger components.

Keywords: Structural Ceramics, Corrosion-Gaseous, Extrusion, Industrial Waste Heat Recovery

73. Assessment of Strength Limiting Flaws in Ceramic Heat Exchanger Components — FY 1986: $ 395,000

DOE Contact - S. Richlen, 202-586-2078
Babcock & Wilcox Contact - T. Powers, 804-522-5038

This project studies the flaw populations and the effect of operating environments on flaw populations of ceramic heat exhcnager components. Currently the project is studying flaw populations and population changes under exposure to thermal environments by using various advanced non-destructive evaluation techniques. The goal of the project is to develop lifetime prediction correlations for ceramic components. Research is conducted cooperatively with the Idaho National Engineering Laboratory.

Keywords: Structural Ceramics, Structure, NDE, Industrial Waste Heat Recovery

74. R&D of a CVD Composite Heat Exchanger — FY 1986: $ 500,000

DOE Contact - S. Richlen, 202-586-2078
Thermo-Electron Co. Contact - W. Cole, 617-890-8700

This project is studying critical problem areas of materials and fabrication techniques for chemical vapor deposition (CVD) of ceramic materials on ceramic fibers, forming a composite assembly.

Keywords: Composites (Structural), Structure, Chemical Vapor Deposition, Industrial Waste Heat Recovery

75. R&D of a Ceramic Tubular Distributor Plate for Advanced Fluidized Bed Heat Recovery — FY 1986: $ 180,000

DOE Contact - S. Richlen, 202-586-2078
Aerojet Energy Conversion Co. Contact - M. Rudnicki, 916-355-2493

This project studies the fabrication and material problems of forming a ceramic tubular distributor plate. As-formed tolerances and loss of tolerance under service conditions are prime areas of study.

Keywords: Structural Ceramics, Creep, Extrusion, Industrial Waste Heat Recovery

76. <u>R&D of a Ceramic Fiber Composite Heat Exchanger</u> <u>FY 1986</u>
$ 500,000

DOE Contact - S. Richlen, 202-586-2078
Babcock & Wilcox Contact - W. Parks, 804-5258660

This project conducts research to study critical problems of fabricating a ceramic fiber reinforced ceramic matrix. Various potential ceramic fibers and chemical systems for matrix formation will be characterized. Various matrix fabrication techniques will be studied and various analytical and exposure tests will be conducted on the formed matrices.

Keywords: Composites (Structural), Structure, Industrial Waste Heat Recovery

77. <u>National Laboratory Support to Assessment of Strength Limiting Flaws in Ceramic Heat Exchanger Components</u>
<u>FY 1986</u>
$ 66,000

DOE Contact - S. Richlen, 202-586-2078
Idaho National Engineering Laboratory Contact - D. Kunerth, 208-526-0103

This project supports the B&W study on strength limiting flaws by the development of advanced NDE, test methods, and other key technologies.

Keywords: Structural Ceramics, NDE, Structure

OFFICE OF TRANSPORTATION SYSTEMS

The Office of Transportation Systems has established a number of programs to conserve energy used for transportation and to shift transportation energy demand to nonpetroleum fuels.

The Heat Engine Propulsion 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's objective 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) 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 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 under construction at ORNL.

Key elements of each program are organized and described briefly in the following. Robert B. Schulz is the DOE contact, (202)-586-8032, for overall coordination of the following Office of Transportation Systems material projects.

78. <u>Silicon Carbide Powder Synthesis</u> <u>FY 1986</u> $ 266,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832

The objective of this task is to develop a volume scaleable process to produce high purity, high surface area sinterable silicon carbide powder. Phase I, which is now complete, included the following elements:

- o Verify the technical feasibility of the gas phase synthesis route.
- o Identify the best silicon feedstock on the basis of performance and cost.
- o Optimize the production process at the bench scale.
- o Fully characterize the powders produced and compare the commercially available alternatives.
- o Develop a theoretical model to assist in understanding the synthesis process, optimization of operating conditions and scale-up.

Phase II will scale the process to 5-10 times the bench scale quantities in order to perform confirmatory experiments, produce flowsheets and to perform economic analysis.

Keywords: Silicon Carbide, Powder Synthesis, Sintering

79. <u>Sintered Silicon Nitride</u> <u>FY 1986</u> $ 86,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
AMTL Contact - G. E. Gazza, 617-923-5408

The program is concentrating on sintering compositions in the Si_3N_4-Y2O3-SiO2 system using a two-step sintering method where the N2 gas pressure is raised from 1-2 MPa during the densification process. During the sintering under high pressure nitrogen, the environment is extremely reducing and the oxygen content of the starting materials is significantly reduced by the formation of SiO. The use of cover powder over the samples reduces the oxygen loss. Milling time also influences "green" density and resultant sintered density by changing the particle size distribution of starting powders, reducing agglomeration and producing a more equiaxed particle morphology. Milling studies are being conducted with three different sources of starting Si_3N_4 powder.

Keywords: Sintering, Silicon Nitride

80. High Pressure Sintering Furnace FY 1986 $ 91,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
AMTL/GEO Contact - G. E. Gazza, 617-923-5408

This task provides technical support for sintering of silicon nitride (AMTL) via on-site personnel assignment to conduct high nitrogen pressure sintering experiments.

Keywords: High Pressure, Sintering, Silicon Nitride

81. Si_3N_4 Powder Synthesis FY 1986 $ 144,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson 615-576-6832
Ford Contact - G. M. Crosbie, 313-574-1208

The goal is to achieve major improvements in the quantitative understanding of how to produce sinterable Si_3N_4 powders having highly controlled particle size, shape, surface area, impurity content and phase content. Of interest to the present powder needs is a silicon nitride powder of high cation and anion purity without carbon residue. The process study is directed towards a modification of the low temperature reaction of $SiCl_4$ with liquid NH_3 which is characterized by: 1) by absence of organics (a source of carbon contamination), 2) by pressurization (for improved by-product extraction efficiency), and 3) by use of a non-reactive gas diluent for $SiCl_4$ (for reaction exotherm control).

Keywords: Silicon Nitride, Powder Synthesis

82. Processing Of Monolithics FY 1986 $ 1,365,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832

The purpose of this task is advanced, cost-effective, near-net-shape processing methods that result in dense, high performance ceramics with fewer and smaller flaws than state-of-the-art. The resulting materials should have high Weibull modulus and good high-temperature strength. This is a new procurement in 1987.

Keywords: Monolithics, Processing, Ceramics, Weibull

83. <u>Whisker Toughened Si_3N_4</u>

<u>FY 1986</u>
$ 349,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
Airesearch Casting Contact - H. C. Yeh, 213-618-7449

The objective of this effort is to develop the technology base for fabricating a ceramic composite consisting of silicon carbide whiskers dispersed in a dense silicon nitride matrix. This is to be accomplished by slip casting as the green shape forming method, and sintering or sinter/HIP as the densification method. A goal of the program is a 2-fold increase in fracture toughness over the unreinforced silicon nitride matrix without a degradation of other properties.

Keywords: Silicon Carbide, Composites, Silicon Nitride, Whiskers

84. <u>Transformation Toughened Si_3N_4</u>

<u>FY 1986</u>
$ 373,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
Rockwell Contact - H. W. Carpenter, 818-700-3411

This work seeks to develop high toughness, high strength refractory ceramic matrix composites that can be made at low cost and to near net shape for heat engine applica-tions. The composite system selected for development is based on a silicon nitride matrix toughened by dispersions of ZrO2, HfO2, or (Hf,Zr)O2 modified with suitable additions of other refractory ceramics to control the physical behavior. The desired microstructure and optimum mechanical properties will be developed by expeditious laboratory process methods including colloidal suspension, press forming, sintering and hot pressing. Once the best composition and microstructure has been demonstrated, parameters will be optimized for producing samples by the injection molding process.

Keywords: Silicon Nitride, Composites, Transformation-Toughened

85. <u>Dispersion Toughened Si_3N_4</u>

<u>FY 1986</u>
$ 347,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
GTE Contact - S. T. Buljan, 617-890-8460

This task has three primary objectives: (1) to develop whisker-and particulate-reinforced silicon nitride matrix composite based on a commercial GTE material utilizing SiC and TiC particles or whiskers dispersed in the matrix; (2) to characterize the material; and (3) to develop a low-cost, near-net-shape process (injection molding) for fabricating CATE turbine blades.

Keywords: Dispersion Toughened, Silicon Nitride, Ceramics

86. Composite Development FY 1986
$ 202,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
Norton Contact - C. A. Ebel, 617-393-5950

The development of toughened silicon nitride composites by glass encapsulated hot isostatic pressure is under investigation.

Keywords: Composites, Glass Encapsulated, Hot Isostatic

87. Advanced Composites FY 1986
$ 10,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
University Of Michigan Contact - T. Y. Tien, 313-764-9449

The objective is to study the feasibility of fabricating Si_3N_4 composites containing SiC whiskers by transient liquid phase sintering.

Keywords: Composites, Silicon Nitride, Whiskers, Silicon Carbide

88. Oxide Matrix Composites FY 1986
$ 355,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832 and T. N. Tiegs, 615-574-5173

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. SiC whisker-reinforced ceramic components show substantial improvements in fracture toughness and strength for whisker reinforced alumina and mullite. The envelope of mechanical properties for each oxide matrix system is being measured.

Keywords: Composites, Alumina, Mullite, Whiskers, Silicon Carbide

89. <u>Transformation Toughened Ceramics Processing</u> FY 1986

$ 0

(FY 85 Carryover)

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
Norton Co. Contact - Giulio A. Rossi, 617-393-6600

The objective of this work is the production of improved zirconia toughened ceramics (ZTC) for advanced engine applications. The scope includes the powder synthesis and characterization of the sintered ceramics, and reporting of results. Materials made from three powder sources are evaluated: a rapid solidification from-the-melt powder, and two chemically derived powders.

Keywords: Composites, Transformation Toughened, Zirconia, Alumina, Powder

90. <u>Layered Ceramic Composites</u> FY 1986

$ 0

(FY 85 Carryover)

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
Ceramatic Contact - R. A. Cutler, 801-486-5071

This project is working on the development of layered ceramic composites which incorporate zirconia as a second phase to achieve improved strength and toughness at temperatures of up to 1000°C. The work also addresses processing methods for fabricating these layered composites via sintering.

Initial studies have shown that it is possible to increase the strength of Al_2O_3-ZrO_2 ceramics by incorporating transformation-induced residual stresses in sintered specimens consisting of three layers. The demonstrating of the retention of residual stresses with temperature is a primary purpose of this project.

Keywords: Composites, Alumina, Zirconia, Transformation Toughened

91. <u>Sol Gel Oxide Powder</u> FY 1986

$ 100,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832 and W. D. Bond, 615-574-7071

Processing requirements to provide homogeneous submicron dispersion of zirconia (yttria) and zirconia (hafnia-yttria) in alumina powders are being investigated, as well as coatings for silicon carbide whiskers.

Keywords: Sol Gel, Oxide Powder, Alumina, Zirconia, Yttria, Hafnia, Silicon Carbide, Whiskers

92. <u>Advanced Transformation Toughened Oxides</u> <u>FY 1986</u>
$ 112,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
AMTL/University Of Michigan Contact - T. Y. Tien, 313-764-9449

The objective is to develop a thermal insulating material which has sufficient strength and toughness for heat engine applications. The approach is to explore the composite materials in the system Al_2O_3: Cr_2O_3/ZrO_2:HfO_2.

Keywords: Composites, Transformation Toughened, Alumina, Mullite, Chromia

93. <u>Injection Molded Composites</u> <u>FY 1986</u>
$ 220,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832 and M. A. Janney, 615-574-4281

The development of advanced methods for forming ceramic matrix composites, such as injection molding with short binder burnout time is under study. The injection molding variables and their relation to sintering and final properties of advanced ceramic composites are being examined. Develop alternate processes for complex shape formation which will reduce binder removal time and increase yield of high reliability fired parts are being tested.

94. <u>Fiber Reinforced Silicates</u> <u>FY 1986</u>
$ 93,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
GE-Valley Forge Contact - S. Musikant, 215-354-3020

The objective is the development of toughened mullite ceramic matrix composites which are amenable to low cost near-net-shape forming for adiabatic diesel application. Liquid phase sintering methods were evaluated to produce a low cost, near-net-shape process.

Keywords: Whiskers, Mullite, Silicon Carbide, Composites

95. Low Expansion Ceramics

FY 1986
$ 155,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
Virginia Polytechnic and State University Contact - J. J. Brown, 703-961-6640

Research is being conducted to develop an isotropic, ultra-low expansion ceramic which can be used above 1200°C and which is relatively inexpensive and determine conditions necessary for synthesis, densification, and characterization of these systems.

Keywords: Aluminum Phosphate, Silica, Mullite, Zirconia, Ultra-low Expansion

96. Active Metal Brazing PSZ Iron

FY 1986
$ 280,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
ORNL Contact - M. L. Santella, 615-574-4805

Brazing processes for joining ceramic components to nodular cast iron for adiabatic diesel application are being developed.

Keywords: Joining, Brazing, Cast Iron, Zirconia, Alumina

97. Intermetallic Materials Development

FY 1986
$ 30,000

DOE Contact - Patrick L. Sutton, 202-586-8012
NASA LeRC Contact - Joseph R. Stephens, 216-433-3195

The advantage of intermetallic compounds is their lightweight, good oxidation resistance and resistance to hydrogen permeation, and potential strength at required temperature. Research is being performed on developing processing 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 low temperature deformation mechanisms of FeAl and NiAl.

Keywords: Intermetallics, Iron Alumide, Nickel Aluminide, Material Properties

98. <u>Cast Iron Alloy Nonstrategic Elements</u> FY 1986
$ 105,000

DOE Contact - Patrick L. Sutton, 202-586-8012
NASA LeRC Contact - C. M. Schevermann, 216-433-3205
United Technologies Research Center Contact - F. D. Lemkey, 203-727-7318

The objective is to identify alloys based on Fe-Cr-Mn (Mo)-Al-C(N) system containing asymmetric iron solid solution matrices reinforced by finely dispersed carbide phases and subsequent use of alloys in Stirling engine cylinder and regenerator housings.

Keywords: Cast Iron, Strategic Materials

99. <u>Adherence Coatings Deposited On Substrates</u> FY 1986
$ 18,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
University Tennessee Contact - J. E. Stoneking, 615-974-2171

Financial support is provided for a graduate research assistantship in Department to conduct studies on adherence of coatings deposited on substrates subjected to ion beam mixing.

Keywords: Adherence, Coatings, Ion Beam

100. <u>Dynamic Interfaces</u> FY 1986
$ 196,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-5768-6832
Battelle Columbus Labs Contact - K. F. Dufrane, 614-424-4618

This task's purpose is to develop mathematical models of the friction and wear processes of ceramic interfaces based on experimental data. The supporting experiments are to be conducted at temperatures to 1200°F under reciprocating sliding conditions reproducing the loads, speeds, and environment of the ring/cylinder interface of advanced internal combustion engines. The test specimens are to be carefully characterized before and after testing.

Keywords: Dynamic Interfaces, Wear Behavior, Monolithics, Ceramic Coatings, Adiabatic Diesels

101. <u>Solid Lubrication Design Methodology</u> FY 1986

$ 0

(FY 1985 Carryover)

DOE Contact - John Fairbanks, 202-586-8055
NASA LeRC Contact - James C. Wood, 216-433-3419
SKF Industries Contact - R. A. Pallini

The aim was to develop quantitative and qualitative guidelines for use in the design of solid lubricated bearings, gears, and other load carrying components. In Phase I, the candidate lubricant and material combinations were evaluated at room temperature to select the most promising combinations for high temperature testing. Analytical models and design guidelines were developed based on these room temperature test results. Phase II was conducted with the selected combinations at high temperatures (up to 540^{o}C) using a specially designed high temperature rolling contact test rig. The Phase II test data was used to refine the analytical models and guidelines to include the effects of high temperature. Project completed in 1986.

Keywords: Solid Lubrication, Traction, Ball Bearings, Diesel Engine

102. <u>Advanced Statistical Calculations</u> FY 1986

$ 62,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832 and W. P. Eatherly, 615-574-5220

Advanced statistical tools for characterizing the strength of structural ceramics in a meaningful and realistic way for use in design codes are to be designed.

Keywords: Statistics, Weibull, Design Codes, Brittle Materials

103. <u>Advanced Statistics Calculations</u> FY 1986

$ 120,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
GE Research Lab Contact - C. A. Johnson, 518-387-6421

The design and application of reliable load-bearing structural components from ceramic materials requires a detailed understanding of the statistical nature of fracture in brittle materials. The overall objective is to advance the current understanding of fracture statistics, especially in the following areas:

- o Optimum testing plans and data analysis techniques

- o Confidence and tolerance bounds on predictions that use the Weibull distribution function
- o Consequences of time dependent crack growth on the evolution of initial flaw distributions.

The studies are being carried out largely by analytical and computer simulation techniques. Actual fracture data are then used as appropriate to confirm and demonstrate the resulting data analysis techniques.

Keywords: Life Prediction, Design Codes, Statistics, Weibull

104. Physical Properties Of Structural Ceramics — FY 1986 $ 120,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
ORNL Contact - D. L. McElroy, 615-574-5976

The objective is an improved understanding of the factors which determine the thermal conductiveness of toughened structural ceramics at high temperatures. The role of photon transport at high temperatures and the influence of second phase additions is under investigation. A study of the effects of Cr_2O_3 and Fe_2O_3 additions on the thermal conductivity of Al_2O_3 has been completed.

Keywords: Thermal Conductivity, Ceramics

105. Translucence Engineering Ceramics — FY 1986 $ 66,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
Integral Technologies Inc. (ITI) Contact - Thomas Morel, 312-789-0003

Ceramic materials are being used as thermal barrier materials, separating the engine metal substructure from the convective and radiative heat fluxes originating in the combustion gases. The heat transfer through the ceramic layer to the substructure will be increased by any translucence, which would allow a part of the radiation heat flux to pass through the barrier material. Analytical studies using detailed computer codes which describe a realistic engine thermal environment including gas-to-wall heat fluxes, as well as the combined radiation/conduction heat transfer through a thermal barrier layer, are used to quantify this effect. A detailed parametric study will be carried out in which the following parameters will be varied, and their effect on heat barrier effectiveness will be studied: (1) material absorption coefficient, (2) material conductivity, (3) material thickness and (4) engine operating conditions (speed, fuel/air ratio, boost).

Keywords: Thermal Conductivity, Ceramics, Diesel Engines

106. <u>Reliability Of Structural Ceramics Literature Search</u>

FY 1986
$ 26,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
University Of Tennessee Contact - J. A. M. Boulet, 615-974-8376

Literature survey of ceramic life prediction models is underway.

Keywords: Life Prediction, Ceramics

107. <u>Mechanical Testing of Structural Ceramics</u>

FY 1986
$ 35,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832 and M. K. Booker, 615-574-5113

A computer data base of mechanical property data generated in the program will be developed.

Keywords: Mechanical Properties, Ceramics, Database

108. <u>Characterization of Transformation Toughened Ceramics</u>

FY 1986
$ 102,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
Army Materials Technology Lab. (AMTL) Contact - Jeffrey J. Swab, 617-923-5410

This study will determine the effect of time-at-temperature on toughened oxide ceramics especially zirconia and alumina zirconia materials and screen advanced and experimental toughened oxide ceramics.

Keywords: Transformation Toughened, Zirconia, Alumina

109. <u>Fracture Behavior of Toughened Ceramics</u>

FY 1986
$ 166,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832 and P. F. Becher, 615-574-5157

Toughening and fatigue properties of transformation toughened and whisker reinforced materials is under examination. Emphasis is on understanding the effect of microstructure upon processes responsible for time-dependent variations in toughness and high-temperature strength. In addition, fundamental insight into the slow crack growth behavior associated with these materials is being obtained. Experimental results were obtained on the high temperature fracture strength behavior in air of the alumina-20 vol % SiC whisker reinforced composites.

Keywords: Fracture Behavior, Toughened Ceramics, Flexure Test, Matrix, Zirconia, Alumina.

110. <u>Cyclic Fatigue of Toughened Ceramics</u> <u>FY 1986</u>
$ 280,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832 and K. C. Liu, 615-574-5116

The objective of this task is to develop and demonstrate the capability of performing uniaxial tension- tension dynamic fatigue testing of structural ceramics at elevated temperature. A new, self-aligning grip system for tensile testing of ceramics was developed and patented. The system has been licensed to Instron Co.

Keywords: Cyclic Fatigue, Toughened Ceramics, Tensile Testing

111. <u>Static Behavior of Toughened Ceramics</u> <u>FY 1986</u>
$ 102,000

DOE Contact - Robert B. Schulz
ORNL Contact - Victor J. Tennery, 615-576-6832
University Of Illinois Contact - M. K. Ferber, 217-333-7579

The interrupted static fatigue (ISF) method is used for determining retained fracture strength of ceramic specimens as a function of stress, time and temperature. The results of these tests are analyzed to calculate fatigue life. The fracture strength of toughened ceramics are determined over time and temperature as a function of applied static stress.

Keywords: Fatigue, Fracture Strength, Toughened Ceramics, Static Behavior

112. <u>Ceramic Corrosion Evaluation</u> <u>FY 1986</u>
$ 120,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
NASA LeRC Contact - Carl A. Stearns, 216-433-5500

Silicon carbide and silicon nitride specimens will be tested in a combustion rig simulating engine conditions. The combustion flow will be seeded with various impurities.

Keywords: Ceramics, Silicon Nitride, Silicon Carbide

113. Corrosion/Erosion Effects FY 1986
$ 51,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson - 615-576-6832
National Bureau of Standards (NBS) Contact - S. M. Wiederhorn, 301-975-2000

The behavior of AGT materials subjected to corrosion by salts in combustion air and/or alternate fuels combined with erosion by combustion will be characterized.

Keywords: Corrosion, Erosion, AGT, Combustion

114. Ceramic Durability Evaluation AGT FY 1986
$ 100,000

DOE Contact - Saunders B. Kramer, 202-586-8012
NASA LeRC Contact - Sunil Dutta, 216-433-3282
Garret Turbine Engine Co. Contact - K. W. Benn, 602-231-4373

Commercially available silicon carbides and silicon nitrides will be evaluated under extended thermal exposures of up to 2500 degrees F for 3500 hours in a gas turbine combustion environment.

Keywords: Silicon Carbide, Silicon Nitride, Gas Turbine Engines

115. Environmental Effects In Toughened Ceramics FY 1986
$ 168,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - Victor J. Tennery, 615-576-6832
University of Dayton Contact - N. L. Hecht, 513-229-4341

This task investigates the effects of water vapor (in combustion gas from adiabatic diesel) on time-dependent strength of transformation- toughened ceramics.

Keywords: Environmental Effects, Alumina, Zirconia, Diesel Combustion, Time Dependent, Transformation-Toughened

116. High Temperature Fracture Toughness Measurement FY 1986
$ 119,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - Victor J. Tennery, 615-576-6832
University of Washington Contact - R. C. Bradt, 206-543-2600

Improved fracture toughness test(s) are being developed and will be demonstrated for both monolithic and composite structural ceramics over the broad temperature range from 25°C to 1400°C. The objective is to develop simple and inexpensive methods to be considered as standard for measuring fracture resistance.

Mathematical modeling of the straight and chevron notched three point bend specimens will continue.

Keywords: High Temperature, Fracture Toughness

117. High Temperature Tensile Testing

FY 1986
$ 0
(FY 85 Carryover)

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
North Carolina A&T State University Contact - V. Sarma Avva, 919-334-7620

The objective of this task is to test and evaluate advanced ceramic materials at temperatures up to 1500C in uniaxial tension. GTE SNW 1000 Si_3N_4 tensile samples will be tested using the new ONRN self-aligning grip system.

Keywords: Tensile Testing, Silicon Nitride

118. Standard Tensile Test Development

FY 1986
$ 122,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
National Bureau of Standards (NBS) Contact - S. M. Wiederhorn, 301-975-2000

Tensile test standards for characterizing strength and creep behavior of ceramic specimens at elevated temperature will be developed.

Keywords: Tensile Testing, Creep, Ceramics

119. Non-Destructive Characterization

FY 1986
$ 195,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832 and R. W. McClung, 615-574-4466

Non-destructive characterization tools for structural ceramics are under development.

Keywords: NDE, Ceramics, Ultrasonics

120. Ceramic Component NDE Technology

FY 1986
$ 90,000

DOE Contact - Saunders B. Kramer, 202-586-8012
NASA LeRC Contact - Alex Vary, 216-433-6019

The objective is to identify and develop NDE techniques for ceramic heat engine compounds. The NDE methods under study are x-ray, radiography, ultrasonics, scanning laser acoustic microscopy, thermo-acoustic microscopy.

Keywords: Ceramics, NDE, X-ray, Ultrasonics

121. <u>Materials Characterization</u> <u>FY 1986</u>
$ 132,000

DOE Contact - Robert B. Schulz, 202-586-8055
ORNL Contact - D. Ray Johnson, 615-576-6832
AMTL Contact - J. W. McCauley, 617-923-5238

A quantifiable powder characterization database and methodology for intelligent processing of reliable engineering ceramics is being developed.

Keywords: Materials, Characterization, Powder Characterization, Reliability, Ceramics

122. <u>Computer-Tomography</u> <u>FY 1986</u>
$ 52,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
Argonne National Lab Contact - W. A. Ellingson, 312-972-5068

The aim of this effort is to develop X-ray beam hardening corrections for polychromatic X-ray sources when used with computed tomography machines to inspect structural ceramics and to develop appropriate test phantoms for calibration of polychromatic X-ray source CT scanners when used to inspect ceramic materials.

Keywords: Computer Tomography, CT Scans, Green State, Silicon Carbide, Silicon Nitride

123. <u>Ceramics For Stirling Engine Applications</u> <u>FY 1986</u>
$ 25,000

DOE Contact - Patrick L. Sutton, 202-586-8012
NASA LeRC Contact - Tom Herbell 216-433-3246

The potential of several candidate ceramics for application to Stirling engines are being assessed, focusing on mullite whose properties appear to be ideally suited to Stirling engine applications, especially in high strength applications. The principal effort was to determine the effect of high temperature hydrogen on the structural properties of mullite and silicon carbide. Significant hydrogen corrosion effects were seen with both materials.

Keywords: Ceramics, Mullite, Stirling Engine, Silicon Carbide, Silicon Nitride

124. High Temperature Creep Evaluation Stirling FY 1986 $ 65,000

DOE Contact - Patrick L. Sutton, 202-586-8012
NASA LeRC Contact - R. H. Titran, 216-433-3198

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

125. Standard Reference Ceramic Powder FY 1986 $ 182,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
NBS Contact - A. L. Dragoo, 301-975-2000

A standard reference material will be developed from the ceramic powder chosen by the U. S. consulting committee for the IEA agreement.

Keywords: NBS, Reference Material, Ceramic Powder, IEA

126. Technology Transfer Assessment, Support Contracts, IEA FY 1986 $ 311,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832

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

Keywords: Technology Transfer, Assessment, Research, Subcontractors, Exhibits, Meetings

127. Management And Coordination FY 1986 $ 640,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832

This effort assess the ceramic technology needs for advanced automotive heat engines, formulates technical plans to meet these needs, and prioritize and implements a long-range research and development program.

Keywords: Management, Coordination, Advanced Heat Engines, AGT, Diesel, Ceramics

128. Metal-Ceramic Joints AGT — FY 1986 $ 104,000

DOE Program Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832

The development of the technology required to reliably join advanced gas turbine (AGT) ceramic rotors to the high-temperature alloy rotor shafts is underway.

Keywords: Joining, Metal-Ceramic, AGT

129. Ceramic-Ceramic Joints AGT — FY 1986 $ 103,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832

This task's objective is to develop appropriate technology for reliable silicon carbide/silicon carbide and silicon nitride/silicon nitride joints.

Keywords: Ceramics, Joining

130. Advanced Coating Technology AGT — FY 1986 $ 147,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
Vapor Technologies Contact - Eduard Pinkhasov, 914-664-1495

An oxidation resistant, adherent coating for SiC and Si_3N_4 that will reduce contact stress between ceramic parts is under development. The low temperature arc vapor deposition (LTAVD) process will be used for coating ceramic substrates.

Keywords: Coatings, Contact Stress, Silicon Nitride, Silicon Carbide, AGT

131. Advanced Coating Technology AGT — FY 1986 $ 259,000

DOE Contact - Robert B. Schulz, 202-586-8032
ORNL Contact - D. Ray Johnson, 615-576-6832
GTE Labs Contact - V. K. Sarin, 617-890-8460

The objective of this project is the development of coating compositions and procedures that will yield long term adherence and reduce or eliminate contact-stress damage to silicon nitride, silicon carbide, or other ceramic materials when utilized in advanced gas turbine engines. Computer controlled CVD process will be used to produce multiple/graded coatings on ceramic substrates.

Keywords: Coatings, Adherence, Contact Stress

132. <u>Thermal Barrier Coatings</u>

FY 1986
$ 300,000

DOE Contact - John Fairbanks, 202-586-8055
NASA LeRC Contact - M. Murray Bailey, 216-433-3416
Cummins Contact - Thomas M. Yonushonis, 812-377-7078

Test specimens of yttria-stabilized zirconia thermal barrier coatings (TBC) systems have been prepared using automated plasma spray and screened for thermal shock/fatigue resistance, ranked according to erosion resistance, and evaluated for corrosion/oxidation resistance. The most promising coating will be applied to valves, fire deck, and piston dome of a single cylinder diesel engine for evaluation.

Keywords: Coatings, Zirconia, Fatigue, Corrosion, Diesel Engine

133. <u>Thermal Barrier Coatings</u>

FY 1986
$ 456,000

DOE Contact - John Fairbanks, 202-586-8055
NASA LeRC Contact - M. Murray Bailey, 216-433-3416
Caterpillar, Inc. Contact - H. J. Larson, 309-578-6549

Test specimens of yttria-stabilized zirconia thermal barrier coatings (TBC) systems have been prepared using automated plasma spray and screened for thermal shock/fatigue resistance, ranked according to erosion resistance, and evaluated for corrosion/oxidation resistance. The most promising coating will be applied to values, fire deck, and piston dome of a single cylinder diesel engine for evaluation.

Keywords: Coatings, Zirconia, Fatigue, Corrosion, Diesel Engine

134. <u>Sliding Seal Materials for Diesel</u>

FY 1986
$ 150,000

DOE Contact John Fairbanks, 202-586-8012
NASA LeRC Contact Howard Yacobucci, 216-433-3415
Southwest Research Institute Contact J. Lankford, 512-684-5111

The project is being conducted in three phases. During the initial year quantitative information was obtained regarding the friction and wear behavior of candidate carbides rubbing against two ceramic cylinder liner materials under conditions representative of the environment of seal rings in adiabatic diesels. The second phase effort concentrated on ion-implantation surface treatments to improve the friction and wear characteristics of the candidate materials. In the final phase, piston seals will be fabricated, tested, and evaluated in a test bed single cylinder engine with a ceramic cylinder liner.

Keywords: Carbides, Tribology, Ion-Implantation, Diesel Engine

135. <u>Advanced Gas Turbine Engine Technology (AGT-100)</u> FY 1986
$ 6,625,000

DOE Contact - Saunders B. Kramer, 202-586-8012
NASA LeRC Contact - P. Kerwin, 216-433-3409
General Motors, Allison Gas Turbine Division Contact - H. E. Helms, 317-242-5355

The requirements of this project are to demonstrate improved fuel economy reduced emissions and alternate fuel capability and to 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, Silicon Carbide, Rig and Engine Testing, Silicon Nitride, Gas Turbine Engines

136. <u>Advanced Gas Turbine Engine Technology (AGT-101)</u> FY 1986
$ 6,855,000

DOE Contact - Saunders B. Kramer, 202-586-8012
NASA LeRC Contact - T. N. Strom, 216-433-3408
Garrett Turbine Engine Co. Contact - E. E. Strain, 602-231-2797

This project will investigate 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, Silicon Carbide, Silicon Nitride, Gas Turbine Engines, Component Design, Rig and Engine Testing

137. <u>HTML Preoperational Support</u> FY 1986
$ 310,000

DOE Contact - William McDonough, 202-586-8032
ORNL Contact - V. J. Tennery, 216-433-3198

Preoperational support includes the planning and management activities associated with the construction phase of the High Temperature Materials Laboratory (HTML). The HTML is a new (in 1987) research and user facility at ORNL for basic and applied research on ceramic and metals.

Keywords: High Temperature, User Center, Ceramics, Metals, Intermetallics

OFFICE OF ENERGY STORAGE AND DISTRIBUTION (OESD)

The mission of the Office of Energy Storage and Distribution is to provide overall direction, interpret policy objectives and establish management procedures for a balanced program of technology planning, research and development, and test and evaluation, which will foster the establishment of a reasonable cross section of Electric Energy Distribution and Energy Storage Systems technology options.

The Office manages the electric energy distribution and storage systems groups of technologies in the formulation, and execution of appropriate national energy policies and programs and the verification of program balance and priorities among the technologies. The goal is to provide reliable, inexpensive devices to correct the timing and location mismatch between energy sources and energy users that is presently corrected by the energy storage inherent in fossil fuels.

Energy Storage

The Energy Storage Program supports research and development of advanced energy storage and electrochemical conversion systems that will facilitate the substitution of oil and gas fuels by nuclear and renewable energy sources, and will increase the reliability and efficiency of the energy economy. Described below are the materials R&D efforts of the three subprograms: Batteries and Electrochemistry; Chemical and Hydrogen Storage; Thermal Storage including Solar Thermal Storage.

138. High Temperature Water Electrolysis

FY 1986
$ 200,000

DOE Contact - M. Gurevich, 202-586-1495
Westinghouse R&D Center Contact - N. Mascalick, 412-256-2020

Experimental efforts in FY86 focused on achieving a better understanding of the processes involved in improving cell interconnection conductivity in high temperature solid oxide cells. Current Phase II activities were directed at reducing cell interconnection resistance by introducing compositional changes in the interconnect film, upgrading cell processing, and improvements in busbar contacting. Cell operation tests have also verified the importance of uninterrupted cell operation to minimize current density gradients which can introduce thermal stresses. Cell performance was tested over a 1300-hr. period at 50% H_2O conversion and 200 mA/cm^2, the longest time on test of all electrolysis cells produced to date.

Keywords: Solid Oxide Electrolytes, Ceramics, Surface Characterization, Energy Storage and Conversion, Hydrogen Production

139. Hydrogen Embrittlement of Pipeline Steels | FY 1986 $ 16,000

DOE Contact - M. Gurevich, 202-586-1495
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. Fundamental studies to determine the mechanism by which certain additive gases can inhibit hydrogen embrittlement effects was conducted during FY 84 and 85. Surface science techniques helped in determining that gas molecules with unsaturated bonds and high heats of adsorption show good inhibiting properties. Reaction mechanisms by which embrittlement was suppressed have also been elucidated. This work was satisfactorily completed in late 1985 and a final report describing the final phase of the program is in press.

Keywords: Metals, Fatigue, Hydrogen Effects, Energy Transmission

140. Hydrogen Technology Evaluation Center | FY 1986 $ 50,000

DOE Contact - M. Gurevich, 202-586-1495
BNL Contact - P.D. Metz, 516-282-3123

A characterization of a photovoltaics/advanced electrolyzer (15 kW) interface for hydrogen production based on one year's operation in various system modes was completed.

A test program to evaluate a second metal hydride hydrogen compressor (3 SFCM) operating in the open loop mode with hydrogen provided by the advanced technology electrolyzer (GE SPE) was completed. This project was a joint effort involving EPRI, PSE&G, Ergenics, Inc., and BNL.

Keywords: Hydrides, Polymers, Energy Storage, Hydrogen Production

141. Medium Temperature Solid Electrolytes: Proton Conductors | FY 1986 $ 125,000

DOE Contact - M. Gurevich, 202-586-1495
BNL Contact - F. Salzano, 516-282-4458

This was a collaborative effort between BNL and the Politecnico di Milano initiated in 1985 which looked at several classes of materials for use as proton conducting electrolytes. This investigation has continued to examine other candidate electrolyte materials that have the potential for both good conductivity and chemical stability. BNL, with a limited effort by Politecnico di Milano, characterized the conductive properties of candiate electrolytes as a function of steam temperature and pressure (up to 200 psi). None of the systems examined thus far based on aluminum phosphate or barium sulfate, have shown satisfactory performance. Zeolites are also being explored at BNL (in terms of thermal and steam resistance, acidity, type of cation) to examine its applicability as a medium temperature electrolyte material.

Keywords: Solid Electrolytes, Ceramics, Microstructure, Hydrogen Production

142. <u>Materials for Advanced High-Temperature Molten Salt Storage</u>

	FY 1986
$	20,000

DOE Contact - M. Gurevich, 202-586-1495
SERI Contact - B. Goodman, 303-231-1005

Under subcontract to SERI, Rockwell International has evaluated various candidate materials for their conical hot storage tank. The cost, availability, and properties of both 304 stainless steel and 9 Cr-1Mo low alloy steel were reviewed to provide a basis for the selection of materials for the molten salt liner and vapor barrier foil. It was determined that the fabrication costs associated with the 9 Cr-1 Mo alloy would roughly offset the cost savings associated with the lower raw material cost resulting in no significant advantage. In addition, 9 Cr-1 Mo alloy does not appear to be available in the form of thin sheet or foil at this time. It was decided, therefore, to use 304 stainless steel as the liner reference material.

Screening tests were conducted on candidate liner and wall interface materials at temperatures up to 1050°F. Materials tested included a glass fiber mat (Tempmat), a ceramic fiber blanket (Fiberfrax Durablanket), and a pad of stainless steel knitted-wire mesh spot-welded to a backing of stainless steel foil. Results have shown that the friction coefficient increases significantly with increasing temperatures; however, it was relatively insensitive to load. The glass fiber mat appears to have the most favorable frictional properties of the materials tested. The friction coefficient was very low at ambient temperature (0.2), before heating, but appeared to change irreversibly at elevated temperatures, resulting in a higher friction coefficient (0.5) at 1050°F. The friction coefficient was then essentially independent of temperature and remained at about 0.4 after cooling the test materials to ambient temperature.

Components and materials selected for the reference nitrate salt storage tank were reviewed for applicability to the higher temperature carbonate salt system. It appears that the same general concept will be applicable; however, some materials substitutions will be necessary to meet the high-temperature requirement. Materials screening programs which evaluated the suitability of various metals and ceramics for use in contact with high-temperature molten salts were examined. The preferred alloys for alkali metal carbonates at temperatures near 900°C are Inconel 600, Incoloy 800, or their equivalents. Available data points for both alloys were plotted as corrosion rate versus the reciprocal of the absolute temperature. There is a wide scatter in the available data and a total absence of data in the temperature range of primary interest (i.e., between 750°C and 850°C). Additional testing is needed to determine corrosion rates in this temperature range to to evaluate the effects of cover gas composition on corrosion.

Problems encountered with the salt tank on the 700°C test loop for direct-contact heat exchange have been related to thermal stress and design errors. SERI researchers have learned from this effort that 316L exhibits no corrosion problems after repeated exposure to carbonate salt at high temperature.

143. <u>Water Electrolysis with Protonic Beta" Alumina Electrochemical Cells</u> — <u>FY 1986</u> $ 53,000

DOE Contact - M. Gurevich, 202-586-1495
University of Pennsylvania Contact - G. Farrington, 215-898-8337

Studies on characterizing H^+/H_3O^+ Beta"-aluminas as electrolytes for electrolysis systems which operate at 300-600°C continued this year. Single-crystal samples were synthesized via ion-exchange technique and thermal decomposition profiles were established using TGA (thermal gravimetric apparatus) analysis. Findings show that hydronium Beta"-alumina single crystals were unstable at temperatures > 400°C. A modification to move from the prior focus on Beta"-aluminas to a new family of ion-conducting materials based on bismuth oxides will be investigated.

Keywords: Fast Ion Conductors/Solid Electrolytes, Structure, Hydrogen Production

144. <u>Metal-Assisted Cold Storage (MACS) of Hydrogen on Activated Carbon</u> — <u>FY 1986</u> $ 135,000

DOE Contact - M. Gurevich, 202-586-1495
Syracuse University - J. Schwarz, 315-423-2807

The cryoadsorption of hydrogen on surface-modified activated carbon has been examined on a microscale at liquid nitrogen temperatures and pressures up to 1 atm absolute. Test results have shown that up to 2.2 wt % hydrogen can be stored on carbon coated with 5 wt % platinum catalyst at 77°K and 1 atm. This investigation has focused on verifying the feasibility of storing

> 4 wt % hydrogen on modified activated carbon for practical mobile or stationary H_2 storage applications. A high-pressure macrobalance apparatus was assembled and made operational to allow screening of candidate materials at pressures up to 60 atmospheres. Enhanced H_2 storage on surface-catalyzed (Pt or Pd) activated carbon was demonstrated. Screening tests also established that activated carbons with high alkalinity and high surface area show increased H_2 storage capacities. Based on these screening studies, "superactivated carbon" was identified as the optimum material for performing further adsorption tests.

Keywords: Hydrogen Storage, Catalysts

145. Hydrogen Production with Photoactive Semiconductor Catalysts

	FY 1986
	$ 50,000

DOE Contact - M. Gurevich, 202-586-1495
Battelle Columbus Laboratories Contact - R. Schwerzel, FTS 976-5637

Research is being conducted to determine whether significant improvements in the performance of photoactive semiconductor catalysts for hydrogen production can be realized using metallized plasma-polymerized films. The main problem being addressed is to obtain films of suitable transparency and conductivity that exhibit stable long life, and are compatible with the semiconductor band gap requirements for photo-assisted electrolysis. The plasma-polymerization process is unique and allows for a variety of film properties not obtainable with conventional polymers. Efforts in FY 86 continued to explore the use of plasma polymerized films deposited on photoactive semiconductor catalysts to eliminate photocorrosion problems and to improve electrode stability and lifetime performance. Newly developed coatings made from co-sputtered gold/Teflon (more recently polyethylene) were tested and appear to exhibit the potential for good conductivity and optical transparency, as well as greater stability in acidic electrolyte solutions. Film adhesion was improved over previous samples (stable for days rather than a few hours), indicating the potential for longer life. Characterization of a number of single-crystal and powdered photocatalysts will be done using the advanced coatings prior to conducting the aqueous electrolysis experiments.

Keywords: Semiconductors, Catalysis, Plasma Synthesis, Coatings and Films

146. Electrochemical Techniques for H_2 Storage in Metal Hydrides

FY 1986
$ 20,000

DOE Contact - M. Gurevich, 202-586-1495
Stanford University Contact - R. Huggins, 415-497-4110

Stanford developed a non-aqueous technique for investigating the electrochemical control of hydrogen absorption/desorption in metal alloys. The initial system studied involved a low melting organometallic salt ($NaAlEt_4$) saturated with NaH in which the H- ions act as hydrogen transmitters. The alloys used were Mg-Cu, Mg-Ni and MgAl which formed hydrides at 170°C and applied voltages of 200-300 mV. While the feasibility of this approach was proven, the kinetics of the overall reaction were too slow for any practical system. Additional studies were done with a KBr/LiBr/LiF eutectic compound serving as an electrolyte. This system, while providing higher ionic conductivity, had some problems with side reactions. Investigatations were concluded at Stanford without identifying a suitable system compatible with useful P-C-T conditions. In a related activity a modest effort was initiated at the University of Hawaii using the above techniques on transition metal sulfide systems.

Keywords: Hydrides, Hydrogen Storage

147. Advanced Hydrogen Storage - Modified Vanadium Hydrides

FY 1986
$ 5,000

DOE Contact - M. Gurevich, 202-586-1495
Allied Corporation Contact - G. Libowitz, 201-455-4571

Allied investigated the general family of modified vanadium hydrides which are easily activated and can take up to 3.8 to 4.0% hydrogen by weight. Desorption of the hydrogen at conditions compatible with practical applications as well as cost of the pure vanadium are the problems being addressed. These are monohydride-dihydride systems and the approach is to try and bring the two P-C-T plateaus closer together by the addition of substitutional metals such that the hydrogen can be desorbed at pressures above 1 atm at temperatures in the 175°C range. Systems studies include V-Ti-Fe, and V-Ti-Fe-Mn. It was hoped an optimum V-Ti-Fe compound would be identified that would permit the use of low-cost ferrovanadium ore with minimal processing. Research has shown however that while some adjustment of the isotherms is possible, the addition of amounts of Fe above a certain level reduces storage capacity to well below the 4% level limiting the prospects of the approach. The work was concluded in FY 86 and a report issued.

Keywords: Hydrides, Metals, Hydrogen Storage

148. <u>Ceramics Research</u> | FY 1986 $ 1,300,000

DOE Contact - A. Landgrebe, 202-586-1483
LBL Contact - E. Cairns, 415-486-5028
SNL Contact - R. Clark, 505-844-6332

Work is being done on sodium/sulfur and lithium/iron sulfide batteries designed to 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. Research is being conducted on the principles of ionic conduction in ceramics and the causes of electrolyte failure.

Keywords: Alloy Development, Alternate Materials, Corrosion, Joining Methods, Fast Ion Conductors and Solid Electrolytes, Batteries

149. <u>Metals and Alloys</u> | FY 1986 $ 500,000

DOE Contact - A. Landgrebe, 202-586-1483
LBL Contact - E. Cairns, 415-486-5028
LLNL 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

150. <u>Organometallic Compounds</u> | FY 1986 $ 300,000

DOE Contact - A. Landgrebe, 202-586-1483
Eltech Systems Corporation Contact - R. W. Fenn, 216-357-4075

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

151. Polymers FY 1986
$ 300,000

DOE Contact - A. Landgrebe, 202-586-1483
LBL Contact - E. Cairns, 415-486-5028
Univ. of Pa. Contact - G.C. Farrington, 215-898-5000

Electronically and ionically conducting polymers are being synthesized, prepared as films, and characterized for use as electrodes, separators, and electrolytes in storage batteries and fuel cells.

Keywords: Polymers, Fast Ion Conductors and Solid Electrolytes, Batteries

152. Analysis of Zeolite Augmented Ice Storage FY 1986
$ 5,000

DOE Contact - Eberhart Reimers, 202-586-5855
PNL 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

153. Geochemical Stability of Sandstones FY 1986
$ 60,000

DOE Contact - Eberhart Reimers, 202-586-4563
PNL 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

154. <u>Composite High Temperature Thermal Storage Media</u> FY 1986 $ 350,000

DOE Contact - Eberhart Reimers, 202-586-4563
IGT Contact - Randy Petri, 312-567-3985

The objective of this project is to 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

155. <u>Formation of Encapsulated Metallic Eutectic Thermal Storage Alloy</u> FY 1986 $ 100,000

DOE Contact - Eberhart Reimers, 202-586-4563
Ohio State University Contact - Robert Rapp, 614-422-2491

The purpose of this project is to 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. An effective way of producing pellets in mass and of the right size and uniformity is being studied. A pellet fabrication process to produce a storage media in the range of 700-800°C is under development.

Keywords: Composites, Materials Characteristics

156. <u>Solid State Radiative Heat Pump</u> FY 1986 $ 50,000

DOE Contact - Eberhart Reimers, 202-586-4563
LBL Contact - Paul Berdahl, 415-486-5278

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

157. Use of Micro Particles as Heat Exchangers and Catalysts

FY 1986
$ 50,000

DOE Contact - Eberhart Reimers, 202-586-4563
LBL Contact - Arlon Hunt, 415-486-5370

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

158. <u>Formation and Dissolution of Gas Clathrates</u> FY 1986
$ 150,000

DOE Contact - Eberhart Reimers, 202-586-4563
ORNL Contact - Jim Martin, 615-576-3977

This project is investigating 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 cool storage 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

159. <u>Evaluation of Advanced Thermal Energy Storage Media</u>
FY 1986
$ 350,000

DOE Contact - Eberhart Reimers, 202-586-4563
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

<u>Electric Energy Systems</u>

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.

160. High-Voltage Breakdown Strengths of Insulating Gases and Liquids

FY 1986
$ 400,000

DOE Contact - Russell Eaton, 202-586-4844
ORNL (Contract No. W-7405-eng-0026) Contact - Lucas Christophorou, 615-574-6199

The factors influencing the breakdown strengths of gaseous and liquid dielectrics are being analyzed from a fundamental physiochemical point of view. Mixtures of gases with superior insulating properties are being sought.

Keywords: Insulators (Gaseous), Energy Transmission

161. Factors Influencing Aging in Extruded Dielectrics

FY 1986
$ 800,000

DOE Contact - Russell Eaton, 202-586-4844
Battelle-Columbus Contact - Mike Epstein, 614-424-6424

An understanding will be developed of the factors influencing aging of extruded dielectrics used for underground transmission cable systems. Several advanced techniques will be applied either simultaneously or sequentially to help identify aging mechanisms. These techniques include thermally stimulated currents, mechanical spectroscopy, and differential scanning calorimetry.

Keywords: Insulators, Organic Polymers, Energy Transmission

162. Threshold and Maximum Operating Electric Stresses for Selected High Voltage Insulations

FY 1986
$ 0

DOE Contact - Russell Eaton, 202-586-4844
Cable Technology Lab. (Contract No. DE-AC02-80RA50156) Contact - Carlos Katz, 201-846-3220

The objective of this project is to 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

163. <u>Multifactor Aging and Evaluation of Polymeric Materials</u>

FY 1986
$ 150,000

DOE Contact - Russell Eaton, 202-586-4844
ORNL (Contract No. W-7506-eng-006) Contact - Steinar Dale, 615-574-4829

The aging of polymeric film materials is being studied. 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

164. <u>Solid Dielectrics and Interfacial Breakdown</u>

FY 1986
$ 125,000

DOE Contact - Russell Eaton, 202-586-4844
ORNL Contact - Steinar Dale, 6150-574-4829

An investigation of electron and ion transports across interfaces between a solid dielectric and metal is underway. Effects of electric fields, impurities, defects, and micro-structures at the interfaces will be studied.

Keywords: Solid Dielectrics

165. <u>Investigation of Interfacial Phenomena in Compressed Gases</u>

FY 1986
$ 0

DOE Contact - Russell Eaton, 202-586-4844
ORNL Contact - Steinar Dale, 615-574-4829

The objective of this project is to 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

166. <u>Interfacial Aging Phenomena in Power Cable Insulation Systems</u>

FY 1986
$ 100,000

DOE Contact - Russell Eaton, 202-586-4844
ORNL Contact - Steinar Dale, 615-574-4829

The aging of semi-conducting/polymer insulator interfaces is under investigation. 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

167. Study of Dynamic Insulation with Advanced Metal Oxide (ZnO) Materials

FY 1986
$ 50,000

DOE Contact - Russell Eaton, 202-586-4844
ORNL Contact - Steinar Dale, 615-574-4829

The performance of ORNL-developed sol-gel ZnO material in overhead line insulators is being determined. The performance will be compared with that of insulators having commercial ZnO material previously studied in FY 84 and FY 85.

Keywords: Insulators, Metal Oxide Materials

168. Development of Amorphous Ferromagnetic Alloy for Motors and Transformers

FY 1986
$ 125,000

DOE Contact - Russell Eaton, 202-586-4844
ORNL Contact - Steinar Dale, 615-574-4829

The investigation of micro-alloying of FeO- and Ni-based metallic glasses will continue. A major effort will be to develop an 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

169. AC Superconducting Power Transmission Cable Development

FY 1986
$ 870,000

DOE Contact - Russell Eaton, 202-586-4844
BNL (Contract No. ET-76-C-02-0016) Contact-E. Forsyth, 516-282-4676

The purpose of this project is to 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). Optimized polymeric film tapes for superconducting and conventional cable systems will also be developed.

Keywords: Superconductors, Insulators (Organic Polymers), Energy Transmission

OFFICE OF SOLAR HEAT TECHNOLOGIES

Solar Buildings Technology Division

The mission of the Solar Buildings Technology Program is to support the national energy policy goal of fostering an adequate energy supply at reasonable costs by providing for the development of solar building technologies. The program goal is to provide industry with the technology base needed to develop solar energy products and designs which are economically competititve and can contribute significantly to building energy supplies. These goals translated into technology objectives are to:

- o Develop solar energy technologies that supply up to 80 percent of building space heating, hot water, cooling, and lighting requirements at competititve costs when integrated with conventional energy conserving technologies.

- o Assist industry to improve component, system reliability and dura-bility to achieve acceptable performance and equipment service life.

170. Thermochromic Materials — FY 1986: $ 248,000

DOE Contact - Ted Kurkowski, 202-586-1788
SAN Contact - Janet Neville, 415-486-6362

The objective of this effort is to develop thin coatings of thermochromatic materials on glazing which will allow solar energy to enter the building when the air is cold, but will switch and reflect solar IR when the coatings reach a designated transition temperature.

Keywords: Thermochromatics, Glazings

171. Optical Switching Apertures — FY 1986: $ 180,000

DOE Contact - Ted Kurkowski, 202-586-1788
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 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, absorbitive coatings will be evaluated and optimized.

Keywords: Coatings

172. Optical Switching Materials FY 1986 $ 100,000

DOE Contact - Ted Kurkowski, 202-586-1788
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

173. Transparent Insulating Materials FY 1986 $ 60,000

DOE Contact - Ted Kurkowski, 202-586-1788
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, 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

174. Phase Change Thermal Storage Materials FY 1986 $ 505,000

DOE Contact - Ted Kurkowski, 202-586-1788
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 in buildings. 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, optimized transformation temperatures or more convenient forms (such as composites) for use in buildings.

Keywords: Composites, Phase Change Materials

175. Daylight Enhancement FY 1986 $ 100,000

DOE Contact - Ted Kurkowski, 202-586-1788
LBL Contact - Mike 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

176. Low-Emittance, High-Transmittance Materials FY 1986 $ 100,000

DOE Contact - Ted Kurkowski, 202-586-1788
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 multiyear 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

177. Thin Film Materials Research FY 1986 $ 248,000

DOE Contact - John Goldsmith, 202-586-8779
SAN Operations Office Contact - Janet Neville, 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

178. Sorption Studies of Desiccant Materials — FY 1986 $ 340,000

DOE Contact - John Goldsmith, 202-586-8779
SERI Contact - Ahmad Pesaran, 303-231-7636

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 gamma-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

179. Advanced Desiccant Materials — FY 1986 $ 130,000

DOE Contact - John Goldsmith, 202-586-8779
SERI Contact - A. Czanderna, 303-231-1240

The objectives of this task are (1) to determine how the desired sorption performance of advanced desiccant materials can be predicted by understanding the role of their surface phenomena and materials modification and (2) performance testing of novel desiccant materials.

Keywords: Surface, Predictive Behavioral Modeling

180. Evaluation of Aperture Glazing Materials — FY 1986 $ 125,000

DOE Contact - Ted Kurkowski, 202-586-1788

The objectives of this effort are to (1) develop and evaluate methods for determining the performance and durability of low-emittance glazing materials and (2) characterize the energy savings potential for low-emittance windows by measuring thermal performance under realistic field conditions.

Keywords: Low-E Glazings, Windows

Solar Thermal Technology Division

Solar Thermal Technology is developing central receivers, parabolic dishes, and parabolic troughs to concentrate the sun's energy. This concentrated energy can then be used for industrial process heat, generating electricity, or producing fuels and chemicals. The combination of concentrated direct solar flux (to 2000 suns) and high temperature (to 2000^{o}F) cause unique material problems that are now being characterized in areas of heat transfer fluids, metals, and ceramics. Additional research is determining if the combination of high flux and high heating rate can beneficially alter the properties of materials such as carbon fibers. In addition, the solar induced degradation of silvered polymers reflectors is also being studied in order to develop a highly reflective, environmentally stable, low-cost reflector.

181. <u>Silver/Polymer Reflector Research</u> <u>FY 1986</u> $ 721,000

DOE Contact - Frank Wilkins, 202-586-1684
SERI Contact - Paul Schissel, 303-231-1226

Applied research is being conducted to develop silver/polymer reflector films that are resistant to ultraviolet and pollutant degradation, cleanable, have specular reflectances of 90% of more (within a 2- mrad cone angle), and useful lives of at least 5 years.

Solar concentrators account for about 50% of the installed cost of a solar thermal system. Research is being carrier out on polymer based reflectors 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.

This research focuses on 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.

Research is also being conducted on optically transmitting and structural polymer materials for solar thermal technology applications. The problems being investigated are: identification, testing, and evaluation of polymeric stabilizers to improve the durability of polymers in solar thermal applications; and identification, testing, and evaluation of these additives that can act as ultraviolet (UV) absorbers and/or quenchers of excitation energy in polymers.

Keywords: Polymers, Coatings and Films, Surface Characterization and Treatment, Corrosion, Radiation Effects, Reflectors, UV Degradation

182. <u>High Temperature Materials</u> <u>FY 1986</u>
$ 352,000

DOE Contact - Frank Wilkins, 202-586-1684
SERI Contact - Gordon Gross, 303-231-1228

The aim of this research is to produce information needed to select the best materials and methods of application for use in testing the feasibility of the direct absorption receiver, as well as information needed to evaluate other advanced innovative receiver concepts.

Research on molten salts which may be used as the working fluid in new central receiver concepts is being carried out. The phase diagrams of mixed carbonate salts are being characterized in the 500-900^{o}C temperature range. In the direct absorber receiver concept, the solar energy is directly transferred to the flowing salt. In order to maximize the efficiency, it is necessary to add absorbing materials to the normally transparent salts. Work is underway to establish the stability limits of metal oxide powders in molten nitrate salts and to establish the compatibility of these mixtures with alloys which are candidates for piping and containment elements.

There is a continuing effort to identify and define failure modes of metal tubes that have been subjected to high solar flux, high temperature, and thermal cycling. In order to establish the durability of ceramic and metallic parts, continuous tests of components under solar conditions are carried out.

Keywords: Ceramics, Thermal Fluids, Alloys, Corrosion, Radiation Effects

183. <u>High Flux Effects on Materials</u> <u>FY 1986</u>
$ 287,000

DOE Contact - Frank Wilkins, 202-586-1684
SERI Contact - Gordon Gross, 303-231-1228

Research is being conducted to investigate high intensity (high flux) photo-enhanced degradation of materials, and identify possible changes in coatings to reduce these effects. Quantitative correlations between high solar fluxes (over 100 suns) and degradation of materials will be produced. Potential beneficial effects of high solar flux on the properties of carbon fibers and carbon-carbon composites will be identified by research on material processing in a solar furnace.

184. <u>Front Surface Reflector on Metal Substrates</u> FY 1986 $ 241,000

DOE Contact - Frank Wilkins, 202-586-1684
SERI Contact - Gordon Gross, 303-231-1228

This research is aimed at identifying ways to use thin stainless steel as a lightweight substrate for silver mirrors. Stainless steel offers many well known advantages in solar thermal applications. As a membrane mirror substrate, it would offer desirable structural and durability properties.

In cooperation with the steel industry, work is being carried out to identify the processing factors which limit the smoothness of rolled strip stock. The surface of rolls used to produce such stock will be evaluated before and after polishing to the maximum smoothness. Runs of stainless steel produced with the polished rolls will be evaluated for their optical properties and the surface features compared with those of the rolls used in the production runs. When material of adequate smoothness is obtained, it will be used as the basis for front surface mirrors or as a substrate for reflective films.

Keywords: Stainless Steel, Surface Characterization, Treatment

185. <u>Composite Materials for Concentrators</u> FY 1986 $ 100,000

DOE Contact - Frank Wilkins, 202-586-1684
SERI Contact - L. Marty Murphy, 303-231-1050

The objective of this research (being conducted by the University of Arizona and Science Applications, Inc.) is to determine the feasibility of designing and building durable, low-cost heliostats fabricated from advanced composite materials and wood laminates.

One of the major thrusts of the Solar Thermal Research Program is conducting research to identify and show the technical feasibility of innovative durable, low-cost concentrators. Since concentrators account for approximately 50% of the capital cost of a solar thermal system, one way to reduce the delivered cost of energy significantly is to reduce the costs of the concentrators.

Three conceptual designs for stretched membrane heliostats are being investigated:

- laminated wood ring with double polymer membranes;

- graphite fiber-reinforced wooden core ring with double polymer membranes; and

- open-weave graphite fiber "fishnet" membrane to support thin membrane reflector panels mounted on a frame.

The conceptual designs are being subjected to a computer-based structural analysis to predict their stress-strain behavior. Scale models are to be fabricated for each of the three conceptual designs and subjected to various mechanical tests (e.g., plane bending stiffness, torsional stiffness, etc.).

The expected results of the research is the identification of at least one conceptual design for a durable, lightweight, and potentially low-cost stretched membrane heliostat fabricated from composite materials and to establish (experimentally) the technical feasibility of that concept.

Keywords: Polymer Membrane, Stretched Membrane, Composite Materials, Wood Laminate, Heliostat

OFFICE OF SOLAR ELECTRIC TECHNOLOGIES

Photovoltaic Energy Technology Division

The National Photovoltaics Program sponsors high-risk, potentially high-payoff research and development in photovoltaic energy technology that will result in a technology base from which private enterprise can choose options for further development and competitive application in U.S. electrical markets. The objective of materials research is to overcome the technical barriers currently limiting the efficiency and cost of photovoltaic cells. Theoretical conversion efficiency of photovoltaic cells is limited by the portion of the solar spectrum that the cell's semiconductor material can respond, and by the extent to which these materials can convert each photon to electricity. The practical efficiency is constrained by the amount of light captured by the cell, the cell's uniformity, and a variety of loss mechanisms for the photo-generated carriers. Cost is affected by the expense and amount of materials required, the complexity of processes for fabricating the appropriate materials, and the complexity and efficiency of converting these materials into cells.

186. Amorphous Silicon for Solar Cells — FY 1986 $ 10,000,000

DOE Contact - Morton B. Prince, 202-586-1725
SERI Contact - Ed Sabisky, 301-231-1483

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

187. Polycrystalline Thin Film Materials for Solar Cells

FY 1986
$ 4,600,000

DOE Contact - Morton B. Prince, 202-586-1725
SERI Contact - Kenneth Zweibel, 301-231-7141

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

188. Growth of Silicon Ribbons for Solar Cells

FY 1986
$ 1,000,000

DOE Contact - Morton B. Prince, 202-586-1725
SNLA Contact - Dan Arvizu, 505-846-0387

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

189. Deposition of III-V Semiconductors for High-Efficiency Solar Cells

FY 1986
$ 3,500,000

DOE Contact - Morton B. Prince, 202-586-1725
SERI Contact - John Benner, 303-231-1396
SNLA Contact - Dan Arvizu, 505-846-0387

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)

190. <u>Materials and Device Characterization</u> — <u>FY 1986</u> $ 3,000,000

DOE Contact - Morton B. Prince, 202-586-1725
SERI Contact - Larry Kazmerski, 301-231-1115

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

191. <u>High-Efficiency Crystal Silicon Solar Cells</u> — <u>FY 1986</u> $ 1,800,000

DOE Contact - Morton B. Prince, 202-586-1725
SNLA Contact - Dan Arvizu, 505-846-0387

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 a 23% efficient one-sun crystal silicon experimental cell by the end of FY 1987 and a 20% efficient one-sun crystal silicon large-area, low-cost cell by the end of FY 1988. This result will be a major step in proving that crystal silicon can be a cost-effective generator of electricity.

Keywords: Semiconductors, Solar Cells

Geothermal Technology Division

The primary goal of the geothermal advanced instrumentation program is to reduce costs of geothermal powerplant design, construction, and operation by extending component life, reducing maintenance and equipment replacement, and minimizing powerplant outages.

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, GTD-sponsored materials R&D.

192. High Temperature Elastomers for Dynamic Sealing Applications

FY 1986
$ 112,000

DOE Contact - R. LaSala, 202-586-4198
BNL Contact - L.E. Kukacka, 516-282-3065

This project performs applied research to optimize a Y-267 EPDM elastomer formulation, developed earlier by GTD 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, Seals and Bearings

193. Advanced Materials for Lost Circulation Control

FY 1986
$ 75,000

DOE Contact - R. LaSala, 202-586-4198
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 muds, 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

194. <u>Geothermal Waste Utilization and Disposal</u> <u>FY 1986</u> $ 125,000

DOE Contact - R. LaSala, 202-586-4198
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. 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

195. <u>Materials for Non-Metallic Heat Exchangers</u> <u>FY 1986</u> $ 135,000

DOE Contact - R. LaSala, 202-586-4198
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/isopentane mixtures. If the goals of the program are attained, the cost of geothermal power will be reduced considerably.

Keywords: Composites, Polymers, Corrosion, Strength, Extrusion

196. <u>Corrosion Resistant Elastomeric Liners for Well Casing</u>

FY 1986
$ 61,000

DOE Contact - R. LaSala, 202-586-4198
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

197. <u>Advanced High Temperature Geothermal Well Cements</u>

FY 1986
$ 125,000

DOE Contact - R. LaSala, 202-586-4198
BNL Contact - L. E. Kukacka, 516-282-3065

Lightweight (<1.2 g/cc) chemically and thermal resistant well cements are needed to reduce the potential for lost circulation problems during well completion operations. Materials designed for temperatures >300°C will be needed as higher temperature resources are developed. Cements resistant to brines containing high concentrations of CO_2 at temperatures >150°C are also needed. Emphasis should be placed on high temperature rheology, phase chemistry, and the mechanical, physical, and chemical resistance properties of the cured materials.

Keywords: Cements, Material Degradation, Strength, Transformation, Bulk Characterization, Drilling

198. <u>Corrosion in Binary Geothermal Systems</u>

FY 1986
$ 69,000

DOE Contact - R. LaSala, 202-586-4198
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

199. Metallic Liners for Well Casing FY 1986
$ 50,000

DOE Contact - R. LaSala, 202-586-4198
BNL Contact - D. van Rooyen, 516-282-4050

Corrosion of conventional well casing is a major problem in geothermal systems, and the use of high chrome steels and nickel alloys is uneconomical. Therefore, the use of clad metallic systems is being investigated. The work consists of the selection and laboratory evaluation of potentially useful cladding systems. If successful, the cost of geothermal wells will be considerably reduced.

Keywords: Alloys, Coatings, Metals, Corrosion, Diffusion, Fatigue

200. Biochemical Concentration and Removal of Toxic Components from Geothermal Wastes FY 1986
$ 130,000

DOE Contact - G. J. Hooper, 202-586-4153
BNL Contact - L.E. Kukacka, 516-282-3065

This program involves the development of biochemical processes which can be used for the concentration and subsequent removal of toxic components from geothermal waste streams. Before the large-scale development of geothermal energy can occur, environmentally and economically acceptable methods for the disposal of large quantities of potentially toxic wastes must be developed. The wastes can also provide a valuable source of strategically important metals. The work involves the identification of biosystems which efficiently select and accumulate the toxic materials of interest. This involves extra- and intracellular fractionation and management of natural sources, i.e., isolation, culturing, and identification of micro-organisms as well as the chemical isolation and characterization of active entitites.

Keywords: Toxic Metal Removal, Absorption, Surface, Dissolution, Solidification, Industrial Waste Recovery

201. Field Tests of Advanced Monitoring Instruments

FY 1986
$ 100,000

DOE Contact - G. J. Hooper, 202-586-1146
PNL Contact - D. W. Shannon, 509-376-3139

This project involves field testing advanced 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. A plan was developed to conduct field tests on a number of prototype instruments at the Heber Binary Plant. Closed test loops were installed in the Heber plant when it was constructed; therefore, the instruments can be easily installed and analyzed without disrupting plant operations. Field tests associated with the previous binary plant resulted in savings of many thousands of dollars in avoided well and equipment failures on the plant where the test equipment was installed. The current tests planned at the Heber plant will allow the prototype instruments to be fully tested under actual field conditions, as well as collecting process chemistry data that can be used to improve future plant reliability.

Keywords: Composites, Corrosion, High Temperature Service

202. Particle Measurement In-Line Instrument

FY 1986
$ 150,000

DOE Contact - G. J. Hooper, 202-586-1146
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 laboratory tested, one based on a laser technique and the other based on a ultrasonic 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

203. pH and Carbon Dioxide Sensors FY 1986 $ 125,000

DOE Contact - G. J. Hooper, 202-586-1146
PNL Contact - D. W. Shannon, 509-376-3139

This project involves development and field testing of advanced instrumentation to monitor the acidity and the carbon dioxide content of geothermal brines in order to control mineral scaling, corrosion, and brine treatment processes. Existing low temperature probes are now being modified to withstand the hot hostile geothermal environment. After the modifications have been made, the instruments will be laboratory tested, and subsequently located on a geothermal power plant. These instruments should assist plant operators in detecting scale formation that could lead to adverse plant conditions, such as equipment failures or plugged wells.

Keywords: Composites, Corrosion, Scaling, High Temperature Service

Biofuels and 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, 202-586-1697.

204. Refuse Derived Fuel (RDF) Binder Research FY 1986 $ 150,000

DOE Contact - Donald Walter, 202-586-6104
ANL Contact - Ole Ohlson, 312-972-5593

The objective of this research study is to develop innovative densified refuse derived fuel (RDF) concepts of 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 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:

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

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

- o Office of Fusion Energy

- o Small Business Innovation Research Program

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 currently 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:

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

- o 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.

- o 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 Iran Thomas, 301-353-3427. For specific detailed information, the reader is referred to DOE publication Materials Sciences Programs Fiscal Year 1985 (DOE/ER-0143/3 dated September 1985). This publication contains: 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

205. Bounds on Dynamic Plastic Deformation FY 1986
$ 123,000

DOE Contact - Oscar P. Manley, 301-353-5822
Argonne National Laboratory Contact - C. K. Youngdahl, 312-972-6149

In many applications where load is transmitted to the structure through a fluid, details of the load history and spatial distribution affect significantly the final plastic deformation. The objective of this project is to devise load correlation parameters based on various weighted integrals of the time-space load distributions which can be used to characterize the effects of the load without resorting to detailed numerical analysis. These load correlation parameters have three important uses: to perform design and safety analyses of structures over a wide range of design variables and loadings; to validate computer programs which have a nonlinear dynamic plasticity capability; and to correlate experimental simulations with actual or predicted events. The dynamic plastic deformation of some basic structural configurations will be analyzed for loadings which vary both in magnitude and region of application with time. Load correlation parameters will be hypothesized and their usefulness in predicting final plastic deformation will be determined. The analyses will be based initially on a rigid, perfectly plastic material model, but will be extended to include strain hardening and elastic effects if the work to determine load parameters is successful.

Keywords: Plastic Deformation

206. Diffusion, Fluid Flow, and Sound Propagation in Disorders Media FY 1986
$ 65,000

DOE Contact - Oscar P. Manley, 301-353-5822
Boston University Contact - Thomas Keyes, 617-353-4730

The basic transport processes, of which those mentioned in the title are important examples, become extremely complicated in the presence of large amounts of disorder. For example, the effect of a low density of fixed scatterers upon diffusion is easy to calculate; at high density, diffusion may cease altogether and the problem becomes difficult. Lattice vibrations on an ordered lattice are described by perfect sound waves, but disorder--perhaps some broken bonds--can cause the vibrations to be "localized" with no ordinary long-wavelength sound at all (localization is thought to occur with an infinitesimal amount of disorder in two dimensions). Of course, large disorder is the rule in nature, as in the interior of a porous rock.

The aim of this project is to apply modern methods of nonequilibrium statistical mechanics to transport with large disorder. Those methods are the "Repeated Ring" kinetic equation, an extension of Boltzmann's equation to complicated systems, the Renormalization Group, and computer simulation. Transport coefficients and correlation functions will be calculated. The project has only just begun, but a molecular dynamics simulation of lattice vibrations (sound) on disordered lattices is running. While the program was being tested, almost accidentally, a clear manifestation of the unusual localization phenomenon in two dimensions was discovered and is now being analyzed; this phenomenon is most interesting theoretically. Lattice vibrations in several disordered systems, and the other transport problems listed, will be investigated as the project develops.

Keywords: Disordered Media, Statistical Mechanics

207. <u>In-Flight Measurement of the Temperature of Small, High Velocity Particles</u> <u>FY 1986</u>
$ 90,000

DOE Contact - Oscar P. Manley, 301-353-5822
Idaho National Engineering Laboratory Contact - J. R. Fincke, 208-526-2031

Knowledge of in-flight particle temperature is fundamental to understanding particle/plasma interactions in the physical and/or chemical processing of fine powders. The measurement of in-flight particle temperature is based on a coincidence technique. A small measurement volume is defined by two independent lens/sensing systems. When a particle is present in the measurement lens/sensing systems. When a particle is present in the measurement volume, a signal will be observed and recorded simultaneously by each sensing system. Once a signal is recorded, the particle temperature may be deduced. The uncertainty in this temperature determination will be due to lack of information concerning the particle size, shape, and emissivity; and due to the presence of an emitting, absorbing, and scattering medium.

The program consists of three phases: In Phase I (FY 85) individual particles were electrodynamically suspended, then heated by a laser beam. The particle temperatures and emissivities were measured. Results to date indicate that optical property data for the parent material are adequate for estimation of particle emissivity. In Phase II (FY 86) the in-flight coincidence technique was developed. This effort included the development of both analog and digital signal processing techniques. Phase III will apply, and modify as necessary, these techniques to measure particle temperatures in a high temperature plasma. This phase of the program will address the problems associated with the presence of an emitting, absorbing, and scattering atmosphere.

This project is one of six projects comprising a collaborative research program with the Massachusetts Institute of Technology.

Keywords: Plasma Processing, Particle/Plasma Interaction

208. Experimental Measurement of the Plasma/Particle Interation

FY 1986
$ 328,000

DOE Contact - Oscar P. Manley, 301-353-5822
Idaho National Engineering Laboratory Contacts - M. E. McIlwain, 208-526-8818, C. B. Shaw, 208-526-8818, S. C. Snyder, 208-526-1507, L. D. Reynolds, 208-526-8335

The objective of this research is to quantitatively describe the heat mass, and momentum transfer associated with metallic or oxide particles immersed in thermal plasma environments. In order to characterize the interaction between plasma constituents and particles, the development of new methods to determine plasma flow velocity and species compositions are being developed. Holographic interferometry is currently being considered for plasma flow velocity determination and planar laser induced fluorescence is being considered for compositional measurements adjacent to particle surfaces. Using these advanced techniques, temporal and spatially resolved distributions of the chemical and physical properties of the plasma/particle environment will be determined. Since this research is performed in collaboration with research at Massachusetts Institute of Technology, the resulting experimental data will be used to validate and correct theoretical models used for thermal plasma processing and for predictions relating to optimal torch and fixture design criteria. Experiments are currently being performed in two plasma torch designs, a constricted nozzle torch and an expanding nozzle torch. Input power dissipation levels ranging from 5 to 180 kW are being studied. These torch designs produce a representative plasma characteristic of those employed for industrial plasma processing.

Keywords: Particle/Plasma Interaction, Plasma Processing

209. Integrated Sensor/Model Development for Automated Welding

FY 1986
$ 496,000

DOE Contact - Oscar P. Manley, 301-353-5822
Idaho National Engineering Laboratory Contacts - H. B. Smartt, 208-526-8333, J. A. Johnson, 208-526-9021, J. O. Bolstad, 208-526-1753

The objectives of this research are: (1) to develop a model of the gas metal arc welding process suitable for real-time process control, (2) to develop an optical sensing capability to provide critical weld bead geometry data, and (3) to develop an untrasonic sensing capability to directly sense weld bead side-wall fusion and penetration. This project is part of a collaborative research program with the Massachusetts Institute of Technology.

A fundamental model of the gas metal arc welding process has been developed which considers wire melting and heat and mass transfer to the base metal. Although iterative numerical solution techniques are requires, finite difference/finite element methods are not used. A computer controlled welding machine has been built and used to demonstrate the ability to independently control the heat and mass input to the weld, using the above model in combination with an adaptive feedback control scheme. This work is being extended to allow real-time, optimized control of pulsed current welding to be achieved.

A pulsed laser enhanced, gated electro-optical sensor has been developed which suppresses most of the welding arc light, providing an image of the electrode wire, weld pool, and surrounding base metal which is suitable for image processing. Image processing techniques are being developed to obtain quantitative information from the above images regarding the weld pool geometry and position.

Direct sensing of the weld pool solid/liquid interface location is being developed using conventional pulse-echo ultrasonic transducers. Signal analysis/pattern recognition techniques are being developed for automated measurements. Signal generation by use of laser pulses directed on the weld pool surface is also being studied.

Keywords: Welding, Ultrasonic Sensing, Optical Sensing

210. Nondestructive Characterization of Fracture Dynamics and Crack Growth

FY 1986
$ 193,000

DOE Contact - Oscar P. Manley, 301-353-5822
Idaho National Engineering Laboratory Contacts - J. A. Johnson, 208-526-9021, B. A. Barna, 208-526-6124, R. A. Allemeir, 208-526-9588

The purpose of this research is to develop instrumentation and models to measure and predict the emission and interaction of ultrasound from growing cracks in engineering materials, and to investigate methods of sensing the properties of growing cracks.

Models of the ultrasonic field/crack interaction are based on a numerical ray-tracing algorithm and on a numerical (finite difference) solution to the partial differential equations (PDE) describing the system. In the ray-tracing model, an ultrasonic transducer, operating in the pulse-eco mode is assumed to be equivalent to a large number of spherical sources spread uniformly over the face of the transducer. The total field in the region of a crack is calculated as the sum of the fields from all these sources. The reflected and diffracted fields fromthe crack are calculated from the incident field from the transducer and a model of the field-crack interaction. These fields are then traced back to the transducer face and the integrated field across the face is determined.

In the finite difference model, a source of acoustic emission (AE) is modeled by changing boundary conditions and the ultrasonic fields that propagate from the source to a receiver are calculated. All mode conversions are automatically included in the numerical solution to the PDE with the boundary conditions of the system.

The dynamic crack growth measurements have used ultrasonics techniques to measure the properties of a growing crack. An advanced AE detection system is being developed which will be capable of detecting and digitizing AE signals at much higher frequencies than in convential systems. This will allow improved resolution in detecting the locations of the sources of emissions and in discriminating between types of sources.

This program is coordinated with the Elastic-Plastic Fracture Analysis program at INEL and the Modeling and Analysis of Surface Cracks at Massachusetts Institute of Technology.

Keywords: Nondestructive Evaluation, Fracture

211. Boiling of Aqueous Polymer Solutions FY 1986
$ 67,000

DOE Contact - Oscar P. Manley, 301-353-5822
University of Illinois at Chicago Contact - J. P. Hartnett, 312-996-4490

The goal of this research is to study the pool boiling behavior of aqueous polymer solutions, both purely viscous and viscoelastic with the objective of providing accurate boiling measurements using well-defined fluids. Detailed measurements of the transport and rheological properties of the test fluids are being carried out prior to and following the experiments. It has been determined that the chemistry (i.e., changes in the polymer structure as a result of increases in operating temperature level, interactions with the materials of the test section, etc.) plays a major role. Consequently, careful monitoring of the rheology is critical if the boiling results are to be meaningful. The direct measurements of the boiling heat flux and surface and fluid temperatures will be supplemented by photograhic studies to provide additional insight into the boiling process.

Measurements of free convection heat transfer from horizontal platinum wires to surrounding purely viscous and viscoelastic non-Newtonian fluids have been carried out prior to the boiling studies. For free convention to purely viscous non-newtonian fluids at Rayleigh numbers of the order of 10^{-2} to 1 it is found that the Nusselt number decreases with decreasing power law index whereas a high Rayleigh number Ra>>1, the Nusselt number increases with decreasing power law index. In the case of free convention to voscoelastic fluids the heat transfer measurements are in agreement with values predicted for Newtonian fluids provided that the zero shear rate viscosity is used for the viscoelastic fluid viscosity.

Keywords: Boiling, Polymers

212. Plasma Reduction of Metallic Oxide Particles FY 1986
$ 76,000

DOE Contact - Oscar P. Manley, 301-353-5822
MIT Contacts - J. F. Eliott, 617-253-3305, J. Szekely, 617-253-3236, R. E. Spjut, 617-253-0252

The objective of this research is to characterize the reduction to metal of oxide particles injected into the tail flame of an arc plasma. At the present time, it is not known if a significant degree of reaction occurs in flight, or if such reduction processes require a molten bath and, hence, a transferred arc plasma. The experimental method involves injecting mixtures of carbon and metallic oxide particles, in the size range of 20 to 100 microns, into an arc plasma just beyond the point of initial generation and sampling downstream at various distances with a sample, water-cooled suction cup. The particles thus removed from the plasma may be examined by microscopy and electron microanalysis to determine the extent of reduction.

Another important aspect of this work is to determine the rate of heat transfer between the plasma and injected solid particles. In a preliminary set of experiments, solid particles of varying thermophysical properties will be injected into the plasma and then collected. By sectioning and analyzing these particles it will be possible to establish the extent to which melting has in fact occurred. These experimental measurements will be critically compared with the theoretical predictions.

The new 50ks furnace has been installed and placed in operation. It can be operated in either the non-transferred arc or transferred arc mode. The system is equipped with automatically controlled devices for feeding powders into the plasma flame. Initial work has been begun on the physical and chemical modifications of simple oxide particles and composite carbon-oxide particles that have passed through the plasma flame.

This work is closely coordinated with the plasma modelling and gas-particle studies in progress at MIT, and with measurements of particle trajectories and temperatures of particles passing through plasma flames that are in progress at the Idaho National Engineering Laboratory.

Keywords: Plasma Processing

213. <u>High-Temperature Gas-Particle Reactions</u> | <u>FY 1986</u> $ 230,000

DOE Contact - Oscar P. Manley, 301-353-5822
MIT Contacts - J. F. Eliott, 617-253-3305, R. E. Spjut, 617-253-3305

The objective of the research program is to examine the physiocochemical behavior of individual inorganic particles in conditions simulating those to which particles are exposed in arc plasmas. In the experimental arrangement, a particle is suspended by the field in an electrostatic balance and it is heated in a laser beam. Manipulation of the charge on the particle and precise measurement of the strength of the field permits determination of the weight of the particle before and after the heating and cooling of the particle in the experiment. The composition of the gas in the reaction chamber is controlled, and the temperature of the particle can be measured and controlled with a time resolution as short as one or two milliseconds.

Experiments are in progress to determine the rate of volatilization of alumina and silica particles in various gas compositions, and the kinetics of reactions in composite carbon-alumina and carbon-silica particles.

This work is closely coordinated with the other plasma processing programs in the Department of Materials Science and Engineering at MIT and with the experimental program on plasma processing at the Idaho National Engineering Laboratory.

Keywords: Plasma/Particle Interaction

214. <u>Mathematical Modeling of Transport Phenomena in Plasma Systems</u> <u>FY 1986</u>
$ 102,000

DOE Contact - Oscar P. Manley, 301-353-5822
MIT Contact - J. Szekely, 617-253-3305

The purpose of this investigation is to develop a comprehensive mathematical representation of the electromagnetic force field, the velocity field, temperature field and chemical composition of plasma flames, together with their interaction with solid particles.

To date, computed results have been obtained describing the flow field, the temperatures and the composition of a non-transferred arc with swirl, with annular and sideways injected gas streams.

It has been shown that swirl plays a profound effect in modifying both the flow and the entertainment of the secondary and tertiary streams. These calculations should form the basis of the rational design of plasma reactors.

The theoretical predictions are being compared to measurements conducted at the Idaho National Engineering Laboratory.

Keywords: Plasma Systems, Transport Properties

215. <u>In-Process Control of Residual Stresses and Distortion in Automatic Welding</u> <u>FY 1986</u>
$ 87,000

DOE Contact - Oscar P. Manley, 301-353-5822
MIT Contact - Koichi Masubuchi, 617-253-6820

The objective of this research program is to develop the technology of in-process control of residual stresses and distortion in automatic welding. The program consists of the following three phases:

Phase 1: In-process control of residual stersses and distortion in some weldments.

Phase 2: Development of technologies for minimizing and eliminating, if possible, tack welds.

Phase 3: Plans for future advancement of the technology of in-process control of residual stresses and distortion.

The effort thus far covers primarily Phases 1 and 2. The program has been carried out smoothly as originally proposed.

Keywords: Automatic Welding, Control

216. <u>Investigation of Visible and Near Visible Light Emissions as Sensors for Control of Arc Welding Processes</u> <u>FY 1986</u>
$ 75,000

DOE Contact - Oscar P. Manley, 301-353-5822
MIT Contact - Thomas W. Edgar, 617-253-3229

The present research is part of a cooperative program among faculty at MIT and Staff at Idaho National Engineering Laboratory to develop sensing and control methods which can be used to automate the gas metal arc welding processes.

Recent research has mapped the light emissions spatially, temporally, and spectrally, from gas tungsten welding arcs. The experimental method makes use of a somewhat unique subtractive double monochromator, which provides a two dimensional image of the arc while filtering out all but a specific range of light wavenumbers. Thus it is possible to photograph the distribution of relatively weak elements in the arc without the disturbance of the strong argon or helium background spectra. By studying the emission of Mn or Cr onstainless steels, it is possible to see clearly the anode spot on the weld surface. Video movies of the spot movement are being made and will be analyzed to determine in true heat distribution on the weld surface. Spectra from arcs on several different materials have been relatively free of light. It is hoped that such regions will identify windows where it will be best to utilize the laser weld pool sensor being developed by INEL.

Additional work has begun on modeling of the mechanism of metal transfer in gas metal arcs. Experimentally, a laser backlit viewing system has been developed which permits viewing of anode and cathode jet phenomena, thus helping to determine the effect of gas flows on metal transfer. An image intensifier has been added to the subtractive double monochromator described above with the intent of studying the metal vapors produced during GMAW welding. This work interfaces with the experimental GMAW control system being developed at INEL.

Keywords: Welding, Optical Sensing

217. <u>Multivariable Control of the Gas-Metal Arc Welding Process</u>

FY 1986
$ 102,000

DOE Contact - Oscar P. Manley, 301-353-5822
MIT Contact - David E. Hardt, 617-253-2429

The process of Gas Metal Arc Welding (GMAW) involves many process control variables such as arc voltage, current, travel speed, wire feed rate, and voltage pulsing profile. These multiple inputs to the weld cause changes in multiple outputs such as weld width, depth, reinforcement height and thermal effects in the weldment. All existing work in closed-loop control of welding, however, has treated this highly coupled, multiple input-multiple output system as a single variable control problem, concentrating, for example, on controlling just the weld width or depth.

The objective of this work is to case the GMAW control problem in its most general sense and then examine the use of advanced multivariable control methods. We have begun this work at two extremes, one starting from a specific two-variable problem in GMAW for which models and measurements exist, and the other from a more basic, but idealized perspective. The former will allow us to quickly identify where gaps in our knowledge of the process and the characterization of the measurements exist, and allow us to perform initial experiments within the first year of the project. The latter will begin building a comprehensive framework for the solution of the complete control problem, defined as independent regulation of all relevant outputs while rejecting a significant range of system disturbances.

This project is coordinated with the experimental work at Idaho National Engineering Laboratory.

Keywords: Welding, Control

218. <u>Modeling of GMA Weld Pool Geometry and Metal Transfer</u>

FY 1986
$ 88,000

DOE Contact - Oscar P. Manley, 301-353-5822
MIT Contact - William Unkel, 617-253-2193

Realtime control of weld parameters such as weld pool geometry can reduce welding flaws and therefore increase the productivity of producing welded structures. One important component to achieving online control is a physically-based model of the welding process. For a complex process such as welding, models play several roles including:

(a) interpreting noisy and often indirect measurement data;
(b) identifying process modifications that make multivariable control easier; and

(c) providing a component of the actual control algorithm.

Previous modeling efforts have concentrated on the Gas Tungsten Arc Welding (GTAW) process and have laid the groundwork for the present work on the Gas Metal Arc Welding (GMAW) process.

The principal goal of the present work is to develop physically based, but computationally simple models for the GMAW stiuation and to use these models to identify process modifications to allow a more effective multivariable control system to be implemented. Those models will be confirmed by comparison with experimental data and will also be considered for use in online interpretation of sensor datas.

This research is coordinated with the experimental work at Idaho National Engineering Laboratory.

Keywords: Welding, Control

219. <u>Modeling and Analysis of Surface Cracks</u> <u>FY 1986</u> $ 200,000

DOE Contact - Oscar P. Manley, 301-353-5822
MIT Contacts - David M. Parks, 617-253-1630

This research focuses on the analysis of ductile crack initiation, growth and instability in part-through surface-cracked plates and shells. The overall approach consists of determining parametric limits of applicability of the "dominant singularity" formalism at nonlinear fracture mechanics in these crack configurations as they are influenced (principally) by material strain hardening, load biaxiality, and crack geometry. When such single-parameter dominance is obtained, correlations of crack response with J-integral or related measures may be justified. The analysis requires detailed finite element computations which are too costly for routine applications, so further development of simplified analytical models such as the so-called "line-spring" model is underway. Exploratory experiments are also being undertaken to probe effects of asymmetry of loading, prior plastic strain history, and other factors on subsequent ductile fracture. Load biaxiality effects have been simulated for axial tension and internal pressure loading on pipes containing a circumferential crack. Accepted solutions for J derived for tension alone can underestimate fully plastic biaxial J-values by up to an order of magnitude.

Recent developments have results in marked improvement in agreement between calculations and experimental data obtained in a parallel effort at INEL.

Keywords: Fracture

220. Thermal Plasma Processing of Materials FY 1986
$ 142,000

DOE Contact - Oscar P. Manley, 301-353-5822
University of Minnesota Contact - E. Pfender, 612-625-6012

A combined analytical/experimental program is carried out directed towards a better understanding of the interaction of particulate matter with thermal plasmas. One of the major objectives of the work is the development and diagnosis of a new plasma reactor which should solve the problems of particle injection, particle confinement, and particle dwell time in the plasma. Finally, it is intended to use this reactor for materials studies involving superconducting alloys.

The modeling work is primarily concerned with a detailed assessment of the relative importance of the numerous effects which determine heat, momentum, and mass transfer to and from particles injected into thermal plasmas. Diagnostic methods for the plasma include emission spectroscopy, laser Doppler anemometry, current, voltage, and calorimetric heat transfer measurements. Product powders will be analyzed using scalling and transmission electron microscopy, x-ray and electron diffraction, and measurements of the trnsition temperature for superconducting compounds.

Keywords: Plasma Processing, Plasma Diagnostics

221. Transport Properties of Disordered Porous Media from the Microstructure FY 1986
$ 90,000

DOE Contact - Oscar P. Manley, 301-353-5822
North Carolina State University Contact - S. Torquato, 919-737-2365

This research is concerned with the quantitative relationship between certain transport properties of a disordered porous medium that arise in various energy-related problems (e.g., thermal (and electrical) conductivity and the fluid permeability) and its microstructure. In particular, we shall focus our attention on studying the effect of: porosity, spatial distribution of the phase elements, interfacial surface statistics, phase conductivity, and size distribution of the phase elements, on the conductivity and permeability of models of both unconsolidated media (e.g., soils and packed beds of discrete particles) and consolidated media (e.g., sandstones and sintered materials).

The program has been broken down into four basic tasks: (1) the development of theoretical expressions for the bulk properties which depend upon the microstructure through various sets of statistical correlation functions, (2) the evaluation of these and other correlation functions that have arisen in the literature for nontrivial models of porous media, using results and methods of statistical mechanics, (3) the calculation of transport-property expressions which involve this statistical formulation, and (4) the comparison of theoretical results to experimental measurements of the conductivity and permeability of porous media. We are in the process of computing microstructure-sensitive property relations for models of porous media with heretofore unattained accuracy.

Keywords: Disordered Media

222. <u>Effects of Crack Geometry and Near-Crack Materials Behavior on Scattering of Ultrasonic Waves for QNDE Applications</u>

FY 1986
$ 65,000

DOE Contact - Oscar P. Manley, 301-353-5822
Northwestern University Contact - J. D. Achenbach, 312-491-5527

Among the methods of quantitative non-destructive evaluation of structural elements, the method based on scattering of ultrasonic (elastic) waves by flaws is particularly useful. The work on this project is concerned with applications of the scattered field approach to the detection and characterization of cracklike flaws. The work is both analytical and numerical in nature. Several forward solutions to model problems have proven to be very helpful in the design of experimental configurations. They have also provided invaluable aid in the interpretation of scattering data for the inverse problem. In recent work, numerical results have been obtained by the finite difference method (flaws near surfaces) and by the boundary element method (distribution of voids). The usual mathematical modeling of ultrasonic wave scattering by cracks is being extended to account for several typical characteristics of fatigue and stress-corrosion cracks, and the environment of such cracks. Work in in progress on scattering by a cloud of microcracks and/or a plastic zone, which surrounds a crack tip. Further parametric 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 idealized crack geometries and idealized material behavior.

Keywords: Nondestructive Evaluation, QNDE

223. <u>Inelastic Deformation and Damage at High Temperature</u>

FY 1986
$ 120,000

DOE Contact - Oscar P. Manley, 301-353-5822
Rensselaer Polytechnic Institute Contact - Erhard Krempl, 518-266-6432

A combined theoretical and experimental investigation is performed to study the biaxial deformation and failure behavior of AISI Type 304 Stainless Steel under low-cycle fatigue conditions at elevated temperature. The purpose is to characterize the material behavior in mathematical equations which are ultimately intended for use in inelastic stress analysis and life prediction. Creep-fatigue interation and ratcheting are of special concern. The long-term goal is the development of a finite element program that can directly calculate the life-to-crack initiation of a component under a given load history.

The previously-developed viscoplasticity theory based on overstress which uses neither a yield surface nor loading and unloading conditions will be augmented to include the effects of recovery and aging. This constitutive equation will be combined with an incremental damage accumulation law. It exists in uniaxial form and will be reviewed and extended to multiaxial, isotropic conditions. The theory will be checked against companion experiments.

For the experiments an MTS servohydraulic axial torsion test system is available together with an MTS Data/Control Processor. Induction heating (10 KHz frequency), MTS biaxial grips and an MTS biaxial extensometer will be used for the first time in this study of biaxial deformation and failure behavior.

At the temperature of interest (presumably 550°C or 600°C) tests will be conducted to ascertain whether aging and recovery are significant. Exploratory experiments and tests intended for identifying material functions of the theory will be performed. They include biaxial, high temperature low-cycle fatigue and ratcheting experiments. These test results and data from the literature are needed to find material constants and functions of the theory. Test results not used in determining the material properties provide for a check of the predictive capability of the theory.

Keywords: Fracture, Damage

224. <u>Energy Changes in Transforming Solids</u> <u>FY 1986</u>
$ 0

DOE Contact - Oscar P. Manley, 301-353-5822
Stanford University Contacts - George Herrmann, David M. Barnett, 415-723-4143

A variety of processes occurring in stressed deformable solids, such as void formation, void growth, motion of dislocations and point defects, grain boundary sliding, etc., are accompanied by energy changes. It is these energy changes which give rise to the concept of generalized configurational (or material) forces and provide a most promising way to characterize state changes and the processes in question. During the past year we have examined material forces associated with solids containing a specified distribution of dislocations and disclinations. Furthermore, a remarkably simple formula has been derived for calculating the hoop stress distribution along the boundary of a circular cavity in an infinite sheet containing arbitrary sources of internal stresses; the calculation can be made without solving an elastic boundary value problem. As several specific examples show, this formula is most useful for calculating energy release rates. Work on generalizing this approach to cavities of arbitrary shape is currently in progress.

Keywords: Stress Analysis, Materials Science

225. Nondestructive Testing | FY 1986 $ 115,000

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

The aim of this project is to arrive at techniques for contactless nondestructive testing and range sensing. Devices which can be rapidly scanned over a surface so as to detect flaws and measure their profiles are badly needed. The measurement of parameters such as surface roughness are also required. For this purpose, we are developing acoustic sensors operating in air and contactless photoacoustic techniques.

We have developed a new type of PZT ceramic acoustic transducer with a quarter wavelength matching layer of RTV rubber which operates in air in the frequency range of 1-8 MHz. The transducer itself has been used for range sensing and for photoacoustic measurements. As an example, it has enabled us to measure regions of high surface recombination rates on semiconductors by varying the number of injected carriers ina semiconductor, using a laser beam modulated at 2 MHz. We detect the rf term in the surface temperature due to recombination. Similar techniques have been used by use to measure film thicknesses and profiles.

We are now developing a new acoustic transducer operating in air which utilized a 1000 A thick pellicle of boron nitride as the detector of acoustic waves in the air. The deflection of the surface is measured by highly sensitive optical phase measurement of an optical beam reflected from the pellicle. The system is as sensitive as our previous acoustic transducer, but has the advantage that it can be operated over a bandwidth from a few Hz to several MHz.

Keywords: Nondestructive Evaluation, Acoustic Sensors

226. Effective Elastic Properties of Cracked Solids FY 1986
$ 107,000

DOE Contact - Oscar P. Manley, 301-353-5822
Tufts University Contact - Mark Kachanov, 617-628-5000, ext. 2821

Effective elastic properties of solids with cracks will be investigated on the basis of the new approach to many cracks problems developed recently by the author. The results will be sensitive to mutual positions of cracks within the representative volume and will be applicable up to quite high crack densities.

Keywords: Fracture, Elasticity

227. Electrochemical Wear Mechanism and Deposit Formation in Lubricated Systems FY 1986
$ 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 and 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

228. Elastic-Plastic Fracture Analysis Emphasis on Surface Flaws
FY 1986
$ 365,000

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 complies initially with requirements for linear elastic-fracture mechanics and extends beyond the range of a J-controlled field. Presently, compact tension and bend specimens 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 tests have been supplemented by data generated from Ti-15-3 heat treated to develop a plastic zone size of nominally 0.1 mm. 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

229. <u>Continuous Damage Theory</u> FY 1986 $ 44,000

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

The research conducted during the past year was focused on two seemingly disparate tasks; establishment of a common mathematical basis for the phenomenological models and formulation of a micromechanically based continuum damage model. As it turned out the two tasks had a lot in common. Using the effective field approximation it was possible to derive the compliance tensor for an elastic solid weakened by an ensemble of microcracks.

Once the essential structure of the analytical model was established it was possible to demonstrate that the so called scalar, second and fourth order tensor models are only the truncations of the general model. Moreover, the phenomenological model developed during the work on this project proves to be directly related to the micromechanical one. In other words, the proposed phenomenological model also contains the scalar, second and fourth order tensor models as special cases.

The so called Taylor approximation was used to simplify the analyses using the micromechanical model. The results in replicating the experimental trends are very encouraging.

The current plans are to further develop the formulated models with an ultimate objective of the combined brittle-dectile phenomena.

Keywords: Metals: Ferrous Including Steels, Fracture, Fatigue, Creep

230. <u>Loss Characteristics of Cord-Rubber Composites</u> <u>FY 1986</u>
$ 73,000

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

231. <u>A Study of the Chemical Mechanism in Lubrication</u>
<u>FY 1986</u>
$ 86,000

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

232. <u>Effects of Crack Geometry and Near-Crack Material Behavior on Scattering of Ultrasonic Waves for QNDE Applications</u>

FY 1986
$ 65,000

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

233. <u>Mechanical Interactions of Rough Surfaces</u>

FY 1986
$ 135,294

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

234. <u>Multiviewing Tranducer System</u> — <u>FY 1986</u> $ 241,000

DOE Contact - Oscar P. Manley, 301-353-5822
Ames Laboratory, Iowa State University Contact - D. O. Thompson, 515-294-5320

The objective of this project is to demonstrate a composite, multiviewing ultrasonic transducer system suitable for detecting, characterizing, and reconstructing flaws in structural materials for flaw sizing. 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. Automated data acquisition has been developed using seven transducer elements multiplexed for both pulse-echo and pitch-catch modes. 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. In the effort to improve the reconstruction reliability with a limited aperture, a multi-angle signal amplitude contour technique was developed which instructed the automated system to acquire data with the most favorable angular configuration. This technique has dramatically improved the reconstruction reliability for flaws oriented at a difficult tilt angle for the reconstruction. In addition, artificial intelligence may be incorporated to determine the shape and angular configuration of the flaw from the signal amplitude contours and the full reconstruction may be constrained by such predetermined information for greater stability and reliability. New techniques have also been developed for generating unipolar stress pulses in both pulse-echo and pitch-catch modes. These pulses show significantly broader bandwidths than do the usual ultrasonic pulses, a feature that is necessary in the application of inversion algorithms for flaw sizing. They are also important in the measurement of gradients of material properties. A new transducer system has also been designed using these advances that will extend reconstruction capabilities to include 2-D computed tomographic and 3-D ultrasonic reconstructions.

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.

235. Semiconductor Radiation Detector Technology — FY 1986 $ 390,000

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

236. Development of Advanced Internal Gain Radiation Detection Structures Based on Neutron Transmutation Doped Silicon

FY 1986
$ 260,000

DOE Contact - G. Goldstein, 301-353-534, FTS 233-5348
University of Southern California Contact - G. Huth, C13-822-9184

Silicon avalanche devices for radiation detection are being developed using neutron transmutation doped silicon single crystals. Successful development could provide an optically sensitive solid state alternative to the vacuum photomultiplier which would have many applications in medical and environmental research. Current-research focuses on studies of overall gain, gain uniformity, and entrance window development. Specific devices fortritium detection, position sensitive array detectors and hybrid photocathode/avalanche detectors are also under development.

Keywords: Semiconductors, Radiation Effects, In Implantation, Instrumentation or Technique Development.

Office of Fusion Energy

237. Plasma Materials Interaction and High Heat Flux Component Development Programs

FY 1986
$ 5,140,000

DOE Contact - M. M. Cohen, 301-353-4253
SNL 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 program 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."

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 discussed 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).

238. Alloy Development for Irradiation Performance (ADIP)

FY 1986
$ 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.

Keywords: Alloy Development, Neutron Radiation Effects, Reduced Activation Alloys, Steels

239. Damage Analysis and Fundamental Studies (DAFS)

FY 1986
$ 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 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.

240. Special Purpose Materials (SPM)

FY 1986
$ 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.

241. Tritium Breeding Materials FY 1986 $ 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.

242. Analysis and Evaluation FY 1986 $ 150,000

DOE Contact - T. C. Reuther, 301-353-4963
McDonnell Douglas Astronautics Co. Contact - J. Davis, 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.

243. Radiation Facilities Operation FY 1986 $ 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.

244. Operation of Oak Ridge Research Reactor FY 1986 $ 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.

Small Business Innovation Research Program

The Small Business Innovation Research (SBIR) program was established in compliance with the Small Business Innovation Development Act of 1982, Public Law 97-219. 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 about 6 months and awards are limited to $50,000. Phase II is the principal research or research and development effort, and awards can be 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 to be 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 materials-related projects, like all other projects in the DOE SBIR program, were selected using the specific evaluation criteria listed in the program solicitation. Conclusions were reached on the basis of detailed reports returned by reviewers drawn from DOE laboratories, universities, private industry, and government. In the case of Phase II, if 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 supported in this program represents high-risk research, but the potential benefits are also high if the objectives are met. Brief descriptions of all DOE SBIR projects (not just those of interest in materials research) are given in the following publications: Abstracts of Phase I Awards, 1985 (DOE/ER-0181/2), Abstracts of Phase II Awards, 1984 (DOE/ER-0209), and Abstracts of Phase II Awards, 1985 (DOE/ER-0209/1). Copies of these publications may be obtained by calling Mrs. Gerry Washington on 301-353-5867.

OFFICE OF NUCLEAR ENERGY

The Office of Nuclear Energy conducts research projects in the Division of HTGR which includes the Office of of Terminal Waste Disposal and Remedial Action; the Office of Uranium Enrichment; the Office of Reactor Systems, Development, and Technology; the Office of Breeder Technology Projects; and the Office of Naval Reactors. Summarized below are the areas of research in which the Department is currently engaged.

Division of High Temperature Gas-Cooled Reactors

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 Gas-Cooled Reactor (HTGR). 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, and heat exchanger tubing and tube sheets. The DOE contact for these projects is J.E. Fox, 301-353-3985.

245. Fuel Process Development

FY 1986
$ 690,000

DOE Contact - J. E. Fox, 301-353-3985
GA Technologies Contact - O. M. Stansfield, 619-455-2895

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°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

246. Fuel Materials Development

FY 1986
$ 940,000

DOE Contact - J. E. Fox, 301-353-3985
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 and advanced process heat HTGRs. These efforts are focused on the low enriched uranium-oxycarbide/thorium-oxide fuel system. 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

247. Fuel Development and Testing | FY 1986 $ 880,000

DOE Contact - J. E. Fox, 301-353-3985
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 and advanced process heat HTGRs. 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

248. Graphite Development | FY 1986 $ 580,000

DOE Contact - J. E. Fox, 301-353-3985
GA Technologies Contact - R. Vollman, 619-455-3310

This work includes the selection, characterization, and qualification of graphite materials for applications in HTGRs. 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 support components, and with sufficient oxidation resistance to be qualified for core 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

249. Graphite Development and Testing FY 1986
$ 575,000

DOE Contact - J. E. Fox, 301-353-3985
ORNL Contact - W. P. Eatherly, 615-574-5220

This work supports the selection, characterization, and qualification of graphite materials for applications in HTGRs. These efforts are focused on the development of an improved fundamental understanding of the behavior of graphite under representative HTGR 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 core support 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

250. Metals Technology Development FY 1986
$ 840,000

DOE Contact - J. E. Fox, 301-353-3985
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 HTGR system, and development efforts to provide the base technology required for selection of alloys for advanced 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

251. Structural Materials Development FY 1986
$ 470,000

DOE Contact - J. E. Fox, 301-353-3985
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 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.

Keywords: Alloys, Strength, Corrosion, Joining, Microstructure, High Temperature Service

252. Advanced Gas Reactor Materials Development — FY 1986 $ 1,205,000

DOE Contact - J. E. Fox, 301-353-3985
General Electric Co. Contact - O. F. Kimball, 518-385-1086

This work includes the identification, evaluation, and development of the high temperature alloys required for application in advanced HTGRs that will operate at temperatures above 750°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 Reactors 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 accordance with national policies and goals. Although no separately identified materials program exists within the projects being sponsored by the division, materials testing and development work is underway within severl 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.

253. <u>Technical Support to West Valley Demonstration Project</u> <u>FY 1986</u> $ 4,500,000

DOE Contact - H. F. Walter, 301-353-4728
PNL Contact - H. C. Brouns, 509-376-0731

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

Keywords: Radioactive Waste Host

254. <u>Materials Characterization Center Testing of West Valley Formulation Glass</u> <u>FY 1986</u> $ 520,000

DOE Contact - H. F. Walter, 301-353-5510
PNL Contact - M. Kreiter, 509-375-2666

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

255. <u>Nuclear Waste Treatment</u> <u>FY 1986</u> $ 0

DOE Contact - H. F. Walter, 301-353-4728
PNL Contact - R. A. Brouns, 509-376-0731

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

Keywords: Radioactive Waste Host

256. <u>Test Development and Testing of West Valley Reference Formulation Glass</u> <u>FY 1986</u> $ 510,000

DOE Contact - H. F. Walter, 301-353-5510
CUA Contact - P. B. Macedo, 202-635-5327

Vitreous State Laboratory, Catholic University of America (CUA), is developing borosilicate glass waste form test methods and is testing nonradioactive reference West Valley Demonstration Project waste formulation glass.

Keywords: Radioactive Waste Host

257. Process and Product Quality Optimization for West Valley Waste Form

FY 1986
$ 290,000

DOE Contact - H. F. Walter, 301-353-5510
AU Contact - L. D. Dye, 607-871-2432

Alfred University (AU) is contributing to maximizing the range of conditions around the optimum which will produce acceptable quality borosilicate glass waste form product and to methods for control of product quality during routine manufacture of the West Valley Demonstration Project waste form.

Keywords: Radioactive Waste Host

258. Special Waste Form Lysimeter for Arid Regions

FY 1986
$ 75,000

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

259. Special Waste Form Lysimeter for Humid Regions

FY 1986
$ 100,000

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 radionuclide emigration from solidifed commercial low-level waste in order to evaluate the benefits of solidification.

Keywords: Radioactive Waste Host

Office of Uranium Enrichment

The specific statutory authority which established the Department of Energy's role in the enrichment of uranium is the Atomic Energy Act of 1954, as amended. 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, secure, 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 the uranium enrichment enterprise. Uranium enrichment is composed of four major offices: Marketing and Business Operations, Operations and Facility Reliability, Technology Deployment and Strategic Planning, and Advanced Technology Projects and Technology Transfer. The Office of Marketing and Business Operations is responsible for enrichment service sales, contracting, supply policy formulation, marketing, financial management, enterprise budgets, and enrichment demand/economic analyses. Operations and Facility Reliability is responsible for overseeing all aspects of the gaseous diffusion plants including the electrical power contracts which are a major cost element. The Technology Deployment and Strategic Planning Office is responsible for integrating production, business, marketing and technology development plans into a single strategic plan for the uranium enrichment enterprise. This includes working with the private sector to determine optimum means of financing new technology deployment. The Office of Advanced Technology Projects and Technology Transfer is responsible for all research/development/demonstration and generation of production plant concepts for the Atomic Vapor Laser Isotope Separation (AVLIS) technology.

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 1986 was $855 million.

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 1986 was $37,332,000. The DOE contact is A.P. Litman, (301) 353-5777.

260. <u>Gaseous Diffusion: Barrier Quality</u> <u>FY 1986</u>
$ 1,088,000

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.

Keywords: Nuclear Fuel Isotopic Separations, Gaseous Diffusion, Barrier, Uranium

261. Gaseous Diffusion: Materials and Chemistry Support

FY 1986
$ 3,080,000

Routine materials and chemistry support of the diffusion plants. Characterization of contaminant-process gas cascade reactions, physical/ chemical properties of UF_6 substances, corrosion of materials, failure analyses, trapping technology, alternative materials replacement.

Keywords: Nuclear Fuel Isotopic Separations, Uranium

Atomic Vapor Laser Isotope Separation (AVLIS)

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.

In June 1986, DOE selected AVLIS for further development and possible future deployment into the uranium enrichment enterprise. The primary emphasis for AVLIS in FY 1986 was to provide the groundwork for significant full-scale operational engineering demonstrations in the next few years. Available resources were focused on this goal and also on the operation of existing testbeds to conduct and evaluate key subsystems. AVLIS continued the development and operation of the first phase of a Laser Demonstration Facility, which is a copper vapor laser pumped dye laser system. In addition, a one-half scale separator facility is planned for operation in FY 1987 to provide component development and design data for a full scale Separator Demonstration Facility (SDF). The SDF atomic vapor source will be tested and operated for extended periods of time. Most of the AVLIS materials activities in FY 1986 revolved around the process separator development.

262. Separator Technology Development

FY 1986
$ 33,164,000

Coating development for various substrates to contain uranium and development/demonstration of engineering subcomponents. Approximately $10,200,000 of the amount shown was and will be used for materials selection, property evaluation and analysis.

Keywords: Enrichment, Gaseous Diffusion, Uranium, Laser Isotope Separation, Atomic Vapor Laser Isotope Separation (AVLIS)

Office of Reactor Systems, Development and Technology

Division of Special Applications

The Division of Special Applications 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.

263. Development of Improved Thermoelectric Materials for Space Nuclear Power Systems

FY 1986
$ 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 systematic study of compositional (i.e., alloy and dopant additions) and processing (i.e., powder preparation techniques, including rapid solidification powder particle size, hot pressing, variables, etc.) parameters. 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 $1 X 10^{-3o}C^{-1}$ over the temperature range of 300^oC to 1000^oC.

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 $1.3 X 110^{3o}C^{1}$ over the temperature range of 300^oC to 1000^oC. 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

264. Development of an Improved Process for the Manufacture of DOP-26 Iridium Alloy Blanks FY 1986
$ 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: Non-ferrous Metals, Extrusion, High Temperature Service

265. Carbon Bonded Carbon Fiber Insulation Manufacturing Process Development and Product Characterization FY 1986
$ 355,000

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 (CBCF) type thermal insulation material is employed in Isotopic General Purpose Heat Source (GPHS) Module assemblies for use in current GPHS-RTG (radio-isotope 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 (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

266. Nondestructive Testing Methods Development and Application to Thermoelectric Materials and Devices FY 1986
$ 175,000

DOE Contact - W. J. Barnett, 301-353-3097 (FTS 233-3097)

No Submission Received

267. Characterization of State-of-the-Art Thermoelectric Device/Materials and Exploratory Studies of Rare Earth Sulfide Thermoelectric Materials FY 1986
$ 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, Thermoelectrics

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, noibium, 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.

Fuels and Core Materials Division

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 for the Fuels and Core Materials Division is Dave Nulton, 301-353-5004. Detailed project summaries were not submitted; project titles and funding are however, listed below.

Oxide Fuel Development - CDE	$4,131,000
Technology Development Support for IFR	$2,400,000
Qualification of 9 Cr-1 Mo Steel for LMF Applications	$ 300,000
Absorber Development	$ 384,000
Metallic Fuel Development	$ 380,000
Mechanical Properties of Materials for LMR Applications	$ 48,000
Structural Design/Life Technology	$ 385,000
Integral Fast Reactor (IFR) Fuel Performance Demonstration	$3,888,000
Oxide Fuel Development - Fuels and Materials Development	$ 866,000
Clad/Duct Alloy Development	$ 0

Materials and Structures Division

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 and Structures Division is Nick Grossman, 301-3533405. Detailed project summaries were not submitted.

High Temperature Structural Design, Mechanical Property Design Data, Tribology Coolant Technology, Fabrication, Handbook, and Advanced Alloy Development	$4,700,000

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 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 1986 including over $30 million as the cost for irradiation testing in the Advanced Test Reactor. The DOE contact is Robert H. Steele, 557-5561.

Office of Storage and Transportation Systems

268. Development of Criteria for Nuclear Spent Fuel Storage in Air

FY 1986
$ 600,000

DOE Contact - D. E. Shelor, 202-586-2836
PNL Contact - E. R. Gilbert, 509-375-2533

This project performs applied research to characterize the oxidation behavior of commercial UO_2 spent nuclear fuel. In case a few spent fuel assemblies containing fuel rods with undetected reactor induced breached cladding are placed into dry storage, this research will assure that dry storage conditions will not permit significant oxidation of the exposed UO_2. Laboratory tests are being conducted to determine the oxidation behavior of spent fuel and unclad UO_2. The tests are in the range of 135 to 230°C and the test matrix was statistically designed to provide data to determine acceptable fuel temperatures and storage criteria. Test variables also include an imposed gamma field, typical of that in a dry storage cask, and moisture and burnup levels bracketing those encountered in a dry storage cask.

Keywords: Spent Nuclear Fuel, UO_2 Oxidation, Interim Dry Storage, Fuel Degradation

269. Development of Zircaloy Deformation and Creep Rupture Models for Predictive Cladding Behavior During Interim Dry Storage

FY 1986
$ 80,000

DOE Contact - D. E. Shelor, 202-586-2836
PNL Contact - E. R. Gilbert, 509-375-2533

This project predicts the temperature-time conditions to which commercial LWR spent fuel can be exposed during interim dry storage without undergoing significant creep rupture of the Zircaloy fuel cladding. It uses the existing data base on nonirradiated Zircaloy cladding to develop theoretical models for deformation and creep rupture for spent fuel interim dry storage conditions, and uses the models to predict the envelope of acceptable temperature-time storage conditions. Models of deformation include diffusional creep, grain boundary sliding, and diffusion controlled dislocation creep. Models of degradation by creep include transgranular cracking, triple point cracking, and cavitation. A comparison of predictions with the

Federal Republic of Germany deformation and creep rupture data on spent fuel rods and irradiated Zircaloy cladding provide a means of verifying the predictions for these prototypic cases.

Keywords: Cladding Rupture, Spent Nuclear Fuel, Zircaloy Cladding

270. <u>Behavior of Water-Logged Spent Fuel During Interim Dry Storage</u>

<u>FY 1986</u>
$ 80,000

DOE Contact - D. E. Shelor, 202-586-2836
PNL Contact - E. R. Gilbert, 509-375-2533

This project performs tests with water-logged spent nuclear fuel to determine their behavior under dry storage conditions. Spent fuel rods with reactor breaches tend to become water-logged. The tests with water-logged spent fuels are designed to determine the moisture inventories and moisture release characteristics from Zircaloy-clad UO_2 during dry storage system drying operations. The tests are performed in the temperature range of 100 to 400°C. The results are expected to reveal if sufficient moisture is released to the storage system to react with cesium and form products corrosive to the storage system components and seals.

Keywords: Spent Nuclear Fuel, Water-Logged Spent Fuel, Moisture Release

<u>Basalt Waste Isolation Project Waste Package Materials Development</u>

271. <u>Metal Barriers Development for Nuclear Waste Packages</u>

<u>FY 1986</u>
$ 1,780,000

DOE Contact - P. E. Lamont, 509-376-6117
Rockwell Hanford Operations Contact - T. B. McCall, 509-376-7114

The objective of the waste package container materials program is to identify and characterize a waste package container material that will provide reasonable assurance of nuclear waste containment for 1000 years in a repository mined in basalt. Materials being considered include low carbon steel, Fe9Cr1Mo steel, copper and 90-10 cupronickel. Investigations include uniform and pitting corrosion testing and testing for environmentally assisted cracking under air-steam, hydrothermal and irradiated conditions expected for a repository constructed in basalt. Data will be used to provide a mechanistic understanding of container degradation and to establish waste package container design requirements.

Keywords: Metals, Ferrous and Non Ferrous, Radioactive Waste Host, Corrosion, Aqueous; Radiation Effects, Nuclear Waste Disposal, Predictive Behavioral Modeling

272. <u>Packing Materials Development for Nuclear Waste Packages</u>

<u>FY 1986</u>
$ 1,280,000

DOE Contact - M. J. Furman, 509-376-7062
Rockwell Hanford Operations Contact - P. F. Salter, 506-376-7207

Crushed basalt and sodium bentonite clay composites are being investigated for use as a packing material around nuclear waste containers which will retard/limit long term radionuclide release from the waste package under conditions expected for a repository constructed in basalt.

273. <u>Waste Package Materials Integrated Testing</u> <u>FY 1986</u>
$ 2,850,000

DOE Contact - M. J. Furman, 509-376-7062
Rockwell Hanford Operations Contact - P. F. Salter, 509-376-7207

The objective of the waste package integrated testing program is to investigate waste package component interactions related to controlling release of radionuclides from the waste package. This information is required in order to determine if the waste package will meet assigned radionuclide release rate design objectives systems. The systems studied include various combinations of the following components: fully radioactive waste forms (spent fuel or borosilicate glass), metal container, packing, basalt host rock and groundwater. The tests are conducted under hydrothermal conditions expected for a repository mined in basalt using Dickson, Parr and flow-through autoclaves. Parameters evaluated during testing include bulk solution composition, radionuclide concentrations, solid phase alteration and system redox conditions. Concentration data are used directly in models analyzying radionuclide release from the waste package; other data collected are used in evaluating the long term (10,000 year) controlled release performance of the waste package.

Keywords: Radioactive Waste Host, Nuclear Waste Disposal, Solubility, Spent Fuel Dissolution, Glass Dissolution, Glass & Refractory Ceramics, Predictive Behavioral Modeling

274. <u>Waste Package Container Welding and NDE Process Development</u>

<u>FY 1986</u>
$ 70,000

DOE Contact - P. E. Lamont, 509-376-6117
Rockwell Hanford Operations Contact - T. B. McCall, 509-376-7114

The objective of this program is to develop a remote welding and non-destructive examination process for waste package containers which will ensure the integrity of the welds such that they have the same corrosion resistance as the base metal in the expected nuclear waste repository environment. The sealed container is being designed to achieve a lifetime of 1000 years for containment of high level nuclear waste. The candidate materials include low carbon steel, cupronickel and copper.

Keywords: Radioactive Waste Host, Metals, Joining/Welding, NDE

275. Waste Package Packing Fabrication Process Development

FY 1986
$ 100,000

DOE Contact - P. E. Lamont, 509-376-6117
Rockwell Hanford Operations Contact - R. B. McCall, 509-376-7114

The objective of this program is to develop a fabrication and emplacment process for waste package packing which will ensure that the packing will meet its post-closure performance requirements. These requirements include structural integrity to limit the flow of groundwater around the nuclear waste container to values sufficiently low to ensure mass transport is dominated by diffusion. The packing consists of a mixture of crushed basalt rock and sodium bentonite clay. The material will be mixed with water and formed into compacted rings and cylinders to envelope the nuclear waste container and provide an engineered barrier between the container and the mined repository borehole wall.

Keywords: Radioactive Waste Host, Nuclear Waste Disposal, Clay, Basalt, Consolidation, Composites (Packing)

276. High Temperature pH and eH Probe Development

FY 1986
$ 150,000

DOE Contact - M. J. Furman, 509-376-7062
Rockwell Hanford Operations Contact - P. F. Salter, 509-376-7207

The objective of this program is to develop high temperature (100-300^{o}C) pH and eH probes for use in the engineered barriers integrated testing program in order to directly measure pH and eH in the systems studies. Ytrium doped zirconia is being investigated for the pH probe and platinum for the Eh probe. A reference electrode also is being developed for the system. These probes are being designed for use in permeameters and high temperature autoclaves currently in use in the waste package materials testing program. The probes are also being designed for use in fully radioactive experiments requiring hot cells.

Keywords: Instrumentation or Technique Development, Hydrothermal, Redox Probe, Nuclear Waste Disposal, pH Probe, Electrochemical

Office of Geological Repositories Nevada Nuclear Waste Storage Investigations Project (OGR/NNWSI)

The primary goal of the OGR/NNWSI materials program is the development of tuff specific waste packages that meet the performance requirements of the NRC criteria and are cost effective. This goal requires the definition of physical and chemical conditions of the site, selection of package materials, waste package design activity, prototype waste package fabrication, and performance testing.

277. Waste Package Environment | FY 1986 $ 970,000

DOE Contact - D. L. Vieth, 702-295-3662
LLNL Contacts - J. Yow; V. Oversby, 415-423-2228; William Glassley, 415-422-6499

Characterize the time-dependent behavior of the hydrogeologic environment in which the waste packages will reside in order to establish the envelope of conditions that define package design parameters, materials testing conditions, and boundary conditions for performance analysis.

Keywords: Near Field Environment

278. Waste Form Testing | FY 1986 $ 2,285,000

DOE Contact - D. L. Vieth, 702-295-3662
LLNL Contacts - J. Yow; V. Oversby, 415-423-2228; R. Aines, 415-423-7184

Develop a fabrication and emplacement process for waste package packing which will ensure that the packing will meet its post-closure performance requirement to limit water flow around the waste package to that necessary to ensure mass transport is dominated by diffusion.

Characterize the behavior of and determine the radionuclide release rates for the various waste forms in the geological tuff environment and as modified by corrosion products in the Metal Barrier Testing.

Keywords: Radioactive Waste Host, Materials Degradation

279. Metal Barrier Testing | FY 1986 $ 3,100,000

DOE Contact - D. L. Vieth, 702-295-3662
LLNL Contacts - J. Yow, V. Oversby, 415-423-2228; R. D. McCright, 415-423-7051

Characterize the behavior of and determine the degradation modes and rates for candidate metallic barrier materials in the environment. This information is needed to establish the data base to support license applications predictions of containment of radioactivity for times required by NRC 10 CFR 60. Characterize the properties and behavior of other engineered barrier waste package components that may be present in a repository.

Keywords: Materials Degradation, Radioactive Waste Host

280. Other Engineered Barrier Waste Package Components

	FY 1986
$	100,000

DOE Contact - D. L. Vieth, 702-295-3662
LLNL Contacts - J. Yow; V. Oversby, 415-423-2228

Characterize the properties and behavior of other engineered barrier waste package components that may be present in a repository. This information is needed to establish the predicted performance of other materials, such as packing materials, that may be present to assist waste forms and metal barriers in meeting NRC 10 CFR 60 performance requirements.

Keywords: Near Field Environment

281. Integrated Testing

	FY 1986
$	410,000

DOE Contact - D. L. Vieth, 702-295-3662
LLNL Contact - J. Yow; 415-423-2228

Characterize the integrated behavior of the waste form, barrier materials, and surrounding environment. Determine thermodynamic properties of Actinide and fission products.

282. Waste Package - Performance Assessment

	FY 1986
$	600,000

DOE Contact - D. L. Vieth, 702-295-3662
LLNL Contacts - J. Yow; V. K. Eggert, 415-423-6779

Provide a quantitative prediction of long-term waste package performance. This information, including uncertainties, is needed to provide feedback to design optimization studies, to demonstrate compliance with NRC performance objectives for the Waste Package Subsystem, and to provide a source term for the Engineered Barrier System and the Total System performance assessments required by NRC 10 CFR 60 and EPA 40 CFR 191.

Keywords: Waste Package Performance, Uncertainty Analysis

283. Research on Geochemical Modeling of Radionuclide Interaction with a Fractured Rock Matrix

FY 1986
$ 1,013,000

DOE Contact - D. L. Vieth, 702-295-3662
LLNL Contact - J. Yow; K. Eggert, 415-423-6779; D. Emerson, 415-422-6504; T. Wolery, 415-423-5789

Further develop the geochemical modeling code EQ3/6 for use in long-term predictions of radionuclide release from a nuclear waste repository.

Keywords: Goechemical Modeling, Computer Modeling, Rock-Water-Waste Interaction

284. Sealing Materials Evaluation

FY 1986
$ 220,000

DOE Contact - D. L. Vieth, 702-295-3662
Penn State University Contact - D. M. Roy
LANL Contact - C. Duffy, 505-843-5154

Develop sealing materials for fractures, boreholes, and access shafts and drifts and assess their chemical stability and possible effects upon water chemistry. In particular, determine how changes in mineralogy or dissolution may affect the permeability of the seals and if interaction between water and seals can change the water chemistry in such a way as to increase waste-element solubility.

Keywords: Radioactive Waste Host

285. Spent Fuel Storage in Crystalline Rock

FY 1986
$ 75,000

DOE Contact - D. L. Vieth, 702-295-3662
LLNL Contact - J. Yow, 415-422-3521

Demonstrate the feasibility of short-term storage and retrieval of spent, unreprocessed fuel; measure the response of a crystalline rock mass to simulated repository conditions and use these data to validate thermal and thermomechanical models; and compare the effects of heat alone and heat in combination with intense ionizing radiation on a crystalline rock mass.

Keywords: Radioactive Waste Host; Crystalline Rock; Field Testing

286. Waste Package - Design, Fabrication and Prototype Testing

FY 1986
$ 555,000

DOE Contact - D. L. Vieth, 702-295-3662
LLNL Contacts - J. Yow; L. Ballou, 415-422-4911; T. Nelson, 415-422-0306

Develop, analyze, fabricate, and test waste package designs that incorporate qualified materials which are fully compatible with the repository design. This work supports license application by demonstrating conformance with requirements for safe handling, emplacement, possible retrieval, and credible accident conditions per NRC 10 CFR 60 and 40 CFR 191 in a cost-effective manner.

Keywords: Radioactive Waste Package Development

287. <u>Waste Package Environment Field Tests</u> <u>FY 1986</u> $ 810,000

DOE Contact - D. L. Vieth, 702-295-3662
LLNL Contacts - J. Yow; L. Ballou, 415-422-4911; J. Yow, 415-423-3521

Develop a detailed engineering test plan for the waste package environment in situ testing program and evaluate, design, fabricate, and test thermomechanical and hydrologic instrumentation for waste package in situ test measurements.

Keywords: Radioactive Waste Packaging Tests; Instrumentation Development; Field Testing

<u>Salt Repository Project</u>

The Salt Repository Project has sponsored a Waste Package Program at PNL that has the objective of conducting nuclear waste package component development and interactions testing, and applying the resulting database to the development of predictive models describing waste package degradation and radionuclide release.

288. <u>Waste Form Evaluation Task</u> <u>FY 1986</u> $ 809,000

DOE Contact - K. K. Wu, FTS 976-5916
PNL Contact - D. J. Bradley, 509-375-2587

The primary objective of this task is to evaluate and understand radionuclide release from spent fuel in a realistic salt repository environment. Since reprocessing of commercial spent fuel is not currently being pursued, the primary form to be considered for repository disposal is unreprocessed spent fuel.

Keywords: Waste Nuclear Fuel, Radionuclide Release

289. <u>Waste Package Environment Studies</u> <u>FY 1986</u> $ 433,000

DOE Contact - K. K. Wu, FTS 976-5916
PNL Contact - D. J. Bradley, 509-375-2587

The purpose of this task is to help define the most probable range of environments to be encountered by a high level nuclear waste package emplaced in a repository in salt, and to determine solubilities of radionuclides in these environments. Factors that contribute to failure of the waste package container and those contributing to radionuclide release after containment failure are considered in the near field of the container (within approximately 1 meter of the package). Definition of the expected range of near field environmental conditions is needed by container materials and waste form testing tasks, and is essential in performance assessment activities.

Keywords: Radioactive Waste Host

290. Metal Barrier Testing | FY 1986 $ 1,693,000

DOE Contact - K. K. Wu, FTS 976-5916
PNL Contact - D. J. Bradley, 509-375-2587

The objective of this task is to test and evaluate selected materials for potential application as long-lived nuclear waste package structural/ containment barriers. Candidate materials have been selected by means of literature reviews and corrosion and environmental-mechanical screening studies. For example, the uniform corrosion rate and stress-corrosion-cracking susceptibility of a low-carbon cast steel is currently being determined in simulated intrusion and inclusion brine environments. Ultimately, accelerated testing methods will be employed, using environments relevant to anticipated repository conditions, to enable predictions to be made of barrier longevity. The resulting data will be useful to the WPP modeling task for development of predictive models and to waste package designers.

Keywords: Corrosion, Radioactive Waste Host

291. Defense Glass Testing | FY 1986 $ 400,000

DOE Contact - K. K. Wu, FTS 976-5916
Pacific Northwest Laboratory Contact - L. G. Morgan, 509-375-3874

No submission received

292. Repository Seal Materials Development Task | FY 1986 $ 664,000

DOE Contact - R. B. Lahoti, FTS 976-5916
Science Applications International Corp. Contact M. B. Gross, 415-351-7807

Laboratory experiments will be designed and conducted leading to the identification of specific compositions and/or forms of the candidate sealing materials (salt, cementitious materials, and earthen materials) that appear, on the basis of performance criteria generated in another project and other considerations, to be acceptable for use as a seal component in penetrations in the salt repository. The justification for selection of material compositions and/or forms will require considerations of emplacement technology, longevity, and interactions with the penetration containing units (host rock or liner) in addition to engineering property considerations.

Keywords: Radioactive Waste Host, Sealing Materials

293. Materials Characterization Center — FY 1986: $ 258,000

DOE Contact - K. K. Wu, FTS 976-5916

No submission received

Sandia National Laboratories: Brittle Fracture Technology Program

The objective of this program is to qualify alternate materials (other than stainless steel) for use in nuclear spent fuel cask construction. Candidate materials include nodular cast iron and ferritic steel. The main technical issue which must be addressed is the application of fracture mechanics to cask analysis and design. Materials, such as nodular cast iron, exhibit a ductile/brittle failure mode transition. Hence, a cask constructed out of this material may be susceptible to brittle fracture under certain environmental and loading conditions. The application of fracture mechanics can provide the cask analyst/designer the ability to guarantee ductile cask material response to design loadings.

294. Microstructure Investigation of Nodular Cast Iron — FY 1986: $ 25,000

DOE Contact - F. Falci, FTS 233-5466
SNL Contact - K. B. Sorenson, 505-844-5360

Standard metallography techniques are being used to quantify graphite nodule size and spacing in sample test specimens used for obtaining fracture toughness values. A strong correlation is evident between nodule size and spacing and fracture toughness. Similar studies were done to establish the effect of nodule size and spacing on tensile properties (tensile strength and ductility).

Keywords: Fracture Toughness, Nodular Cast Iron

295. Composition Investigation of Nodular Cast Iron — FY 1986: $ 25,000

DOE Contact - F. Falci, FTS 233-5466
SNL Contact - K. B. Sorenson, 505-844-5360

The investigation concluded that compositional features controlled the tensile behaviors of nodular cast iron, particularly nickel and silicon. Compositional features had no apparent effect on fracture toughness.

The conclusion drawn from the above two studies was that fracture is a phenomena controlled by microstructural features, whereas tensile properties (ductility) are controlled by compositional features. There is no apparent mechanistic link between fracture toughness and ductility.

Keywords: Microstructure, Nodular Cast Iron

296. <u>Generate Material Property Database for Nodular Cast Iron</u>
<u>FY 1986</u>
$ 140,000

DOE Contact - F. Falci, FTS 233-5466
SNL Contact - K. B. Sorenson, 505-844-5360

Existing material property data for nodular cast iron are being assimilated into a common format. Data sources include technical reports and industry (foundries and cask vendors). In addition, testing is being performed to fill in gaps of the existing database. Significant lack of data includes fracture toughness values as a function of strain rate and temperature. The main focus of the testing program is to generate fracture toughness values for nodular cast iron.

Keywords: Database, Fracture Toughness, Nodular Cast Iron

297. <u>Investigate the Feasibility of Using Depleted Uranium as a Structural Component in Cask Construction</u> <u>FY 1986</u>
$ 5,000

DOE Contact - F. Falci, FTS 233-5466
SNL Contact - K. B. Sorenson, 505-844-5360

A brief literature search was conducted to determine the feasibility of using depleted uranium (DU) as a structural component in cask body construction. Sandia has performed a study (1982) to identify material properties pertinent to structural considerations. The material may be suitable for this application. It exhibits a relatively strong toughness and high tensile strength. A 2 percent Mo alloy exhibits better mechanical properties than unalloyed DU. An extensive testing program would be required to qualify this material for cask construction. Fracture toughness values as a function of strain rate and temperature need to be generated.

Keywords: Radioactive Waste Casks, Uranium

298. <u>Evaluate Current NDE Methods for Applicability to Thick Section Nodular Cast Iron</u> <u>FY 1986</u>
$ 130,000

DOE Contact - F. Falci, FTS 233-5466
SNL Contact - K. B. Sorenson, 505-844-5360

Sandia has contracted with the National Bureau of Standards to perform an evaluation of current NDE procedures. The nature of nodular cast iron requires a study limited to this candidate material. The nodularity of the graphite tends to inhibit NDE sensitivity. The thick-walled nature of the casks pose additional restrictions on the sensitivity of NDE procedures.

Keywords: Nondestructive Evaluation, Nodular Cast Iron

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

Applied research and development oriented toward producing controlled thermonuclear fusion reactions in a laboratory environment for military and energy applications.

Fusion Research Division

299. Target Fabrication — FY 1986 $ 1,500,000

DOE Contact - Carl B. Hilland, 301-353-3687
LANL Contact - Richard Mah, 505-667-3238
KMS Fusion, Inc. Contact - Timothy Henderson, 313-769-8500, ext. 302
LLNL Contact - W. Hatcher, 415-422-1100

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: Inertial Fusion, Target Fabrication

300. <u>Laser Materials and Optical Components</u> FY 1986 $ 1,500,000

DOE Contact - Carl B. Hilland, 301-353-3687
LLNL Contact - E. Storm, 415-422-0400
KMS Fusion, Inc. Contact - A. Glass, 313-769-8500
University of Rochester Contact - R. McCrory, 716-275-5286

This project is concerned with developing Nd:glass amplifier discs and optical components for kilojoule-class laser systems. The optical components include lenses, frequency-conversion crystals, anti-reflective coatings, and mirrors.

Keywords: Inertial Fusion, Coatings and Films

<u>Office of Military Applications</u>

<u>Sandia National Laboratories - Albuquerque</u>

<u>Solid State Sciences Directorate,1100</u>

<u>Ion Implantation and Radiation Physics Research Department, 1110</u>

301. <u>Ion Implantation Studies for Friction and Wear</u> FY 1986 $ 250,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL (Contract No. DE-AC04-76DP00789) Contacts D. M. Follstaedt, 505-844-2102; S. M. Myers, 505-844-6076 and 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

302. <u>Silicon-Based Radiation Hardened Microelectronics</u> FY 1986 $ 550,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL (Contract No. DE-AC04-76DP00789) Contacts - H. J. Stein, 505-844-6279; K. L. Brower, 505-844-6131 and J. A. Knapp, 505-844-2305

Optical, electrical and compositional measurements, in conjunction with electron paramagnetic resonance, Rutherford backscattering, and related techniques are used to determine the fundamental defect structures and materials properties required for radiation-hardened Si-based microelec-tronics. Recent studies have concentrated on amorphous silicon nitride, which is the charge storage medium for radiation-hard nonvolatile semiconductor memories, defects at the Si-SiO_2 interface, which markedly affect the radiation tolerance of MOS devices, and the formation of buried dielectric layers which may be essential for next generation radiation hard microelec-tronics. 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: Microelectronics, Radiation Hardened, Silicon Nitride, Silicon, Silicon Dioxide, Defects

303. <u>New Concepts in Microsensors</u> <u>FY 1986</u>
$ 500,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - R. C. Hughes, 505-844-8172; A. J. Ricco, 505-844-4907 and M. A. Butler, 505-844-6897

New concepts in microsensors are being developed for a variety of stimuli, including radiation, magnetic fields, chemical species and viscosity, using principles of semiconductor device operation and fabrication, surface acoustic wave propa-tion, and optical properties of solids. Microsensors based on the properties of semiconductor surfaces include a radiation-sensing field-effect transistor (RADFET), which operates by the trapping of radiation-produced holes in the silicon dioxide gate dielectric of the FET, and chemical sensors which operate by inducing charged layers at the metal-silicon dioxide interface in response to the chemical species. Surface acoustic waves have been exploited to make new sensors for various vapors and the viscosity of liquids. Optical detectors based on the properties of new materials, like semi-magnetic semiconductors and strained layer superlattices, are being developed.

Keywords: Microsensors, Microcircuitry

<u>Condensed Matter and Surface Science Department, 1130</u>

304. <u>Shock Chemistry</u> <u>FY 1986</u>
$ 500,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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. Shock-activated thermal batteries are being studied to determine the mechanisms and materials parameters which influence electrical output. The work also provides insights about the nature of the shock process itself.

Keywords: Organic Solids, Inorganic Solids, Molecular Structure, Shock

305. Initiation of Granular Explosives FY 1986
$ 350,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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: Shock Waves, Granular Explosives

306. Surface Science FY 1986
$ 400,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - D. W. Goodman, 505-844-5435

Field ion microscopy, Auger electron spectroscopy, UV photoemission spectroscopy, and thermal desorption are being used to understand at an atomic level the early stages of oxidation and corrosion of metals, the nature of the adhesion of polymers to metals and how to improve it, and the mechanisms by which gaseous species are dissociated at the surface and transported to the insulator-semiconductor interface in MIS gas sensors.

Keywords: Surface Physics, Field Ion Microscopy, Auger Electron Microscopy, UV Photoemission Spectroscopy

307. Materials Growth by Molecular Beam Epitaxy (MBE)
FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - L. R. Dawson, 505-846-3451

Forwth of AlGaAs/GaAs, InAsSb/InAs and InGaAs/GaAs strained layer superlattice (SLS) and strained quantum well (SQW) structures for electronic and optoelectronic applications. These structures are either uniformly doped for application in a typical electronic device or modulation doped for novel device structures, including high speed electronic devices, light emitting diodes and detectors.

Keywords: Semiconductor Device Fabrication, Strained Layer Superlattices, Strained Quantum Well

308. <u>Materials Growth by MOCVD</u> <u>FY 1986</u>
$ 300,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - R. M. Biefield, 505-844-1556

Growth of GaP/GaAsP and InAsSb/InSb SLS's for high temperature radiation-hard electronic devices and for long wavelength IR detectors, respectively. Another major effort centers on the AlGaAs/GaAs and InGaAs/GaAs systems for detailed studies of the electrical and optical properties. This work has led to a variety of devices, including bistable optical switches, photon-hard photodetectors and high speed p-channel modulation doped FET's.

Keywords: Semiconductor Dvices, Fabrication, Strained-Layer Superlattices, Radiation Hardened Semiconductors

309. <u>Strained Layer Superlattices for IR Detectors</u> <u>FY 1986</u>
$ 300,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - G. C. Osbourn, 505-844-8850

Strained layer superlattices based on the InAsSb/InSb and InAsSb/InSb/AlSb systems are being investigated for use as attractive alternatives to the unstable HgCdTe alloys for IR detector applications in the 8-12 um range. These IR materials are being grown by both MBE and MOCVD techniques.

Keywords: Strained-Layer Superlattices, Infrared Detectors

310. <u>Novel Processing Technology for Semiconductor Technologies</u>
<u>FY 1986</u>
$ 300,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - D. S. Ginley, 505-844-8863

This program involves studies of new technologies for formation of diffusion barriers for improved expitaxial growth, novel metallurgies for Skottky barrier and Ohmic contact formation, and development of new metallurgical techniques for deposition of reactive alloys.

Keywords: Semiconductor Devices

311. Materials Processing for Sensors FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - D. S. Ginley, 505-844-8863, R. J. Baughman, 505-844-6337

High quality semimagnetic semiconductors are grown for magnetic field sensors, processing technologies are developed for fabricating fiber-optic based strain and chemical sensors, and thin dielectric and organic films for chemical sensors.

Keywords: Sensors: Magnetic Field, Strain, Chemical

Organic and Electronic Materials Department, 1810

Chemistry of Organic Materials Division, 1811

312. Dyed Antireflective Photoresist Material FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - C. Renschler, 505-844-8151

Photopatterning of photoresist materials on reflective substrates can be highly problematic. Reflective notching and standing wave effects can give rise to irregular geometries which lead to device failure. We have developed a photoresist formulation containing small concentrations of a dye molecule which eliminates this problem. The material is a modification of standard photoresist formulations, and the fact that it has virtually identical properties, allows its direct substitution into production runs without significant modifications of processing facilities or techniques.

Keywords: Polymers, High Temperature

313. Sulfonated Aromatic Polysulfones FY 1986
$ 100,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - R. L. Clough, 505-844-3492; C. Arnold, Jr., 505-844-8728 and 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. Future work will also involve sulfonation of other high stability polymers including polyphenylene.

Keywords: Polymers, Coatings and Films, Batteries

314. Radiation Hardened Dielectrics FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - R. L. Clough, 505-844-3492; S. R. Kurtz, 505-844-5436 and 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. Capacitors made from this material have been fabricated and successfully tested. Future studies will involve alternate dopants and thicker films.

Keywords: Radiation Effects, Polymers, Weapons

Physical Chemistry and Mechanical Properties of Polymers Division, 1812

315. Effects of Material and Processing Variables on the Mechanical and Thermal Expansion Behavior of Graphite/Epoxy and Kevlar/Epoxy Composites FY 1986
$ 250,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - J. M. Zeigler, 505-844-0324 and 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

316. <u>Polysilanes, Photoresists, Photoconductors, and Non-Charring Dielectrics</u> <u>FY 1986</u>
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL (Contract No. DE-AC04-76DP00789) Contact - J. M. Zeigler, 505-844-0324

Some alkyl substituted polysilanes undergo depoloymerization-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 electron 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 structure, 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 meltastable crosslinkable materials and current efforts are directed toward polysilanes with these properties.

Keywords: Polymers, High Temperature Materials, Photoresists, Photoconductors, Semiconductor Fabrication

317. Plasma Deposition of Inorganic Materials FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - J. M. Zeigler, 505-844-0324 and 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. The method used 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.

Keywords: Plasma Chemistry, Plasma Polymerization, Thin Films, Molecular Beam, Glow Discharge, Coatings

318. Electron and Photon Stimulated Desorption from Organic Surfaces FY 1986
$ 100,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - J. M. Zeigler, 505-844-0324 and 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 quadrapole 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 surface structure and its interactions with water and organic materials with the aim of understanding the determining factors in adhesion to these surfaces.

Keywords: Electron Stimulated Desorption, Photon Stimulated Desorption, Desorption, Organic, Metals, Metal Oxides, Polymer Adhesion, Adhesion

319. <u>Materials Structure and Properties by NMR Spectroscopy</u>

FY 1986
$ 70,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - J. M. Zeigler, 505-844-0324 and R. A. Assink, 505-844-6372

Nuclear magnetic resonance (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

<u>Physical Properties of Polymers Division, 1813</u>

320. <u>Carbon Foam Development</u>

FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - J. H. Aubert, 505-844-5604 and P. B. Rand, 505-844-7953

We have discovered a new way to produce carbon foams of low density and small cell size. The process involves the production of polyacrylonitrile (PAN) by a solution-gelation technique followed by CO_2 solvent extraction. The resulting PAN foam is then carbonized by exposure to elevated temperatures. These foams are of potential use in several weapons applications.

Keywords: Foams, Carbon Foams, Polymeric Precursor Route, Weapons

321. <u>Mechanical Properties of Encapsulants</u>

FY 1986
$ 20,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - D. Adolf, 505-844-4773

The bulk modulus of polymeric encapsulants is essential for predicting internal stresses from thermal cycling. Up to now, only estimated values of the bulk modulus have been used since it is a difficult quantity to evaluate. Recently we have demonstrated that the bulk modulus can be obtained by using the tri-axial testing facility. Preliminary measurements indicate significant departures from previous estimates of the bulk modulus for polymeric encapsulants.

Keywords: Polymeric Encapsulants, Organic, Tests, Bulk Modulus

322. <u>The Strength of Kevlar Narrow Fabrics</u> <u>FY 1986</u>
$ 70,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-2098
SNL Contact - R. H. Ericksen, 505-844-8333

The tensile strength of dry Kevlar narrow fabrics is reduced 10% to 30% after wet compression relative to the strength of samples compressed dry. This phenomenon is peculiar to the fabric, individual yarn strength is not changed. The influence of variables important for parachute applications was studied and tests to determine the fabric deformation mechanisms are underway.

Keywords: Fibers, Polymers, Fracture, Creep, Parachutes

<u>Electronic Property Materials Division, 1815</u>

323. <u>High Electric Field Varistors</u> <u>FY 1986</u>
$ 100,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - R. G. Kepler, 505-844-7520 and 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°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, Varisters

324. <u>Highly Polarizable Dielectrics</u> <u>FY 1986</u>
$ 100,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - R. G. Kepler, 505-844-7520 and R. A. Anderson, 505-844-7676

New organic dielectric materials are being developed by molecular engineering to have greatly enhanced dielectric constants. In thin film form, these materials will be wound into high energy density capacitors. To achieve desired stored energy densities, the molecular modifications must not diminish the dielectric breakdown strength of the material, and so this is being tested. The effect of elevated temperature on the dielectric is also being measured.

Keywords: Dielectrics, Organic, High Energy

325. High Resistivity Thin Film Polycrystalline Silicon

	FY 1986
$	100,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - R. G. Kepler, 505-844-7520 and 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 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, Grain Growth, Ion Implantation, Diffusion

Materials Characterization Department, 1820

Analytical Chemistry Division, 1821

326. Development of Automated Methods for Chemical Analysis

	FY 1986
$	200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - S. H. Weissman, 505-844-0820

New automated methods for chemical analysis of materials are being developed to meet new or anticipated needs and to improve accuracy and efficiency. New or anticipated facilities include a new automated gas chromatography/mass spectroscopy (GC/MS) and updating the dielectric constants. In thin film form, these materials will be wound into high energy density capacitors. To achieve desired stored energy densities the molecular modifications must not diminish the dielectric breakdown strength of the material, and so this is being tested. The effect of elevated temperature on the dielectric is also being measured.

Keywords: Dielectrics, High Energy

327. Thermomechanical Threat of U Alloys FY 1986 $ 80,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - K. H. Eckelmeyer, 505-844-7775

Strengthening mechanisms are being investigated in U-Ti and U-Nb alloys with the goals of simplyfying 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 gamma-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%. Work is continuing to determine the natures of the wide variety of phase transformations which occur during these treatments and how these transformations and their resultant microstructures influence toughness.

Keywords: U-Alloys, Strengthening Mechanisms, Thermochemical Processing

328. Advanced Methods for Electron Optical, X-Ray, and Image Analysis FY 1986 $ 200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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) have resulted in the identification of an intermetallic phase in a weldment that another weapons lab could not identify. A program was initiated in 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. Current efforts are concentrating on developing systems for light and scanning electron microscopy. In the future, this system will be expanded to include transmission electron microscopy and surface analysis techniques.

Keywords: Automation, Electron Optics, Transmission Electron Microscopy, X-Ray Analysis, Electron Diffraction

329. <u>Advanced Methods for Surface and Optical Analysis</u>

	FY 1986
$	200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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. Also, the data acquisition and reduction system for the x-ray photoelectron spectrometer, which is used for surface analysis on a broad range of materials, has been improved. In addition we have combined a gas chromatograph with a Fourier transform infrared spectrometer to enable us to do reaction studies on organic materials. In FY87, we plan to purchase an additional scanning Auger spectrometer which will enable us to reduce our backlogs of analytical work and develop new Auger techniques for the analysis of exotic materials.

Keywords: Laser Raman Spectroscopy, Fourier Transform Infrared Spectroscopy, X-Ray Photoelectron Spectroscopy, Auger Spectroscopy

330. <u>Design and Fabrication of a Multi-Source X-Ray Gauge</u>

	FY 1986
$	150,000

DOE Contract - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - W. D. Drotning, 505-844-7934

The design and fabrication of a gamma-ray attenuation spectrometer or x-ray gauge was completed and has been used to analyze special materials for SDI programs. More complex systems using multi-isotopic sources are being designed, constructed, and tested for more complicated materials.

Keywords: Gamma-Ray Spectrometer, Non-Destructive Analysis

331. <u>Infrared Reflectometer Development</u> <u>FY 1986</u> $ 120,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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, and the development is almost complete. Additional work will require automation for high throughput, data reduction, and setting experimental parameters. This system will be used to measure 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.

Keywords: Infrared Reflectometer, Reflectance Emittance

<u>Metallurgy Department, 1830</u>

<u>Coating Technology Division, 1831</u>

332. <u>Plasma Deposition of Amorphous Metal Alloys</u> <u>FY 1986</u> $ 70,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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

333. <u>Electrophoretically-Deposited Coatings</u> <u>FY 1986</u> $ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - A. K. Hays, 505-844-9996 and 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 copolymers and acrylic/titanium dioxide composites. Future work will include the development of insulator/conductor composites.

Keywords: Coatings and Films, Polymeric Insulators/Dielectrics, Ceramic Insulators/Dielectrics, Electrophoretic Deposition

334. Near-Net-Shape Processing of Nickel-Based Alloys

	FY 1986
$	150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - A. K. Hays, 505-844-9996 and 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: Ferrous Metals including Steels, Coatings and Films, Chemical Vapor Deposition

335. High Temperature Semiconductors

	FY 1986
$	80,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - A. K. Hays, 505-844-9996 and 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°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 chemical vapor deposition. 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

336. Optical Diagnostics for Metallurgical Processing

FY 1986
$ 440,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - A. K. Hays, 505-844-9996; H. C. Peebles, 505-846-3454

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

337. Development of Materials for Magnetic Fusion Reactors

FY 1986
$ 500,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - M. F. Smith, 505-846-4270

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 and delivered to the ISX-B Tokomac 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

Physical Metallurgy Division, 1832

338. Toughness of Ductile Alloys

FY 1986
$ 330,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - R. J. Salzbrenner, 505-846-9949 and 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: Ferrous Metals, Fracture, Predictive Behavioral Modeling

339. Properties of Ni-B Alloys FY 1986
$ 50,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - A. N. Campbell, 505-844-7452

The mechanical response of Ni-B alloys produced by chemical vapor deposition (CVD) is being characterized. Microstructural examination is being performed to explain and model the deformation process for this material.

Keywords: Alloys, Chemical Vapor Deposition, Microstructure, Deformation

340. Analytical Electron Microscopy of Engineering Alloys
FY 1986
$ 130,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contact - A. D. Romig, 505-844-8358

Analytical Electron Microscopy (AEM) allows the local chemistry within a thin foil to be determined with high resolution. 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 to 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: Ferrous and Non-Ferrous Metals, Joining and Welding, Transformation, Electron Beam Methods, Weapons

341. <u>Friction and Wear of Modified Surfaces</u> <u>FY 1986</u>
$ 230,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - R. J. Bourcier, 505-844-6638 and 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: Ferrous and Non-Ferrous Metals, Erosion/Wear/Tribology, Ion Implantation, Weapons

342. <u>Alloy Deformation Response and Constitutive Modeling</u>
<u>FY 1986</u>
$ 300,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - W. B. Jones, 505-844-4026 and 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: Ferrous Metals, Creep, Fatigue, Nuclear Reactors, Predictive Behavorial Modeling, Weapons

Process Metallurgy Division, 1833

343. Vacuum Arc Remelting

FY 1986
$ 120,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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: Ferrous and Non-Ferrous Metals, Conventional Solidification

344. Toughness of Inertia Welds

FY 1986
$ 10,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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: Ferrous Metals, Joining/Welding, Fracture

345. Aluminum Laser Welding

FY 1986
$ 40,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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: Non-Ferrous Metals, Joining/Welding, Conventional Solidification

346. Low Temperature, Solid State Welds of Copper — FY 1986 $ 20,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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: Non-Ferrous Metals, Joining/Welding, Fracture

347. Dissimilar Metal Welds — FY 1986 $ 200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - M. J. Cieslak, 505-846-7500 and 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: Ferrous and Non-Ferrous, Joining/Welding, Solidification- Conventional

348. Welding of Nickel-Based Alloys FY 1986
$ 225,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - M. J. Cieslak, 505-846-7500 and 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: Non-Ferrous Metals, Joining/Welding, Conventional Solidification

349. Plasma Arc Welding FY 1986
$ 175,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - P. W. Fuerschbach, 505-846-2464 and 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: Non-Ferrous Metals, Joining/Welding, Conventional Solidification

350. Laser Welding FY 1986
$ 175,000

DOE Contact - A. E. Evans, 301-353-3098 , FTS 233-3098
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: Lasers, Joining/Welding, Process Modeling

351. Electrode Gap Controller | FY 1986 | $ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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: Ferrous and Non-Ferrous Metals, Melting, Process Control

Surface Metallurgy Division, 1834

352. Deposition of Amorphous Materials With a Dual Beam Ion System | FY 1986 | $ 80,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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 are dependent on the conditions of deposition of the sputter-deposited amorphous material, specifically hardness. Future work will emphasize the development of hard, wear-resistant coatings for mechanical applications.

Keywords: Metallic Glass, Erosion/Wear/Tribology, Coatings and Films

353. Modification of Mechanical Properties by Ion Implantation

FY 1986
$ 25,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - L. E. Pope, 505-844-5041; D. M. Follstaedt, 505-844-2102; S. T. Picraux, 505-844-7681 and 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 twders are being prepared by sol-gel chemistry techniques. Materials prepared include ZrO_2, PZT, 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

359. Fracture of Ceramics

FY 1986
$ 680,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
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

360. <u>Glass and Glass-Ceramic Development</u> FY 1986
$ 2,500,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - F. P. Gerstle, Jr., 505-844-4304 and D. H. Doughty, 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 is 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

361. <u>Corrosion</u> FY 1986
$ 1,150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - R. B. Diegle, 505-846-3450 and 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.

Keywords: Metals, Amorphous Materials, Glassy Alloys, Corrosion

Sandia National Laboratories - Livermore

362. Powder Metallurgy — FY 1986 $ 200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - J. A. Brooks, 415-422-2051; J. E. Smugeresky, 415-422-2910; J. W. Zindel, 415-422-2051

The installation of two gas atomizers, and a spark erosion system for the production of fine metal powders has further expanded our powder metallurgy capabilities. Emphasis is being placed on the effect of atomization parameters on material characteristics and on the development of alloy systems utilizing rapid solidification processing. Studies on spark erosion are emphasizing the effect of processing parameters on powder size distribution, surface morphologies, and production rates of micron-size particles.

Metallurgical studies are being conducted on a variety of alloy systems. The relationship between strength, toughness, microstructure, and fracture modes of blended elemental PM titanium alloys is being studied to optimize HIP cycles and heat treatments for improved properties of near-net-shape processed components. The relationships between starting powder size and sintering parameters on the microstructure, permeation and filtration characteristics of porous stainless steel compacts is being established. The dynamic compaction of Al-Si alloys has produced fully dense compacts, retained metastable microstructures of the original powder, and has provided further insight into the mechanisms at inter-particle bonding. The effect of particle size distribution and morphology on the quality of compacts is also being established. The new atomization facilities will also be utilized to produce powders for matrix composites.

Keywords: Alloys, Rapid Solidification, Metals, Near-Net-Shape Processing, Shock Wave Compaction

363. Advanced Electrodeposition Studies — FY 1986 $ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - L. R. Thorne, 415-422-2636; J. C. Farmer, 415-422-3418; H. R. Johnson, 415-422-2822

Engineering applications, electroanalytical development, and fundamental studies are being pursued in the area of electrodeposition of metals from both aqueous and nonaqueous media.

Electrodeposition of a variety of metals is being studied with a focus on the relationship between critical process variables and the mechanical properties of the deposit. The role surface active agents play in this process is also being determined. To this end, an in-situ, real-time monitor for organic additives has been developed that will allow bath examination and control during deposition. The electronics for this instrument have now all been placed in one small module, making the device portable and amenable to industrial application. Techniques involving AC impedance, laser Raman, and Fourier transform infrared spectroscopy are providing the fundamental information necessary to permit process improvements and new and improved techniques for electrodeposition.

Keywords: Metals, Electrodeposition, Mechanical Properties, Aqueous and Non-Aqueous Electrolytes, Spectroscopy, Organic Additives

364. Metal Forming FY 1986
$ 200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - J. Lipkin, 415-422-2417; T. C. Lowe, 415-422-3187

Fundamental understanding of nonelastic deformation processes is being developed through crystal plasticity modeling and experimentation. This work focuses upon large-strain phenomena and anisotropy which are important in metal forming and failure processes. Experimental and model results are applied directly to process development and to metal forming problems through the Interagency Metal Forming Working Group (established under this program). Recent work has revealed a new understanding of microstructure texture evolution and anisotropy. In particular, strain-rate sensitivity has been found to influence texture evolution in shear. This result impacts how yield surfaces, anisotropy, and material rotations are represented in phenomenological models for finite element analysis. Large-strain expriments examining axial effects during shear have been compared with both physical model and phenomenological model predictions for the purpose of improving our ability to predict failure due to strain localization. The fundamental understanding developed in this work is being expressed in constitutive relations which can be incorporated into multi-dimensional finite-element codes.

Keywords: Ferrous and Nonferrous Metals, Fatigue, Fracture, Near-Net-Shape Forming

365. <u>Advanced Organic Materials</u> FY 1986
$ 250,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - D. L. Lindner, 415-422-3306; J. G. Curro, 505-844-3936; W. R. Even, 415-422-3217 and C. B. Frost, 415-422-2048

Recent developments in our understanding of the relationship between microstructure and macroscopic properties has led to the ability to produce polymeric foams with unique physical properties in collaboration with personnel at Sandia National Laboratories, Albuquerque. Engineering applications and basic studies designed to optimize properties are being pursued. Studies are presently centered on understanding the relationship between processing conditions, cooling rate, solution composition, and solidification direction in controlling the microstructure. We have begun determining the relationship between these unique microstructures and physical and mechanical properties of the foams. We have been successful in producing a continuum in morphologies ranging from very open cell-low density, to nearly closed cell-higher density polymeric foams. These materials are ideal candidates for catalyst support structures or low-pressure-drop, high-efficiency filters. By incorporating molecular sieves into the structure, foams that adsorb and retain various gases and liquids under specific temperature and pressure conditions can be produced.

Keywords: Polymers, Catalysis, Molding, Microstructure

366. <u>Helium-Induced Crack Growth in Metals and Alloys</u> FY 1986
$ 650,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - S. L. Robinson, 415-422-2209; S. H. Goods, 415-422-3274 and 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 inducing 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 makes these techniques relevant to a wide variety of technologies. Slow crack growth experiments at ultra-high hydrogen pressures are also being conducted to determine the effects of mechanical processing, microstructure, and welding on the resistance of advanced materials to hydrogen-induced cracking. The observed effects of hydrogen on crack growth kinetics and thresholds are being used to identify mechanisms and evaluate models of hydrogen embrittlement. Theoretical analysis based on the Embedded Atom Method developed at Sandia have begun to elucidate the role of helium in altering microstructures and mechanical properties of the alloys.

Keywords: Metals: Ferrous and Non-Ferrous, Crystal Defects/Grain Boundaries, Fracture

367. Joining Science and Technology — FY 1986 $ 450,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - J. A. Brooks, 415-422-2051; K. W. Mahin, 415-422-2051 and 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 weld geometry, distortion, and microstructure, thereby improving both the fundamental understanding of the complex welding process, and the performance of welded structures. The studies include modeling of heat transfer, coupling thermal and mechanical computer codes to allow simultaneous calculation of both temperature and stress as a function of time throughout the weld, and the modeling of microsegregation during weld solidification. The computer-generated results are being compared to experimental measurements of important parameters, including microanalytical analysis of elemental segregation.

Additional welding metallurgy activities include the evaluation of alloy modifications to improve the weldability of specific alloys, the evolution of weld microstructure during solidification and cooling, the study of weldment cracking mechanisms, the weld microstructure property relationships, the measurement and modeling of mechanical properties of brazed joints, and the design, testing, and analysis of joints in composite materials. In solid state welds, the current emphasis includes establishing specifications for weld evaluation and acceptance, and improved NDE techniques to verify weld quality. 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, NDE, Microstructure, Metals, Transformation, Solidification, Modeling

368. Composites: Characterization and Joining FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - J. B. Woodard, 415-422-3115; B. C. Odegard, 415-422-2789 and J. R. Spingarn, 415-422-3307

The stability, compatibility, and joining of polymer matrix composite materials are being investigated in conjunction with efforts at Sandia National Laboratories, Albuquerque. The work focuses on graphite-fiber-reinforced composites and includes both thermosetting and thermoplastic matrix materials. The measurements of moisture saturation levels for several resin systems has agreed well with previous investigators. Characterization of water adsorption sites in thermosetting matrix materials will be studied by autoradiography after exposure of samples to tritiated water. The influence of matrix materials and post-cure thermal processing on adsorption sites and the coefficient of moisture expansion will be investigated. Condensible volatile materials in resins considered for space applications are being identified. Coatings for composite materials are under investigation to enhance stability for special design needs (e.g., mirrors). Thermoplastic matrix materials will be studied to determine the influence of matrix crystallinity upon performance. The influence of galvanic corrosion upon composite/metal joints is also under investigation to assess long-term storage effects.

Joining of composite materials is being studied and includes mechanical fasteners, adhesives and the welding of thermoplastics. Techniques are being developed to measure the fracture toughness of adhesive bonds and predict the strength of mechanically fastened joints.

Keywords: Composites, Joining/Welding, Fibers, Corrosion, Coatings

369. Compatibility, Corrosion, and Cleaning of Materials
FY 1986
$ 100,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - L. R. Thorne, 415-422-2636; H. R. Johnson, 415-422-2822 and D. K. Ottesen, 415-422-2787

Examination of surfaces to determine compatibility, corrosion, and cleanliness is being carried out using sophisticated electroanalytical and spectroscopic means. Many potential problems exist during production and assembly of components if parts are not prcperly cleaned. However, it is difficult to quantify cleanliness and many parts have interiors inaccessible for examination by conventional methods. We have developed a unique technique using Fourier transform infrared spectroscopy to peer inside small diameter tubes and identify wall-surface contamination. This method has been shown to be applicable to production environments. Other methods are also being investigated with transfer of this technology to production agencies as a goal.

Keywords: Compatibility, Corrosion, Cleaning, FTIR

Instrumentation and Facilities

370. New Spectroscopy FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - L. R. Thorne, 415-422-2636; D. L. Lindner, 415-422-3306; M. C. Nichols, 415-422-2906 and B. E. Mills, 415-422-3230

New spectroscopic techniques are being developed for special applications. For example, a micro-fluorescence spectrometer is being assembled using a rotating anode source. This unit will permit the examination of very small areas for elemental composition and do it in an automated way to provide coverage of large areas with high resolution. A high-resolution electron energy spectrometer (HREELS) has been built and is now being used to investigate adsorption of oxygen and water vapor on uranium. This work will add insight into the mechanisms governing the oxidation and corrosion of metals used within the DOE complex.

Keywords: Spectroscopy, Elemental Composition, Actinides, Gas-Solid Reactions

371. Tritium Facility Upgrade for Materials Characterization and Testing FY 1986
$ 400,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
SNL Contacts - S. H. Goods, 415-422-3274 and S. L. Robinson, 415-422-2209

Continuing materials research in the Tritium Research Laboratory has prompted the need for new analytical techniques and equipment and the upgrading of existing experimental test equipment. New capabilities being developed include a quantitative ^3He mass spectrometer for characterizing helium build-in levels resulting from tritium decay. A high-pressure T_2 thermal charging and quench facility is being built which, in conjunction with a dissolution/scintillation-counting apparatus, will allow for the precise measurement of tritium solubility as a function of temperature and pressure. Mechanical test capabilities have been upgraded by the addition of a computer-interfaced servohydraulic test frame. A modern scanning electron microscope with light-element analysis capability has been installed to provide for fractographic analysis of failed materials.

Keywords: Spectrometer, Tritium Charging, Mechanical Testing, Scanning Electronic Microscopy

Lawrence Livermore National Laboratory

372. Materials Modification by Ion Beams | FY 1986 $ 229,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - R.G. Musket, 415-422-0483, FTS 532-0483

Research on the applications of ion implantation and ion-beam mixing for the modification of the surface properties of materials was continued. Efforts were concentrated on three materials development activities and the establishment of an ion implantation facility. Aluminum ion implantation into 304L stainless steel combined with post-implant selective oxidation treatments was shown to provide surface oxides highly enriched in Al_2O_3. Such surfaces will be evaluated with regard to their ability to reduce the permeation of tritium. A new hydriding apparatus was successfully employed to study the hydriding behavior of uranium specimens implanted with the following ions: oxygen, nitrogen, carbon, neon, and aluminum. In all cases, the hydriding process was modified relative to that for the non-implanted specimens. Details of the formation of Al_2O_3 layers inside aluminum by oxygen ion implantation were investigated. The C&MS 200 keV, 1.5 mA ion implanter was installed and became fully operational.

Keywords: Actinides, Hydrogen Attack, Insulators/Dielectrics-Ceramic, Metals: Ferrous, Corrosion - Gaseous, Ion Implantation

373. Synchrotron Radiation Studies | FY 1986 $ 335,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contacts - J.H. Kinney and Q. C. Johnson, 415-422-6669, FTS 532-6669

The near-edge structure in the x-ray absorption coefficient of an element (XANES) is affected by chemistry and local environment. Experiments during the past year have demonstrated that this property can be exploited in x-ray imaging both to identify and to enhance the detectability of different chemical states of the same element. Chemical contrast images have been obtained by digital subtraction of absorption images taken at carefully selected x-ray energies. A high-resolution CCD array detector has been developed for performing computer tomography. We demonstrated 3-D elemental mapping capability using this detector at Stanford this past year. Present 3-D resolution is 40 microns.

Keywords: X-Ray Imaging, Tomography

374. Metal Deformation Modeling FY 1986 $ 90,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - E. C. Flower, 415-423-1572, FTS 532-1572

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 non-isothermal, large, elastic/plastic deformation, and friction. The 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-aided-simulation technology and transfer this analytical tool within the DOE/MA complex while moving toward a total synthesis of design and manufacture. Metal deformation modeling has been extended to include modeling of two-phase materials and residual stresses due to non-uniform plastic deformation.

Keywords: Metals, Modeling, Metalforming, Deformation

375. Rapid Solidification Processing of Alloys FY 1986 $ 270,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - L.E. Tanner, 415-423-2653, FTS 532-2653

This research program is aimed at developing a comprehensive understanding of the phase relations, phase transformations, structure, morphology, and related physical properties of metallic alloys that have been rapidly solidified from the melt. One important objective is the generation of new understanding of the mechanisms by which fine-scale microdispersions of one phase in another can be formed in eutectic and monotectic systems, and emphasis will be expanded to include other systems similar to Al-Be in which metastable liquid phase separation is expected to occur. Other areas of study will include: (1) alloys that form amorphous solids, to include the thermodynamic and structural aspects of solid-state reactions that lead to glassy metallic alloys; and (2) further investigation of the formation and structure of metastable quasi-crystalline phases in systems other than Al-Mn.

Keywords: Rapid Solidification Processing, Phase Transformation Mechanisms

376. Microstructure of Stainless Steel Welds FY 1986 $ 70,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - J. W. Elmer, 617-253-6474 (MIT)

The technical objective of this investigation is to study the effects of solidification velocity on microstructure over a cooling rate range extending from 10^2 K/s to 10^6 K/s for stainless steels. The intent of this research is to develop a relationship between solidification velocity and microstructure that will provide predictive capabilities that do not presently exist and to advance the solidification theory of stainless steels.

The investigation is being approached in three phases: (1) development of a method to reproducibly vary solidification velocity in a weld over a large solidification rate range; (2) modeling the findings from (1) to determine the actual solidification velocities based on material properties, welding parameters and weld bead geometry; and (3) experimentally establishing the solidification velocity-composition-microstructure relationships for stainless steel welds.

Keywords: Stainless Steel, Welding, Solidification, Predictive Behavioral Modeling

377. Coating Adhesion FY 1986 $ 30,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - R. S. Rosen, 415-422-9559, FTS 532-9559

The objectives of this work is to obtain a fundamental understanding of the role of the chemistry and structure of the interface between substrate and metal coating on the metal film formations, growth, and adhesion. This includes a knowledge of oxides and contaminants in this interface. Well characterized surfaces have been prepared and subsequently coated and analyzed "in-situ," using modern surface analytical tools. The role of oxides, impurities, and mobility (affected by substrate temperature) on the film formation and adhesion is being studied.

Keywords: Coatings and Films, Surface

378. Dislocation Structures and Reversed Strains FY 1986 $ 89,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contacts - G. F. Gallegos and M. E. Kassner, 415-422-7002, FTS 532-7002

Some studies have shown that the behavior of yield surfaces are not limited to the two classic effects of expansion (isotropic hardening) and translation (kinetic hardening) in stress space. The independent variables, temperature and strain, may be significant in describing distortion of yield surfaces, yet no work appears to have been performed on metal about 0.5 T_m, where T_m represents absolute melting temperature. Descriptions of the distortion over wide ranges of temperature and strain are important in characterizing materials which are subject to loading histories where strain reversals are encountered.

Yield surfaces are generated by straining a material at known biaxial stress states, which can be achieved by applying a simultaneous tension/torsion to a thin-walled tubular specimen. Special grips aheve been designed and fabricated which can have a simultaneous tension/torsion load, while being heated to temperatures of 900^oC under vacuum or inert-gas purge to minimize oxidation. Methods to precisely measure strains have been developed.

The degree of yield surface distortion after the combination of large forward and small reverse strains at temperatures in excesses of 0.5 T_m in 304 stainless steel is under investigation. This study will test the classic metallurgical assumptions of isotropic and kinematic hardening that were recently placed in question by an "adjacent" study by the principal investigators. Determining the degree of distortion is critical to the development of constitutive equations that would model material behavior over a wide range of temperatures, such as those required by the Weld Modeling project to predict residual in welds. Such weld models would be of great value in ensuring reliability in the fabrication of weapons components.

Keywords: Stainless Steel, Deformation Mechanisms, Constitutive Equations, Multiaxial Deformation

379. <u>Weld Library Generation</u> <u>FY 1986</u>
$ 40,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - E. N. Kaufmann, 415-423-2640, FTS 532-2640

A weld library is being built from existing welding files, storing this library on a computer database. In addition to collecting data, the project involves statistical comparison of data files to try and generate trends in parameters for given materials and shapes. The NPL database was used to develop a program by which the main library could be stored on the Octopus system and downloaded to an IBM PC for changes. The availability of statistical packages for either the IBM or the Octopus system is being investigated.

This database will be shared with similar databases being developed at other DOE laboratories. The goals of such a library are to minimize development time and to preserve our welding technology.

Keywords: Database, Fusion Welding, Ferrous and Non-Ferrous Metals

380. Deformation of Aluminum to Large Strains | FY 1986 $ 90,000

DOE Contact - A. E. Evans, 301-353-3098
LLNL Contact - M. E. Kassner, 415-423-2329, FTS 543-2329

The dislocation microstructure of aluminum is being examined after transient and steady-state deformation at temperatures ranging from ambient to $0.8T_m$. Large strain deformation is permitted by torsional deformation. The microstructural information at uniquely large strains provides strong new insight into the fundamental mechanisms of plastic flow over the temperature range. In addition, an understanding of the development of microstructure during various thermal-mechanical processes is being developed.

Testing is being performed on the Stanford Torsion Testing machine. Specimens are deformed to various transient and steady-state (large) strains and quenched. The microstructures are examined by optical microscopy as well as by TEM. The average subgrain size, forest dislocation density, and subgrain misorientation angle are determined. By examining the dependence of these variables with strain during steady-state (where both flow stress and strain-rate are constant), the conflicting theories of the rate-controlling mechanism in creep can be evaluated in a new light. The experimental procedures for this project are proven and work is progressing on the strain measurements.

This project provides an understanding of the microstructural evolution during large strain deformation of aluminum. The large strain thermal-mechanical processing as, for example, extrusion of aluminum, is central to the production of very many parts of significance to the DOE.

Keywords: Non-Ferrous Metals, Microstructure, Subgrain, Extrusion, Predictive Behavioral Modeling

381. Microstructure Research | FY 1986 $ 300,000

DOE Contact - A. E. Evans, 301-353-3098
LLNL Contact - H. R. Leider, 415-423-1884, FTS 533-1884

Structures and devices in the same range 10nm-100mm 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.

The project focuses on a basic research effort and a feasibility demonstration effort runs 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 this year's engineered microdevices are a sensor for insulator and gasket degradation, a sensor for evolved hydrogen, selective sensors for evolved gases and vapors, and a universal sensor for organic vapors in an enclosure.

Keywords: Semiconductors, Coatings and Films, Metals, Catalysts, Diffusion, Surface Characterization, Sensors, Degradation, Performance Monitoring, Gas Monitors.

382. Pu Metallurgy — FY 1986 $ 180,000

DOE Contact - A. E. Evans, 301-353-3098
LLNL Contact - P. H. Adler, 415-423-4417, FTS 533-4417

Both the basic mechanisms responsible for the $\delta\alpha$ and $\alpha\delta$ phase transformation in Pu alloys, as well as utilization of one or more of these first-order transitions in achieving a dense, ductile δ Pu alloy are being investigated. It has been shown that despite the 20-25% volume change associated with the $\delta\alpha$ transformation, it is geometrically possible for this transformation to occur martensitically. Subsequent computer calculations predict a (.817, .538, .208)α δ habit and a [.947, .269, .174] δ shape strain of magnitude 0.324 for $\delta\alpha$ transformation where (001)[100} α twinning is the favored lattice-invariant deformation. For $\alpha\delta$ transformation a (.255, .844, .471) α habit and [.822, .446, .355] δ shape strain of magnitude 0.417 is predicted with slip on (111)[101] δ as the favored lattice-invariant shear system. Sterographic plots of these crystallographic predictions indicate that transformation plasticity via a deformation-induced α δ transformation will require the operation of more than one lattice correspondence, and will likely require additional deformation mechanisms to provide the sufficient five independent deformation systems to accommodate an arbitrary shape formation.

Keywords: Martensitic Transformation, Plutonium, Alloys, Deformation Plasticity

383. Pu Alloy Characterization FY 1986

$ 220,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - P. H. Adler, 415-423-4417, FTS 533-4417

Based on the Pu-Ga and Pu-Fe binary phase diagrams and an isopleth section, the Pu-Ga-Fe ternary phase diagram has been developed up to 10a/oGa and 10a/oFe, over the temperature range 425°C to 600°C. Critical experiments have demonstrated that very little refinement of the ternary diagram is required. Close inspection of the ternary diagram reveals equilibrium and non-equilibrium temperature-composition-phase field relationships heretofore unknown. The ternary diagrams have also provided a theoretically plausible explanation for the observed accelerated stabilization rate of Fe-containing Pu-Ga alloys, viz. that small amounts of dissolved Fe at high temperatures result in biasing high-Ga regions of cored grains, i.e., grain centers, towards melting, thus providing temporary fast diffusion paths for Ga. Preliminary calculations based on a rule-of-mixtures model predict a 2-3-order-of-magnitude reduction in the time necessary to attain complete homogenization consistent with experimental observations.

Keywords: Plutonium Alloys, Gallium, Iron, Homogenization, Phase Diagram

384. Pu Sputtering FY 1986

$ 180,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - H.F. Rizzo, 415-422-6369, FTS 542-6369

This is a study to explore the glass forming ability of various elements with plutonium by sputtering. Composite targets of Fe, Ta, V, Os, Re, Co, and Si with plutonium have been sputtered and the resulting binary coating compositions are being examined by x-ray and metallographic techniques. All these binary systems show strong evidence for the formation of glassy alloys of plutonium. The composition range for amorphous alloy phases was found to be directly related to the atomic size mismatch between the solute element for each of the systems studied and the Pu solvent. Differential scanning calorimetry (DSC) measurements will be made to determine the stability and transformations of the plutonium metastable alloys as a function of composition for a few systems studied.

Keywords: Amorphous Materials, Alloys, Plutonium, Sputtering, Corrosion, Microstructure

385. <u>Directed Energy Surface Processing</u> <u>FY 1986</u>
$ 180,000

DOE Contact - A. E. Evans, 301-353-3098
LLNL Contact - E. N. Kaufmann, 415-423-2640, FTS 543-2640

The use of directed energy beams such as lasers, electron beams and ion beams to rapidly melt metal surfaces, which then cool rapidly enough to retain crystal structures and micro-structures not attainable by equilibrium means, is being pursued. New surface alloys prepared in this way may display superior corrosion and fatigue resistance and be less susceptible to attack by hydrogen, liquid metals, etc. Alloys involving uranium and beryllium are of particular interest. Retention of the bcc gamma phase of U at low alloy concentrations is one objective. Developing high-specific-strength alloy precursors in the Be, Al, Li family is another potential benefit of these studies.

Keywords: Metallic Glasses, Surface Structure, Electron Beam Methods, Ion Implantation, Laser Melting, Solidification-Rapid

386. <u>Homogeneity of Dry-Powder Substrates for Generating Low-Density Carbon/Polymer Networks</u> <u>FY 1986</u>
$ 30,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contacts - James Carley, 415-422-6601, FTS 532-6601 and Robert Hopper, 415-423-2420, FTS 533-2420

One method for making cellular, high-carbon structures of very low density is to impregnate a porous, refractory substrate with a polymer solution, evaporate the solvent, stabilize the deposited polymer network by pyrolysis, then dissolve away the substrate. This project was concerned with pressing substrate bars from fine salt (NaCl) by unidirectional and isostatic molding in metal and rubber molds. The focus was on porosity variations along the bars as related to molding conditions and techniques. A report on the work, UCRL-95433, has been issued and submitted for publication.

Keywords: Porous Material Formation, Salt Molding, Polymeric Foams, Powder Pressing

387. <u>Formation of Metastable Surface Alloys</u> <u>FY 1986</u>
$ 193,000

DOE Contact - A. E. Evans, 301-353-3098, FTX 233-3098
LLNL Contact - E. N. Kaufmann, 415-423-2640, FTS 543-2640

Using laser and electron-beam surface melting and rapid solidification under the controlled conditions obtainable with these tools, quantitative data are gathered on such solidification phenomena as maximum growth rate of crystalline phases and nucleation time for crystallization transformations. These, coupled with auxiliary measurements of glass crystallization temperatures and simulation of sample thermal history using advanced codes, allow comparison with the theories applicable to the kinetic factors determining actual microstructures. These in concert with the equilibrium phase diagram and estimates of metastable phase available lead to predictive understanding of the rapid solidification process.

Keywords: Metallic Glasses, Surface Structure, Electron Beam Methods, Ion Implantation, Laser Melting, Solidification-Rapid

388. Mechanics of Low Density Materials FY 1986 $ 100,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - Richard Christensen, 415-422-7136, FTS 532-7136

Symmetry conditions are found that assure isotropy of the fourth rank tensor of elastic moduli for low density materials. Crystallography provides the answer to this problem in the two-dimensional context, namely one axis of 3-fold symmetry assures the isotropy of properties in the plane normal to the axis. The present work provides the answer in the three-dimensional problem: 6 axes of 5-fold symmetry are sufficient to give isotropy of the elastic moduli. The derivation is given in the special form appropriate to low density materials which have a microstructure that transmits load according to the axial deformation of a space network of material distributed into micro-struts.

Keywords: Composites (structural)

389. Polymeric Materials Computer Modeling FY 1986 $ 60,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - Robert Cook, 415-422-6993, FTS 532-6993

A model of polymeric materials has been developed which includes many of the features of condensed phase polymer chain dynamics, central among them chain relaxation via both conformational motion and crack formation. The stress-strain behavior of the model has been examined using molecular dynamics simulations, finding qualitative agreement with the observed experimental behavior of polymeric materials. Particular attention is paid to the role of chain relaxation. Other material properties are currently under study.

Keywords: Polymers, Fracture

390. Lifetime Prediction Theory for Polymeric Materials

FY 1986
$ 60,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - Robert Cook, 415-422-6993, FTS 532-6993

A simple kinetic theory of fiber failure has been developed that predicts not only the median lifetimes of fiber samples under constant load but also the dispersion in these lifetimes based upon the dispersion in the static strength of the fiber samples. The theory is applied to Kevlar fibers where data for lifetime under loads from 90 to 50 percent of static strength are known. The theory can also be readily adapted to deal with environmentally induced degradation of strength.

Keywords: Polymers, Fracture, Predictive Behavioral Modeling

391. Weapons Database Development

FY 1986
$ 200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LLNL Contact - D. D. Jackson, 415-422-8054, FTS 532-8054

A computer database system is under development to facilitate the analysis of stockpile life data so that the current condition of the stockpile can be assessed better, leading to predictions of 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, the following documents are being generated: (1) critical components document; (2) handbook-describes how the data will be displayed and handled; and (3) Surveillance and Stockpile Return Summary (SSRS). The documents for the B83 system have been revised to include new surveillance data as scheduled. Handbooks for the W84 and W70 have been completed and the SSRS reports are well advanced. Extension of the task to the W87 system has been started and will be completed in FY 1987.

Keywords: Weapons, Stockpile, Database

Instrumentation and Facilities

Los Alamos National Laboratory

Materials Synthesis, Deposition, Growth, or Forming

392. Fluidized Bed Coatings — FY 1986 $ 200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. W. Carroll, 505-667-2145, FTS 843-2145

Techniques have been developed for low-temperature deposition of tungsten, molybdenum, rhenium, and nickel on hollow substrates of spherical and cylindrical shapes. Ultra-thin, free-standing shapes have been fabricated.

Keywords: Coatings, Metals, Chemical Vapor Deposition

393. Materials Synthesis by Solid State Combustion — FY 1986 $ 250,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - R. G. Behrens, 505-667-8327, FTS 843-8327

Solid state combustion is being investigated as a viable technology for rapid, high-temperature synthesis of alloys, ceramics, ceramic composites, and metals either as powders or as near-net-shape forms.

Keywords: Alloys, Ceramics, Composites, Metals, Near-Net-Shape Processing

394. Powder Preparation by Plasma Chemical Synthesis — FY 1986 $ 350,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - G. J. Vogt, 505-667-5813, FTS 843-5813

Plasma-assisted chemical vapor deposition is being developed as a technique for the production of ultrafine, ultrapure ceramic powders. Development work has extended this technology to ultrafine metal and metal alloy powders.

Keywords: Alloys, Ceramics, Metals, Chemical Vapor Deposition

395. Precision Tungsten Tubes FY 1986 $ 170,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. W. Carroll, 505-667-2145, FTS 843-2145

A technique has been developed for producing precision tungsten tubes of various wall thicknesses in substantial lengths by chemical vapor deposition.

Keywords: Coatings, Metals, Chemical Vapor Deposition

396. Superhard Materials FY 1986 $ 38,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

B_4C has been added to conventional W-Ni-Fe alloys to improve hardness, wear resistance, and resistance to deformation. These alloys have been developed to eliminate the use of critical materials such as cobalt in high-hardness materials. Problems being investigated include optimum composition and processing to attain uniform microstructure, and characterization of fracture toughness and hardness.

Keywords: Alloys, Composites, Erosion and Wear, Strength, Hot Pressing, Cutting Tools and Bearings

397. Glass Fabrication Technology FY 1986 $ 50,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contacts - H. Casey, 505-667-4365, FTS 843-4365 and R. Mah, 505-667-3238, FTS 843-3238

Casting and hot forming into hemispheres, disks, plates, sheets, and rods. Composition is controlled to yield good strength, hardness, nuclear requirements, or chemical durability. The forming process is optimized to yield precise shapes, for example by glass-blowing in a gravity-free environment. Silica, sodalime, and pyrex glasses are under investigation. Perfection of shape by surface forces in a high temperature microgravity experiment are being investigated in the space shuttle. A contract with the University of Missouri at Rolla and joint activities with KMS Fusion are being pursued to accomplish the shuttle experiment terrestrially.

Keywords: Amorphous Materials, Glasses, Near-Net-Shape Processing, Hot Forming, Space Shuttle, Microgravity Experiment

398. Slip Casting of Ceramics FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

We are slip casting many ceramics including alumina, magnesia, and thoria. The technology uses colloidal chemistry and powder characterization theory along with materials engineering. Bodies so formed are used in many energy technologies including nuclear reactors. Development problems include processing of powder to yield satisfactory sintering and shrinkage. Success may lead to improved materials with superior strength. We are now investigating the use of this technology to form thermal-shock-resistant bodies from transformation-toughened ceramic alloys.

Keywords: Ceramics, Microstructure, Strength, Sintering Refractory Liners, Thoria, Transformation Toughened Ceramics, Thermal Shock

399. Whisker Growth Technology FY 1986
$ 785,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Silicon carbide whiskers are grown by a vapor-liquid-solid process which produces very long fibers. Research on this program is focusing on four areas: improving control over the process itself so as to obtain mono-sized whiskers of regular morphology; processing whiskers after growth to remove detritus and impurities, characterizing the whiskers and relating their properties to structural features; and growth of Si_3N_4 whiskers by the same process.

Keywords: Structural Ceramics, Whiskers

400. Development of Ceramic Matrix Whisker-Reinforced Composites
FY 1986
$ 250,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Structural ceramic materials, borosilicate glass, $MoSi_2$, and Si_3N_4-matrix composites reinforced with SiC whiskers produced at Los Alamos are being fabricated, primarily by hot pressing. Objectives are to achieve uniform microstructures of dispersed whiskers with low porosity which result in high fracture toughness. Ceramic-whisker-reinforced ceramic matrix composites can potentially replace critical and strategic metals in high temperature applications.

Keywords: Ceramics, Whiskers, Composites, Metals, Fracture Toughness, High Temperature Service, Microstructure, Critical and Strategic Materials

401. New Hot Processing Technology FY 1986
$ 210,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Hot pressing techniques are used to consolidate bodies of materials such as Al_2O_3, ZrO_2, UO_2, B_4C, copper, aluminum, and carbon. Applications are for Los Alamos and other national laboratory programs, and include armor, ceramic components for nuclear reactor meltdown experiments, nuclear shielding, and filters.

Keywords: Ceramics, Metals, Composites, Microstructure, Hot Pressing, High Temperature Service, Nuclear Reactors, Filters

402. Glass and Ceramic Coatings FY 1986
$ 10,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Vitreous enamels and general ceramic coatings are being developed to provide radiation-hardened, electrical-insulating components for accelerator technology. Research involves synthesizing formulations to bond various metals, matching thermal expansion, and preserving electrical insulating qualities over very large areas.

Keywords: Enamels, Ceramic Coatings, Metals, Radiation Effects, High Temperature Service

403. Cold Pressing, Cold Isostatic Pressing and Sintering
FY 1986
$ 175,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Cold pressing and cold isostatic pressing are used to consolidate ceramic and metal powders to support laboratory programs. Materials processed include UO_2, ThO_2, Al_2O_3, and MgO, and metals such as copper. End uses include plutonium processing hardware and fluxes, simulated fuel pellets, high temperature resistant ceramics for nuclear reactors, and metal filters.

Keywords: Cold Pressing, Sintering, Ceramics, Metals

404. <u>Plasma-Flame Spraying Technology</u> <u>FY 1986</u> $ 170,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Free-standing shapes and metallic and ceramic coatings are fabricated by plasma spraying. Materials examined recently include Fe_3O_4, Al_2O_3, tungsten, and LiF, among others. Parts of this work involve investigation of ultrasonic-assisted densification to produce high density coatings. Applications include: radiochemical detectors; temperature-, oxidation-, and corrosion-resistant coatings; and electrically insulating coatings.

Keywords: Coatings, Metals, Ceramics, Plasma-Flame Spraying, High Temperature Service, Surface Characterization and Treatment

405. <u>Electroplating Low Atomic Number Materials</u> <u>FY 1986</u> $ 120,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

Aqueous solutions presently limit the metals that can be electroplated. This project will look at electroplating low-atomic-number metals (aluminum and beryllium) by using non-aqueous plating baths. These new baths will include solvents and fused salts. Applications include weapons components and inertial confinement fusion (ICF) target fabrication.

Keywords: Electroplating, Aluminum, Beryllium, Coatings, Metals

406. <u>Superhard Parylene Coating Development</u> <u>FY 1986</u> $ 80,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

Use of a unique plasma cross-linking technique during the deposition of thermally pyrolyzed p-xylene monomer in an inert atmosphere yields a highly cross-linked, hard, polymer product. This new polymer has a thermal stability in an inert atmosphere of greater than 500°C.

Keywords: Polymer Coating, Parylene, Encapsulant

407. Three New Conducting Polymers FY 1986
$ 50,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

One polyphenylguinoxaline and two polypyrrones, heretofore unknown materials, have been synthesized and all show unique electrically conductive properties when treated with appropriate doping agents. These new polymers all show better thermal stability than polyacetylene.

Keywords: Polyphenylguinoxaline, Polypyrrone, Conducting Polymers

408. New Highly Conductive Doped Polyacetylene FY 1986
$ 200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

A new, unique, cesium electride has been found to induce a high level of electrical conductivity in polyacetylene films. This dopant has also been found to significantly improve the stability of polyacetylene.

Keywords: Conducting Polymers, Polyacetylene

409. Liquid Crystal Polymer Development FY 1986
$ 200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

Conventional liquid crystal polymers possess high strength in only one direction. Working with theoretical physicists, an attempt will be made to synthesize a liquid crystal polymer with strength in three dimensions. This will be a unique polymer with a number of possible applications.

Keywords: Liquid Crystal Polymers

410. Surface Property Modified Plastic Components FY 1986
$ 130,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

The surface properties of plastic components can be modified by a solvent infusion process. This process may be used to improve the biocompatibility properties of such plastics as acrylics and silicones.

Keywords: Acrylics, Silicones, Polymers, Surface Properties

411. <u>High-Z Loaded Parylene Polymer Coatings</u> <u>FY 1986</u>
$ 50,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

High-Z metals such as gold can be infused into parylene coatings using organometallic-solvent systems. Both uniformly loaded and graded Z coatings can be prepared by this method.

Keywords: Parylene, Metal Doped Polymers

412. <u>Low-Density, Microcellular Plastic Foams</u> <u>FY 1986</u>
$ 400,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

Microstructural polyolefin foams with densities between 0.01 g/cc and 0.2 g/cc are manufactured by a nonconventional foaming process. Foams are open-celled and have large surface areas. This process is being expanded to other polymeric materials for a wide variety of applications.

Keywords: Foams, Polyolefins, Polyurethanes, Silicones, Polyesters

413. <u>Radiochemistry Detector Coatings</u> <u>FY 1986</u>
$ 250,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

Physical vapor deposition of metallic and nonmetallic coatings for radiochemical detectors.

Keywords: Coatings and Films, Physical Vapor Deposition, Radiochemical Detectors

414. <u>Target Coatings</u> <u>FY 1986</u>
$ 600,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

Single and multilayer metallic and nonmetallic thin-film coatings, smooth and uniform in thickness. Substrates are planar and nonplanar and made of metal, glass, or plastic. Coatings may be bulk density or fractional bulk density and may also be free standing.

Keywords: Coatings and Films, Physical Vapor Deposition

415. Physical Vapor Deposition and Surface Analysis FY 1986 $ 700,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

Physical vapor deposition and sputtering are employed to produce materials for structural applications, corrosion resistance, optical properties, and thin film transducers. Materials being developed include doped, in-situ laminates of aluminum and Al_xO_y having high strength and smooth surface finish. Ion plating of aluminum and rare earth oxides onto various substrates for corrosion resistance to gases and liquid plutonium. Deposition of oriented AlN onto various substrates to enable nondestructive evaluation of materials. Reflective and anti-reflective coatings for infrared, visible, ultraviolet and x-ray wavelengths.

Keywords: Coatings and Films, Physical Vapor Deposition, Sputtering, Ion Plating, Corrosion, Nondestructive Evaluation

416. High Energy Density Joining Process Development FY 1986 $ 410,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Microcomputer technology and signal analysis are used for process control, together with multiaxis, programmable component manipulation for high-voltage electron beam welding. A high voltage electron beam welder has been modified and a spectrometer obtained for beam/target interaction studies. A high-voltage electron beam welder is now operational for fabrication of products in the fissile material area.

Real-time diagnostics of laser welding efficiency are thus under investigation. Plasma effects on laser welding efficiency are being studied. Photodiode, acoustic, light-spectral and electron current measurements have been made and are being correlated with high speed cinematography and resultant weld geometry.

Keywords: Welding, Laser, Electron Beam, Diagnostics

417. <u>Arc Welding Process Development</u> FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Video monitoring and Varistraint testing have been established as techniques to investigate crack susceptibility of gas-tungsten-arc welds. Emphasis is directed toward dissimilar metal welds between 304L stainless steel and Inconel 625.

Keywords: Welding, Hot Cracks, Stainless Steel, Inconel, Varistraint, Video

418. <u>Superplastic Forming</u> FY 1986
$ 150,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Superplastic forming of titanium and uranium alloys is being investigated. Demonstration components made with titanium alloys will be completed. Fine grained U-6 wt% Nb (2mm grain size) has been shown to exhibit superplasticity and will be evaluated in biaxial forming.

Keywords: Superplastic Forming, Near-Net-Shape, Titanium, Uranium Alloys

419. <u>Actinide Alloy Development</u> FY 1986
$ 1,350,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. C. Christensen, 505-667-2556, FTS 843-2556

The aim of this project is the development of new alloys of plutonium. Research involves casting, thermomechanical working, sputtering, and stability studies. Measurements of resistivity, thermal expansion and bend ductility are made to evaluate fabrication processes and alloy stability.

Keywords: Radioactive Materials, Plutonium Alloys, Ductility, Thermal Expansion, Electrical Resistivity, Stability

420. <u>Metallic Glasses</u> FY 1986
$ 160,000

DOE Contact - Louis Ianiello, 301-353-3427, FTS 233-3427
LANL (Contract No. W-7405-ENG-36) - S. E. Bronisz, 505-667-4665, FTS 843-4665

We conduct experimental and calculational modeling studies of atomic mobility phenomena and irradiation effects in metallic glasses ($Fe_{40}Ni_{40}P_{14}B_6$ and $Pd_{80}Ge_{20}$). We develop radiation resistant, amorphous metal magnetic materials.

Keywords: Alloys, Amorphous Materials, Coatings and Films, Surface Characterization and Treatment, Radiation Effects

421. <u>Structural Ceramics</u> <u>FY 1986</u>
$ 887,000

DOE Contact - Robert Gottschall, 301-353-3428, FTS 233-3428
LANL (Contract No. W-7405-ENG-36) - H. Casey, 505-667-4365, FTS 843-4365

We are developing ceramic materials based on SiC or Si_3N_4 to improve fracture toughness and strength through controlled processing. Current efforts are involved with colloidal processing of plasma-produced powders.

Keywords: Ceramics, Composites, Chemical Vapor Deposition, Colloidal Processing, Strength, High Temperature Service

422. <u>Surface Studies</u> <u>FY 1986</u>
$ 500,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. K. McDowell, 505-667-4686, FTS 843-4686

Studies of surface structures and atomic and electronic properties of uranium alloys and intermetallics, UO_2 and ThO_2 single crystals, heavy fermion system, and palladium/hydrogen systems are underway in order to develop essential atomic-level understanding of surface properties of materials and physical and chemical processes. Problems being investigated are: surface modification, synchrotron radiation studies of uranium, UPt_3 surface properties, valence bands of UO_2, residues on electropolished/oxidized uranium, and use of MeV ion beams to probe surface structure. Techniques used are: Low Energy Electron Diffraction (LEED), Auger and Loss Spectroscopies, Ion-Scattering Spectroscopy (ISS), Ultraviolet Photoelectron Spectroscopy (UPS), Synchrotron Radiation, and MeV-ion-beam scattering.

Keywords: Alloys, Radioactive Materials, Microstructure, Surface Characterization and Treatment

423. Tritiated Materials FY 1986
$ 730,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. H. W. Carstens, 505-667-5849, FTS 843-5849

Advanced research and development efforts are focused on low-Z, tritiated materials with the emphasis on Li(D,T) (salt) and other metal tritides. New methods for preparing, fabricating, and containing such compounds are under investigation.

Keywords: Tritium, Li(D,T), Tritiated Materials, Radioactive Materials

424. Actinide Surface Properties FY 1986
$ 700,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D.C. Christensen, 505-667-2556, FTS 843-2556

Characterization of actinide metal, alloy and compound surfaces using the techniques of x-ray photoelectron spectroscopy, Auger analysis, ellipsometry and Fourier-transform infrared spectroscopy. Surface reactions, chemisorption, attack by hydrogen, and the nature of associated catalytic processes are being studied.

Keywords: Actinides, Hydrides, Surface Characterization, Hydrogen Effects, Radioactive Materials

425. Mechanical Properties and Alloy Development FY 1986
$ 500,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - S.E. Bronisz, 505-667-4665, FTS 843-4665

Thermomechanical processing of plutonium alloys is being employed to optimize mechanical properties. Complex microstructures, grain refinement, and deformation-induced transformations are being studied.

Keywords: Alloys, Radioactive Materials, Microstructure, Strength, Transformation

426. Mechanical Properties of Uranium FY 1986
$ 60,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - S. E. Bronisz, 505-667-4665, FTS 843-4665

Mechanical properties of U-6 wt% Nb and pure U at high strain rates are being evaluated. The effects of crystallographic texture on high rate (shock regime) uranium deformation are being determined.

Keywords: Alloys, Radioactive Materials, Microstructures, Strength

427. <u>Low Temperature Electronic Properties</u> <u>FY 1986</u>
$ 1,060,000

DOE Contact - Louis Ianiello, 301-353-3427, FTS 233-3427
LANL (Contract No. W-7405-ENG-36) - S. E. Bronisz, 505-667-4665, FTS 843-4665 and R. H. Heffner, 505-667-4838, FTS 843-4838

Understand electronic properties of materials through their superconducting and magnetic behavior. Emphasis on actinide elements and their alloys.

Keywords: Alloys, Magnetic Materials, Radioactive Materials, Superconductor

428. <u>Phase Transformations in Pu and Pu Alloys</u> <u>FY 1986</u>
$ 505,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - S. E. Bronisz, 505-667-4665, FTS 843-4665

Mechanisms, crystallography, and kinetics of transformations in plutonium and alloys, pressure and temperature dilatometry, optical metallography, and x-ray diffraction are under study.

Keywords: Alloys, Radioactive Materials, Microstructure, Transformation

429. <u>High Strain Rate Testing</u> <u>FY 1986</u>
$ 510,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - P. S. Follansbee, 505-667-8021, FTS 843-8021

Testing of metals at rates up to, but not including, the shock-wave regime is underway in order to elicit fundamental understanding of changes in mechanism as a function of deformation rate.

Keywords: High Strain Rate, Metals, Microstructure

430. Neutron Diffraction of Pu and Pu Alloys FY 1986

$ 160,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - S. E. Bronisz, 505-667-4665, FTS 843-4665

Physical structure of plutonium is being studied by neutron diffraction at the Los Alamos WNR pulsed neutron source. A time-of-flight technique is used to measure diffraction at elevated temperatures and pressures.

Keywords: Alloys, Radioactive Materials, Transformation, Microstructure

431. Powder Characterization FY 1986

$ 90,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Processing of metal or ceramic powders critically depends on the characterization of the powder being used. This project characterizes starting powders, for example, RF plasma SiC, commercial powders of ThO_2, tungsten, copper, Si_3N_4, MgO and Al_2O_3. Properties determined include particle size and distribution, morphology, state of agglomeration, zeta potential, and surface area.

Keywords: Metal Powder, Ceramic Powder, Particle Size, Zeta Potential

432. Dielectric Loss Measurements in Ceramics FY 1986

$ 210,000

DOE Contact - M. Cohen, 301-353-4253
LANL (Contract No. W-7405-ENG-36) - F. W. Clinard, 505-667-5102, FTS 843-5102

Loss tangent measurements in ceramics are made at very high frequencies to evaluate effects of neutron damage for magnetic fusion energy applications, also to evaluate microwave sintering properties of ceramics for fabrication purposes.

Keywords: Dielectric Constant, Ceramics, Loss Tangent Measurements, Microwave Measurements, Radiation Damage

433. <u>Polymers and Adhesives</u> <u>FY 1986</u>
$ 700,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - W. A. May, Jr., 505-667-6362, FTS 843-6362

The project involves development of fabrication processes, and the evaluation and testing of commercial plastic materials for weapons programs as well as development of plastic-bonded composites, cushioning materials, and compatible adhesives. Included are applications of commercial and developmental plastics fabrication techniques to specific weapons-related materials and components for the purpose of improving efficiency and economy of weapons design.

Keywords: Adhesives, Composites, Polymer Strength, Near-Net-Shape Processing, Surface Characterization, Treatment

434. <u>Salt Fabrication</u> <u>FY 1986</u>
$ 426,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - J. E. Nasise, 505-667-1459, FTS 843-1459

We are involved in development and evaluation of fabrication processes of lithium tritide such as hot pressing and hot isostatic pressing to near-net-shape to improve part shape versatility, density, and surface quality; also, component integrity studies involving radiation induced growth and outgassing.

Keywords: Tritium, Hydrides, Radioactive Materials, Near-Net-Shape Processing

435. <u>Ceramic Technology</u> <u>FY 1986</u>
$ 60,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Castable ceramics are used to fabricate bodies for energy technologies. Typical materials are based on alumina or magnesia with a cement binder; parts fabricated include molds, crucibles, liners, and electrical insulators.

Keywords: Ceramics, Cements, Sintering, Refractory Liners

436. <u>Glass and Ceramic Sealing, Metallizing Technology</u>

<u>FY 1986</u>
$ 65,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Seals are formed to join ceramic and metal components which are used in experimental devices for energy technologies. One component now under development is an alumina assembly consisting of a large number of oval tubes joined together to form an arc of accelerator path. These segments will be metallized, with conductive paths separated by insulating layers, and both ends of the segment will be joined to metal rings for brazing to the metal portion of the accelerator. Due to the size and complexity, sealing and metallizing will be graded in melting point to permit sequential processing and assembly.

Keywords: Ceramics, Coatings and Films, Glasses, Metals, Joining, Graded Melting Temperature, Accelerator, Metallizing

437. <u>Microwave Sintering/Processing</u>

<u>FY 1986</u>
$ 200,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

In this program, techniques of bonding and sintering ceramics are being investigated. Materials under study include Al_2O_3 and glass. The method involves the use of very high frequency microwaves which suscept directly to the area in which the heat is needed. It has potential technical advantages related to heat distribution effects and a cost advantage because only the part is heated. Problems to be investigated include the control of the heating and its effect on microstructure.

Keywords: Ceramics, Sintering, Microwaves, RF Heating

438. <u>Injection Mold Process for Making Snap-On Fittings</u>

<u>FY 1986</u>
$ 50,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

High-strength, snap-on tube fittings are made from carbon-fiber reinforced polyether ether ketone, polycarbonate and nylon by an injection molding process. Fittings are functionally equivalent to brass counterparts.

Keywords: Snap-On Fittings, Nylon Composites, Injection Molding

439. <u>Composite Spring Support Structures</u> <u>FY 1986</u>
$ 300,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - D. V. Duchane, 505-667-3238, FTS 843-3238

Composite spring support structures can be fabricated from filament-wound, carbon-fiber epoxy composites. Such spring structures can support relatively heavy masses and show a high degree of self-centering characteristics in levitation configurations.

Keywords: Composites, Springs

440. <u>Solid State Bonding</u> <u>FY 1986</u>
$ 110,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - H. Casey, 505-667-4365, FTS 843-4365

Initial experimentation has been conducted on aluminum solid state bonding for seamless ICF targets. A new system has been procured to evaluate bond load modulation and ion bombardment cleaning. Bonding technique optimization will be investigated. Emphasis on aluminum and beryllium will continue with primary application to pure fusion experiments.

Keywords: Joining, Solid State Bonding, Sputtering

441. <u>Nondestructive Evaluation</u> <u>FY 1986</u>
$ 450,000

DOE Contact - A. E. Evans, 301-353-3098, FTS 233-3098
LANL (Contract No. W-7405-ENG-36) Contact - A. Wilson, 505-667-6404, FTS 843-6404

Develop nondestructive evaluation techniques that produce quantitative estimates of material properties are under development. Multivariate analysis is applied to welding processes. Tomographic techniques are used to extend radiographic inspections.

Keywords: Nondestructive Evaluation, Radiography, Acoustic Emission

OFFICE OF FOSSIL ENERGY

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 ongoing 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 suports workshops to identify research needs in all fossil energy technologies and manages selected training programs for faculty and students at Energy Technology Centers.

442. Evaluation of the Feasibility of Pressure Quenching to Produce Hard Metastable Materials FY 1985
$ 0*

DOE Contact - E. E. Hoffman, 615-576-0735; FTS 626-0735
R&D Associates (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 22X-72819C) Contact- H. L. Weisberg, 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 at 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 usec or less, that the high-pressure phases will be retained. It is possible that new materials, hitherto never seen, will result.

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*Prefunded in FY 1984.

Specific experiments on selected materials will be undertaken to demonstrate the capability of producing such materials.

Keywords: High Pressure, Materials, Decompression

443. Consolidation of Rapidly Solidified Aluminide Metal Powders

FY 1986
$ 238,000

DOE Contact - E. E. Hoffman, 615-576-0735; FTS 626-0735
Idaho National Engineering Laboratory (Contract No. DE-AC07-76ID01570) Contacts - A. D. Donaldson, J. E. Flinn, R. N. Wright, FTS 583-2627

The purpose of this project is to determine the most effective means of, and associated parameters for, consolidating rapidly solidified nickel-iron aluminide powders. Three consolidation techniques will be explored for the rapid solidification process (RSP) powders: hot extrusion (baseline), hot isostatic pressing (HIP), and dynamic (i.e., explosive) methods. The investigation of these consolidation techniques will emphasize the influence of pressure, temperature, and time on RSP structures. Structure/property assessments will be performed on the consolidated materials. In particular, thermal stability, mechanical properties, and oxidation response will be determined. The RSP aluminide powders and extrusions will be obtained from outside sources. Limited atomization investigations will be performed at the Idaho National Engineering Laboratory to assess RSP parameters for the aluminide powders. Compositions of the aluminide powders will be based on Oak Ridge National Laboratory's assessment, and initially will involve Ni-80, Fe-10, Al-10, B-0.02 (all in wt. %), with and without microalloying additions, e.g., hafnium.

Keywords: Aluminides, Powders, Consolidation

444. Investigation of Electrospark Deposited Coatings for Protection of Materials in Advanced Steam Cycle Superheat Applications

FY 1986
$ 48,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Hanford Engineering Development Laboratory (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc. Subcontract No. 10X-21664V) Contact - R. N. Johnson, 509-376-0715

The purpose of this task is to examine the use of the electrospark deposition coating process for the application of corrosion-, erosion-, and wear-resistant coatings to candidate superheater alloys. Materials to be deposited may include MCrAl, MCrAlY, highly wear-resistant carbides, and other hardsurfacing materials.

Keywords: Coatings, Materials

445. <u>Short Fiber Reinforced Structural Ceramics</u> <u>FY 1986</u>
$ 229,000

DOE Contact - E. E. Hoffman, 615-576-0735; FTS 626-0735
LANL (Contract No. W-7504-eng-36) Contacts - F. D. Gac, 505-667-9498; FTS 843-9498

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.

Keyword: Ceramics

446. <u>Fabrication of Fiber-Reinforced Composites by CVD Infiltration</u> <u>FY 1986</u>
$ 324,000

DOE Contact - E. E. Hoffman, 615-576-0735; FTS 626-0735
ORNL (Contract No. DE-AC05-84OR21400) Contact - D. P. Stinton, 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 $MPa \cdot m^{1/2}$ 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 across the surface to be coated. In addition, depending on the deposition reaction, a vacuum may be used to assist the flow of 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

447. Transfer of CVD Infiltration Technology to Industry

FY 1986
$ 100,000

DOE Contact - E. E. Hoffman, 615-576-0735; FTS 626-0735
ORNL (Contract No. DE-AC05-84OR21400) Contact - D. P. Stinton, 615-574-4556; FTS 624-4556

An innovative joint research and development program with Babcock & 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

448. Development of Advanced Fiber Reinforced Ceramics

FY 1986
$ 160,000

DOE Contact - E. E. Hoffman, 615-576-0735; FTS 626-0735
Georgia Institute of Technology, Georgia Tech Research Institute (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., 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

449. Development and Microstructural Evaluation of Austenitic Alloys

FY 1986
$ 90,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Oak Ridge National Laboratory (Contract No. DE-AC05-84OR21400)
Contact - R. W. Swindeman, 615-574-5108, FTS 624-5108

Alloys based on modifications to four groups of alloys will be developed on the basis of attributes required for advanced steam cycle superheater service. The four alloy groups to be studied include modified type 316 stainless steel, modified type 310 stainless steel, modified high nickel (alloy 800H) steels, and aluminum-containing steels. The bases for the alloy design include long-term strength and stability. Strength will be developed by control of chemical composition, and stability will be assured by suppression of intermetallic and other embrittling phases by the addition of elements that promote austenitic stabilization. Added strength will be achieved through the precipitation of fine carbides, nitrides, or phosphides that stabilize dislocation networks, prevent grain boundary migration, and resist coarsening during long service under constant and varying load conditions. Metallurgical tools used in these studies will include optical microscopy, electron microscopy, and microhardness measurements.

Keywords: Steam Cycle, Materials, Mechanical Properties

450. Technical Monitoring of Coal Gasification Subcontracted Materials Projects for the AR&TD Fossil Energy Materials Program

FY 1986
$ 29,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Argonne National Laboratory (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

451. <u>Study of Damage Mechanisms in Coal Conversion Atmospheres Affecting the Fatigue and Creep Rupture Properties of Cr-Mo Steels</u> FY 1986

$ 150,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
University of California, Department of Materials Science (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-27429C) Contacts - E. R. Parker and R. O. Ritchie, 415-642-0863

The purpose of this project is to evaluate the effects of high temperature service in adverse environments on the metallurgical properties (particularly on fatigue crack propagation and creep rupture properties) of weld metal and heat affected zone (HAZ) regions in thick section weldments of 3 Cr-Mo steels. The overall objective is to develop techniques for modifying the microstructures (in the HAZ and base plate) resulting from welding in order to provide adequate resistance to environmentally-induced damage while at the same time maintaining other desired mechanical properties.

Microstructures in the base metal, HAZ, and weld will be fully characterized in terms of microconstituents and phases. Damage in the form of microcavities or methane bubbles, situated in areas expected to be high-damage areas resulting from extended environmental exposure (e.g., to high pressure, high temperature hydrogen) and from welding, will be introduced. Fatigue crack growth characterization studies of weldments will be carried out to determine the influence of metallurgical features and environment on the fatigue crack growth rate from near threshold to near-instability. Creep rupture testing will be done in order to investigate the influence of damage mechanisms in weldments that are time dependent in their effect on microstructure/mechanical property relationships.

Keywords: Damage, Mechanisms, Creep, Fatigue, Materials

452. <u>Mechanical Properties and Microstructural Stability of Advanced Steam Cycle Materials</u> FY 1986

$ 140,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Cornell University, Materials Science and Engineering Department (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-27488C) Contact - Che-Yu Li, 607-256-4349

The purpose of this project is to rank the strengths and metallurgical stabilities of advanced steam cycle superheater alloys at temperatures ranging from 650 to 760^{O}C. Mechanical testing of the steels consists of relaxation experiments (~24 h duration each) that cover stresses producing deformation rates from about 10^{-3} to 10^{-9}/sec. The precipitate or dislocation microstructure of the steels in the grain boundary and matrix regions is being studied to determine the role of strain-time history on the stability of the microstructure. The relaxation data will be correlated with constant-load creep data provided by Oak Ridge National Laboratory and analyzed in terms of deformation mechanisms to determine relative contributions of grain boundary and matrix deformations. The most promising alloys from the screening test will be included in relaxation tests at 700°C to determine optimum heat treatments for strength and metallurgical stability.

Keywords: Steam Cycle, Microstructure, Mechanical Properties

453. <u>Transformation, Metallurgical Response and Behavior of the Weld Fusion and Heat Affected Zone in Cr-Mo Steels for Fossil Energy Applications</u> <u>FY 1986</u>
$ 0*

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
University of Tennessee, Department of Chemical, Metallurgical, and Polymer Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., 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 heat affected zone cracking, (4) 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.

*Prefunded in FY 1985.

454. <u>Investigation of Correlation of Carbide Size and Percentage with Mechanical Properties of High-Strength, Low Alloy Steels</u>

FY 1985
$ 0*

DOE Contact - E. E. Hoffman, 615-576-0735; FTS 626-0735

Westinghouse Electric Corporation Research and Development Center (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 86X-22006C) Contact - B. J. Shaw, 412-256-1201

The purpose of this project is to examine the correlation between the size and percentage of carbides in high-strength low-alloy steels with the mechanical properties. Carbides from a set of at least 20 high-strength Cr-Mo steels will be analyzed by scanning transmission electron microscopy to determine the size, percentage, and type of carbides as a function of composition and tempering parameter. A model developed for characterization of the carbides will be used to develop correlations of composition and heat treatment with the following properties: (1) shift in the 54 J Charpy-V transition temperature due to temper embrittlement; (2) room-temperature yield strength and ultimate strength; (3) room-temperature Charpy-V impact energy; and (4) crack arrest threshold stress intensity.

Keywords: Materials, Mechanical Properties, Carbides

455. <u>Analysis of Hydrogen Attack on Pressure Vessel Steels</u>

FY 1986
$ 95,000

DOE Contact - E. E. Hoffman, 615-576-0735; FTS 626-0735

University of California at Santa Barbara, Department of Chemical and Nuclear Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., 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 fracure 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

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*Prefunded in FY 1984.

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

456. Evaluation of 3 Cr-1.5 Mo Steel in a Simulated Coal Conversion Environment

FY 1986
$ 0*

DOE Contact - E. E. Hoffman, 615-576-0735; FTS 626-0735
Westinghouse Electric Corporation Research and Development Center (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., 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_2S 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_S and (2) 10.4 MPa pressure at 315°C (1500 psig at 600°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

*Prefunded in FY 1985.

457. Investigation of the Weldability of Ductile Aluminides

FY 1986
$ 50,000

DOE Contact - E. E. Hoffman, 615-576-0735; FTS 626-0735
Colorado School of Mines, Center for Welding Research (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-27421C) Contact - G. R. Edwards, 303-273-3773

The purpose of this project is to study the weldability of nickel-iron aluminides. The major thrust of the project is to determine the role of microstructure in the intergranular cracking of aluminides, with special emphasis on weld cracking susceptibility. This project is a cooperative effort of Oak Ridge National Laboratory (ORNL) and Colorado School of Mines (CSM) and will be conducted as a PhD thesis project by a CSM student working at CSM and at ORNL.

Keywords: Joining Methods, Materials Characterization

458. Development of Iron and Nickel Aluminides

FY 1986
$ 143,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Oak Ridge National Laboratory (Contract No. DE-AC05-84OR21400), Contact - C. T. Liu, 615-574-4459, DTS 624-4459

New, improved alloys are needed for components in severe environments for applications such as coal gasifiers, fluidized bed combustors, and fuel cells. The purpose of this task is to design and test 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. Aluminides based on the pseudobinary systems Hi_3Al-Fe_3Al and NiAl-FeAl will form the basis for development of iron and nickel aluminides as structural materials could substantially improve the performance and reliability of advanced fossil energy conversion systems.

The approach of this task is to develop aluminides based on the pseudobinary system Ni_3Al-Fe_3Al. 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

459. <u>Joining of Advanced Aluminides</u> FY 1986
$ 238,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Idaho National Engineering Laboratory (Contract No. DE-AC07-76ID01570) Contact - D. E. Clark, FTS 583-0746

The objective of this project is to investigate weldability problems limiting the use of aluminides in welded structures. This includes weldability effects of minor alloying elements, process and process variable effects, solidification mechanics, filler material development, and extension to heavier sections.

Keywords: Joining, Aluminides

460. <u>Corrosion of Alloys for Internal and Heat Exchangers in Mixed-Gas Environments</u> FY 1986
$ 110,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
ANL (Contract No. W-31-109-eng-38) Contacts - 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

461. <u>Corrosion of Alloys in FBC Systems</u> FY 1986
$ 105,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Argonne National Laboratory (Contract No. W-31-109-eng-38) Contacts - W. A. Ellingson and 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^{o}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

462. A Mechanistic Study of Low-Temperature Corrosion on Materials in the Coal Combustion Environment FY 1986
$ 0*

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
General Electric Comany, Gas Turbine Division (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 86X-00224C) Contact - R. W. Haskell, 518-385-4226

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

463. Investigation of Corrosion Mechanisms of Coal Combustion Products on Alloys and Coatings FY 1986
$ 80,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
University of Pittsburgh ((Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-43346C) Contact - G. H. Meier, 412-624-5316

The objective of this research project is to investigate the formation and breakdown of protective oxide scales in mixed oxidant gases. The results of this research will support the

*Prefunded in FY 1985.

development of improved heat exchanger materials for applications in (1) heat recovery systems for coal conversion plants (particularly gasification) and (2) coal-fired, industrial and utility boilers. The materials used in this study will be model alloys selected for their ability to form single oxides of chromium, aluminum, and silicon. The temperature range of interest is 500°C to 700°C and the test environments contain mixed oxidants (O_2, CO_2, SO_2, H_2S, and Cl_2). Specific objectives include determination of the effect of surface pretreatment and preoxidation on the structure and properties of oxide scales, and the correlation of these treatments and the resulting structures and properties with the breakdown of the scales in mixed oxidant gases. Loss of scale protection by mechanical means (cracking, spalling, etc.) and by transport of corroding species (S and Cl) will be considered.

Keyword: Corrosion

464. <u>Investigation of the Mechanisms of Molten Salt Corrosion of Candidate Materials for Molten Carbonate Fuel Cells</u>

FY 1986
$ 100,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Oak Ridge National Laboratory (Contract No. DE-AC05-84OR21400)
Contact - H. S. Hsu, 615-576-4810, FTS 626-4810

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 resistant 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, and NiO) in molten carbonate salt under anodic and cathodic conditions.

Keywords: Fuel Cells, Current Collectors

465. Erosion in Dual-Phase Microstructures FY 1986
$ 0*

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
University of Notre Dame, Department of Metallurgical Engineering and Materials Science (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., 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 include 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

466. Evaluation of Advanced Materials for Slurry Erosion Service
FY 1986
$ 0**

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Battelle-Columbus Laboratories (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 85X-69611C) Contacts - I. G. Wright and A. H. Clauer, 614-424-4377

This 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

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*Prefunded in FY 1984.

**Prefunded in FY 1984.

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

467. Mechanisms of Erosion-Corrosion in Coal Combustion Environments
FY 1986
$ 180,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Oak Ridge National Laboratory (Contact No. DE-AC05-84OR21400)
Contact - J. R. Keiser, 615-574-4453, FTS 624-4453

This project involves the evaluation of erosion and erosion-corrosion of alloys using microscopic techniques. Selected alloys will be subjected to single particle impacts both with and without a flowing corrosive gas stream. The degradation of the alloys will be followed by examination of the alloy surfaces with a scanning electron microscope. This technique should provide direct evidence of the erosion and erosion-corrosion modes of materials degradation in these systems.

Keywords: Erosion and Wear, Corrosion, Metals, Alloys

468. Study of Particle Rebound Characteristics and Materials Erosion at High Temperature
FY 1986
$ 80,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
University of Cincinnati (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., 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

469. Development of Nondestructive Evaluation Techniques for Structural Ceramics FY 1986
$ 197,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Argonne National Laboratory (Contract No. W-31-109-eng-38)
Contact - W. A. Ellingson, 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, inclusins, 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

470. Effect of Flaws on the Fracture Behavior of Structural Ceramics FY 1986
$ 128,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Argonne National Laboratory (Contract No. W-31-109-eng-38)
Contact - J. P. Singh, 312-972-5123, FTS 972-5123

The purpose of this work is to (a) establish correlations between the composition, microstructure, and mechanical properties of structural ceramics (Si_3N_4 and SiC) with well-defined flaws, and (b) provide information which will be used to relate mechanical properties to nondestructive evaluation (NDE) results. The work will include fabricating specimens of Si_3N_4 and SiC with controlled flaws and measuring their mechanical properties (fracture stress, fracture toughness and elastic modulus). Subsequently, microstructures of the fracture surface will be evaluated in order to locate the critical flaws. Information obtained from these studies will help control processing of structural ceramics to result in improved mechanical properties. Furthermore, correlation of mechanical properties with NDE results will provide additional information which will help verify the ability of NDE to detect failure-initiating flaws.

Keywords: Nondestructive Evaluation, Ceramics, Flaws, Fracture

471. Joining of Silicon Carbide Reinforced Ceramics FY 1986
$ 238,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Idaho National Engineering Laboratory (Contract No. DE-AC07-76IDO1570) Contact - R. M. Nielson, FTS 583-8274

The purpose of this project is to identify and to develop techniques for joining silicon carbide fiber-reinforced composite materials. Primary emphasis will be on composite materials with either a silicon nitride or a silicon carbide matrix; lesser emphasis will be placed on silicon carbide fiber-reinforced silica. The work will investigate oxynitride and oxide glass joining materials and joining techniques which promote the devitrification of these materials to produce glass-ceramics and joints which are both strong and tough. Joining of composite matrix materials will be studied, and the resulting information applied to the joining of the fiber-reinforced composities. The joining material, surface preparation, heat treatments, methods of binder application, joining technique, and joint configuration will be considered during joint design and fabrication. Microstructural examination of the joints will be conducted to investigate wetting, microstructure, mass transfer, and process parameter effects. Limited mechanical testing of joints will be performed for selected composite joints. Practical joining techniques must be developed to fully realize the advantages of silicon carbide fiber-reinforced ceramic composite materials. Successful joining methods will permit the design and use of complex component shapes and the integration of component parts into larger structures.

Keywords: Joining, Ceramics, Composites

472. Nondestructive Evaluation of Advanced Ceramic Composite Materials FY 1986
$ 238,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Idaho National Engineering Laboratory (Contract No. DE-AC07-76IDO570) Contact - J. B. Walter, FTS 583-0033

The purpose of this project is to develop an effective capability for nondestructive evaluation of ceramic fiber reinforced ceramic composites. The response of selected samples of sintered composite materials consisting of SiC fibers in SiC and Si_3N_4 matrices to both ultrasonic and radiographic techniques will be investigated. Experimental techniques and signal processing algorithms will be developed for (1) characterizing acoustic properties and sample morphology, including fiber size and distribution and the degree of bonding of the fibers to the matrix, (2) detecting flaws including cracks, porosity, fiber clusters, and bonding anomalies, and (3) detecting flaws in joints. The NDE techniques developed in this project will result in more effective and extensive use of advanced ceramic composite materials in fossill energy applications.

Keywords: Ceramics, Composites, Nondestructive Evaluation

473. Investigation of the Mechanisms of Failure of Ceramic Materials for Hot Gas Filtration

FY 1986
$ 0*

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
United Kingdom Coal Research Establishment/Oak Ridge National Laboratory (Contract No. DE-AC05-84OR21400) Contact - R. R. Judkins, 615-574-4572, FTS 624-4572

High temperature ceramic candle filters used for removing particulates from gas streams have been under evaluation at the United Kingdom Coal Research Establishment (UKCRE). These filters have been tested at 950°C in gasification atmospheres. Cracks at the point of attachment to the manifold have been a drawback not only to the application of this specific ceramic design, but represent a phenomenon generic to most ridig ceramic filters. No detailed phenomenological explanation of the failure has been determined. This task is a cooperative project of the DOE Fossil Energy AR&TD Fossil Energy Materials Program and the UKCRE to develop an understanding of the mechanisms of failure of ceramic hot gas filtration materials and, thereby, provide a basis for material and system improvements.

Keywords: Ceramics, Filters, Failure

474. High-Temperature Creep Behavior of Refractory Bricks

FY 1986
$ 60,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Iowa State University, Engineering Research Institute, Department of Materials Science and Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-07949C) 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

*Prefunded in FY 1985.

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

475. <u>Investigation of the Effect of Slag Penetration on the Mechanical Properties of Refractories</u> <u>FY 1986</u>
$ 0*

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
National Bureau of Standards, Center for Materials Science (Contract No. DE-AI05-83OR21349) Contact - S. M. 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 ona systematic compilation of data relating to slag properties and corrosion of refractories for advanced coal conversion systems.

Keywords: Corrosion, Slag, Refractories

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*Prefunded in FY 1985.

476. <u>Weldability Studies of Advanced Austenitic Alloys</u>

FY 1986
$ 60,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Oak Ridge National Laboratory (Contact No. DE-AC05-84OR21400)
Contact - R. W. Swindeman, 615-574-5108, FTS 624-5108

Evaluation of the weldability of alloys will include a specialized technique on a device called a Sigmajig, which evaluates the hot cracking tendency of the weldments. Ranking of alloys is by the extent of cracking as a function of applied load and plate thickness. Weldments in the alloys produced as tubing will be evaluated against requirements of the ASME BPV Code Sections I and IX, which involve bend testing, tensile testing, and metallography. Additional evaluation will be based on varestraint and circular groove tests. Other tests not required by the Code may be identified during the course of this work, and those tests will be included as appropriate. The development of a suitable filler metal is an important part of this work. Oak Ridge National Laboratory will work with university and industrial subcontractors in this development.

Keywords: Steam Cycle, Materials, Mechanical Properties

477. <u>Investigation of Corrosion-Resistant Oxide Scales on Iron-Based Alloys in Mixed Gas Environments</u>

FY 1986
$ 150,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Oak Ridge National Laboratory (Contact No. DE-AC05-84OR21400)
Contact - H. S. Hsu, 615-576-4810, FTS 626-4810

The purpose of this task is to develop protective oxide scales on Cr_2O_3- and Al_2O_3-forming iron-based alloys in mixed oxidant (O_2, SO_2, H_2S, H_2O) environments for coal-related applications at 600 to 800°C. Specific objectives include (1) the development of protective oxide scales by modifying oxide chemistry and microstructure to reduce the transport of sulfur through the scale; (2) the formation of a sulfur-diffusion barrier (i.e., SiO_2 layer) under or above the protective oxide scale to minimize the sulfur attack; (3) the study of the effects of alloy chemistry, oxide morphology, and temperature on the breakdown of protective oxide scales; and (4) the examination of methods to limit internal sulfidation. The mechanical performance and adherence of oxide scales in mixed oxidant gases will be studied by impinging tungsten carbide particles on the oxide within a scanning electron microscope under controlled temperature and environmental conditions.

Keywords: Corrosion, Iron-Based, Mixed Gas, Scales

478. <u>Solid Particle Erosion in Turbulent Flows Past Tube Banks</u>

FY 1986
$ 50,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
University of California, Berkeley, Department of Mechanical Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-55936C) Contact- J. A. C. Humphrey, 415-642-6460

The purpose of this investigation is to improve the understanding of erosion processes in gas streams. To fully understand erosion processes caused by particles entrained in gas streams, the fluid dynamic behavior of the particulates must be understood. Laboratory experiments have generally focused on erosive particles interacting with materials under carefully controlled flow conditions (particle velocity and impact angle). This project should aid attempts to correlate the results of the carefully controlled laboratory experiments with the experience of plant systems.

Keywords: Materials, Erosion, Particle, Gas Streams

479. <u>Modeling of Fibrous Preforms for CVD Infiltration</u>

FY 1986
$ 40,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Georgia Institute of Technology, Georgia Tech Research Institute (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-559001C) Contact - T. L. Starr, 404-894-3678

The purpose of this project is to conduct a theoretical and experimental program to develop an analytical model for the fabrication and infiltration of fibrous preforms. Chemical vapor deposition (CVD) has demonstrated considerable promise as a technique for fabrication of fiber-reinforced ceramic composites. Unidirectional and cloth-reinforced composites of SiC fibers in a SiC matrix have shown good strength and exceptional strain tolerance. However, results have been inconsistent with the fabrication of randomly oriented short-fiber composites. A critical problem has been the inability to consistently fabricate fibrous preforms with both high fiber loading and a permeability suitable for infiltration. A better understanding of the fundamental parameters controlling preform fabrication and CVD infiltration of such preforms is needed to guide further development. The proposed analytical model will (1) predict preform structure (density, porosity, fiber orientation, etc.) based on fabrication technique and fundamental fiber parameters (diameter, aspect ratio, etc.) and (2) predict permeation and heat conduction through the preform structure and, thus, predict the CVD infiltration performance. Initially, the model will be developed for preforms containing only one type of fiber, but extension to mixed fiber and fiber-particle blends is planned.

480. <u>Structural Reliability and Damage Tolerance of Ceramic Composites</u> <u>FY 1986</u>
$ 240,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
National Bureau of Standards, Center for Materials Science (Contract No. DE-A105-800RS0679) Contacts - E. R. Fuller and 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

481. <u>Evaluation of Mechanical Properties of Advanced Austenitic Alloys</u> <u>FY 1986</u>
$ 140,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Oak Ridge National Laboratory (Contract No. DE-AC05-84OR21400) Contact - R. W. Swindeman, 615-574-5108, FTS 624-5108

Creep-rupture data on alloys developed in the above task (Item 17) will be gathered in the temperature range 600 to 760^{o}C for times from 10 to 10,000 h. The effects of mechanical and thermal cycles will be examined, and results from testing will be used to establish cumulative damage models. Multiaxial stress testing, notched-bar stress-rupture testing, and creep crack-growth testing will be undertaken for constant and variable load conditions to verify cumulative damage models.

Keywords: Steam Cycle, Materials, Mechanical Properties

482. <u>"Materials and Components in Fossil Energy Applications" (Newsletter)</u> <u>FY 1986</u>
$ 105,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Battelle-Columbus Laboratories (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 11X-78931C) Contact - E. E. Hoffman (DOE/ORO), 615-576-0735, FTS 626-0735 and 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

483. <u>Membrane Separation of Gases From Coal Combustion and Coal Conversion Processes</u> <u>FY 1986</u>
$ 30,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Oak Ridge National Laboratory (Contract No. DE-AC05-84OR21400)
Contact - B. Z. Egan, 615-574-6868, FTS 624-6868

The objective of this task is to assess the applications of membrane technology for separating and recovering gases (e.g., SO_2, H_2S, CO_2, NO, N_2, and O_2) encountered in coal combustion and coal conversion processes.

Commercial membranes will be selected and evaluated for use in separating gases such as SO_2, H_2S, CO_2, NO, N_2, and O_2, which occur in coal combustion and conversion processes. The permeability of pure gases through different types of membranes will be determined by measuring the flow rates of the gases through the membranes at different pressures. The most promising membranes will then be used to study the separation of gas mixtures such as H_2S and CO_2, NO_x, and SO_2, as well as other gas mixtures of interest in coal combustion and conversion processes.

Keywords: Membrane, Gases, Combustion, Conversion

484. <u>Three-Dimensional Residual Stress Characterization of Thick Plate Weldments with Advanced Instrumentation and Methodologies</u> <u>FY 1986</u>
$ 0*

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Pennsylvania State University, Materials Research Laboratory (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-89603C) Contact - C. O. Rudd, 814-863-2843

This project is designed to (1) continue and expand previous work at Pennsylvania State University, (2) 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) 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

*Prefunded in FY 1985.

485. <u>Studies of Materials Erosion in Coal Conversion and Utilization Systems</u> <u>FY 1986</u>
$ 286,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Lawrence Berkeley Laboratory (Contract No. DE-AC03-76SF00098)
Contact - A. V. Levy, 415-486-4822, FTS 451-5822

The erosion of materials surfaces by small solid particles carried in gas and liquid streams is being investigated. The materials are tested over a range of conditions that simulate portions of the operating environments of containment surfaces in coal gasification, liquefaction, and fluidized-bed combustion processes. The effects of the materials properties, microstructures, and compositions on their erosion behavior are determined. The effects of elevated temperature corrosion in combination with the erosion are studied to determine the mechanisms and rates of the combined surface degradation modes.

Keywords: Corrosion, Erosion and Wear

486. <u>Mechanisms of Galling and Abrasive Wear</u> <u>FY 1986</u>
$ 75,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
National Bureau of Standards, Center for Materials Science (Contract No. DE-AI05-83OR21322) Contact - L. K. Ives, 301-921-2943

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

487. <u>Thermomechanical Modeling of Refractory Brick Linings for Slagging Gasifiers</u> <u>FY 1986</u>
$ 0*

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Massachusetts Institute of Technology (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-07862C) Contact - Oral Buyukozturg, 617-253-7186

The objective of this task is to study the failure mechanisms of refractory-brick-lined coal gasification vessels

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*Prefunded in FY 1985.

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 stress and strain distributions in brick-mortar linings during the heat-up and cool-down cycles. Through simulation and parameter studies, design recommendations will be made for vessel configuration, material property combinations, and optimum heating schedules.

Keywords: Refractory Liners

488. <u>Alkali Attack of Coal Gasifier Refractory Linings</u>

	FY 1986
	$ 0

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Virginia Polytechnic Institute and State University, Department of Materials Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-43397C) Contact - J. J. Brown, Jr., 703-961-6777

This task will investigate the physical and chemical characteristics of alkalai attack of coal gasifier linings under nonslagging conditions. Various refractories will be exposed to simulated coal gasification atmospheres containing alkalai metals. Phase changes and compound formations that occur in the refractories will be evaluated and compared with theoretical calculations.

Keywords: Corrosion, Ceramics, Glasses

489. <u>Thermodynamic Properties and Phase Relations for Refractory-Slag Reactions in Slagging Coal Gasifiers</u>

	FY 1986
	$ 40,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Pennsylvania State University (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., 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.

Keywords: Thermodynamics, Refractory, Slag, Phase

490. <u>Assessment of the Causes of Failure of Ceramic Filters for Hot-Gas Cleanup in Fossil Energy Systems and Determination of Materials Research and Development Needs</u> <u>FY 1986</u>
$ 56,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Acurex Corporation (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 11X-57964C)
Contact - R. L. S. Chang, 415-961-5700

The purpose of this project is to determine the principal causes of fialure of ceramic filters used for removal of fine particulates from high-temperature, high-pressure gas streams in coal conversion and utilization systems such as fluidized-bed combustors, direct coal-fired gas turbines, and coal gasification systems. As part of this project, the current practice for design and engineering of ceramic filters will be researched, and the current use for such filters in industrial and utility applications similar to those in the fossil energy systems listed above will be described. Materials failure experience will be examined, and causes of failure of ceramic filters will be determined through conversations with manufacturers and users and through laboratory failure analyses. Materials research and development that would improve the reliability of these filters, and design features of current filters that contribute to materials failure, will be identified.

Keywords: Gas Cleanup, Filters, Ceramic, Assessment.

491. <u>Oxide Electrodes for High-Temperature Fuel Cells</u>
<u>FY 1986</u>
$ 191,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Pacific Northwest Laboratory (Contract No. DE-AC06-76RL01830)
Contact - J. L. Bates, 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 O -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 O -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 temperature 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.

Keyword: Fuel Cells

492. <u>Development of a Design Methodology for High-Temperature Cyclic Application of Materials Which Experience Cyclic Softening</u> <u>FY 1986</u>
$ 100,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
University of Illinois, Department of Mechanical and Industrial Engineering (Contract No. DE-AC05-84OR21400, Martin Marietta Energy Systems, Inc., Subcontract No. 19X-27488C) Contact- D. L. Mariott, 217-333-7237

The objective of this project is to develop a design methodology for high-temperature cyclic conditions, taking into account the effects of strain softening. Since the problem of cyclic softening is generic to a wide class of medium- to high-strength low alloy steels, it is not the main purpose of this investigation to examine specific characteristics of any one steel but to investigate the general behavior of components subject to the cyclic softening phenomenon.

The specific objectives of the project are: (1) the development of simplified methods of component analysis to evaluate overall and local effects of cyclic softening on time-dependent deformations, (2) the development of an improved understanding of the mechanisms of interaction between intermittent cyclic stresses and reduction of resistance to creep deformation, (3) an evaluation of the possible effects of cyclic softening on the initiation and propagation of defects, (4) an evaluation of the possible effects of cyclic softening on the procedure for determining allowable design stresses for high-temperature design, and (5) provision of input into the material effort to extend life in existing power plants by examining the relation between material damage parameters and component performance criteria, for possible use in remmant life assessment.

Keywords: Materials, Cyclic Softening

Instrumentation and Facilities

493. Management of the AR&TD Fossil Energy Materials Program

FY 1986
$ 350,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Oak Ridge National Laboratory (Contract No. DE-AC05-84OR21400)
Contacts - R. A. Bradley, 615-574-6094, FTS 624-6094, R. R. Judkins, P. T. Carlson, 615-574-4572, FTS 624-4572

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 implementation 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

494. Coal Conversion and Utilization Plant Support Services

FY 1986
$ 40,000

DOE Contact - E. E. Hoffman, 615-576-0735, FTS 626-0735
Oak Ridge National Laboratory (Contact No. DE-AC05-84OR21400)
Contact - J. R. Keiser, 615-574-4453, FTS 624-4453

This task will provide screening data on the susceptibility to corrosion and stress-corrosion cracking of potential materials of construction for coal conversion and utilization plants. This task will also provide failure analyses and on-site examinations for the Wilsonville, Alabama, Advanced Coal Liquefaction Research and Development Facility and other coal conversion plants as needed.

Keywords: Corrosion, Liquefaction, Failure Analysis

Surface Gasification Materials Program

Office of Surface Coal Gasification

495. Electroslag Component Casting — FY 1986 $ 96,000

DOE Contacts - J. P. Carr (HQ), 301-353-5985, FTS 233-5985 and D. Dubis (METC), 304-291-4399, FTS 929-4399
Oak Ridge National Laboratory (Contact No. DE-AC05-84OR21400) Contact - V. K. Sikka, 615-574-5112, FTS 624-5112

The Surface 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 confersion systems by the ESC process.

Keywords: Alloys, Near Net Shape Processing, Alternative Fuels

496. Protective Coatings and Claddings: Application/Evaluation — FY 1986 $ 181,000

DOE Contacts - J. P. Carr (HQ), 301-353-5985, FTS 233-5985 and D. Dubis (METC), 304-291-4399, FTS 929-4399
Argonne National Laboratory (Contract No. W-31-109-eng-38) Contact - D. J. Baxter, 312-972-5117, FTS 972-5117

The coating/cladding development activity provides experimental evaluation and thermodynamic analysis of metallic protective coatings for coal gasifer 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 (about 480 to 540°C) required for good plant efficiency.

Keywords: Coatings and Films, Nondestructive Evaluation, Corrosion, Alternative Fuels

497. <u>Development of Iron Aluminides for Coal Gasification Systems</u>

<u>FY 1986</u>
$ 205,000

DOE Contacts - J. P. Carr (HQ), 301-353-5984, FTS 233-5985 and D. Dubis (METC), 304-291-4399, FTS 923-4399
Oak Ridge National Laboratory (Contact No. DE-AC05-84OR21400) Contact - C. T. Liu, 615-574-5120, FTS 624-5120

The purpose of this project is to develop low cost and low density intermetallic alloys based on Fe_3Al with an optimum combination of strength, ductility, and corrosion resistance for use as components in advanced fossil energy conversion and utilization systems. Initial emphasis is on the development of iron aluminides for heat recovery applications in coal gaisification systems.

498. <u>Ceramic Fiber-Ceramic Matrix Hot-Gas Filters</u>

<u>FY 1986</u>
$ 98,000

DOE Contacts - J. P. Carr (HQ), 301-353-5985, FTS 233-5985 and D. Dubis (METC), 304-291-4399, FTS 929-4399
Oak Ridge National Laboratory (Contact No. DE-AC05-84OR21400) Contact - D. P. Stinton, 615-574-4556, FTS 624-4556

The purpose of this project is to develop a ceramic fiber-ceramic matrix composite that will be suitable as a high-temeprature particulate filter for use in hot-gas cleanup systems. The goal is to produce a composite that has the requisite strength and toughness and which also has sufficient porosity to be permeaable to the gas stream, but with the proper size and distribution of porosity to be an effective filter. A practical process for fabricating porous ceramic fiber-ceramic matrix filter materials will be developed.

499. <u>Corrosion of Structural Ceramics in Coal Gasification Environments</u>

<u>FY 1986</u>
$ 0*

DOE Contacts - J. P. Carr (HQ), 301-353-5985, FTS 233-5985 and D. Dubis (METC), 304-291-4399, FTS 929-4399
Argonne National Laboratory (Contract No. W-31-109-eng-38) Contact - T. E. Easler, 312-972-4250, FTS 972-4250

This structural ceramics project provides experimental data (corrosion resistance, effect of environment on mechanical properties) for SiC when exposed to coal gasification heat exchanger environments. In addition, this project evaluates the corrosion resistance of joints made by specific SiC joining methods. The first phase of the project consists of running corrosion screening tests on -SiC, NC-430, and CX-589. These materials are tested as a function of: (1) fabrication method

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*Prefunded in FY 1985.

(slip cast and extruded as well as isostatically pressed); (2) status of surface (machined or as-received); (3) coal slag (acidic, basic, or no slag); and (4) temperature. Initial corrosion screening tests were conducted for 200 h at 1250°C in simulated medium-Btu tests on those SiC materials that are best able to withstand the corrosive environments as shown by their performance in 200-h tests were run subsequently.

Keywords: Ceramics, Near Net Shape Processing, Corrosion, Alternative Fuels

<u>Office of Oil, Gas, Shale, and Coal Liquids</u>

500. <u>Coating Studies for Coal Conversion</u> <u>FY 1986</u>
$ 0

DOE Contacts - T. B. Simpson, 301-353-3913 and S. R. Lee, 412-675-6137
ORNL Contact - A. J. Caputo, 615-574-4566

Development of a chemically vapor deposited coatings which offer the hope of extending the life of valve trim materials in coal conversion applications.

Determination of erosion rates using an established test in order to evaluate whether these coatings appear promising for valve trim and other severe erosion environment fossil applications.

501. <u>Assessment of Materials Selection and Performance for Coal Liquefaction Plants</u> <u>FY 1986</u>
$ 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

502. <u>Materials Review and Support for the SRC-1 Liquefaction Project</u> FY 1986

$ 0

DOE Contacts - J. P. J. A. Reafsnyder, 615-576-1051
ORNL Contact - A. R. Olsen, 615-574-1753

This project is concerned with the review and evaluation of materials performance in coal gasification pilot and demonstration plants. The purposes of this task are threefold: (1) to review and evaluate materials selection and performance in new and on-going plants, including providing failure analysis support; (2) to assess the materials performance of components exposed to the various operating environments in plants that have been closed down or are to be dismantled; and (3) to document the results of these studies so as to provide guidance for future materials utilization in coal conversion systems.

Keywords: Alloys, Ceramics, Corrosion, Erosion and Wear, Alternative Fuels

503. <u>Coal Liquefaction Pilot Plant Materials Testing and Failure Analysis</u> FY 1986

$ 0

DOE Contact - T. B. Simpson (HQ), 301-353-3913; FTS 233-2913; S. R. Lee (PETC), 412-675-6137; FTS 723-6137
ORNL Contact - J. R. Keiser, 615-574-4453

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

504. <u>Elastomer Test Programs</u> FY 1986

$ 0

DOE Contacts - T. B. Simpson (HQ), 301-353-3913; S. R. Lee (PETC), 412-675-6137
ORNL Contact - J. R. Keiser, 615-574-4453

O-ring elastomers are being tested for use in coal liquids. Laboratory immersion tests are being performed at the Wilsonville Advanced Coal Liquefaction Research and Development Facility.

Keywords: Elastomers

Office of Coal Utilization

505. Molten Carbonate Fuel Cell and Stack Technology Development

FY 1986
$ 0

DOE Contact - J. E. Copley, 304-291-4747
International Fuel Cells Contact - W. Johnson, 203-727-2215

Materials which maintain springiness under molten carbonate fuel cells (MCFC) operating conditions with temperatures approaching 700°C are being evaluated for use in the construction of flexible flanges which maintain sealing pressures against electrolyte-filled ceramic matrices. Corrosion of 316 stainless steel and other alloys are being studied in a MCFC cathode gas/molten corbonate 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. Also, ZrO_2 materials are being evaluated for use as gasket materials between gas manifolds and the MCFC stack.

Keywords: Fuel Cells, Performance/Endurance, Corrosion

506. Molten Carbonate Fuel Cell Component Technology Development

FY 1986
$ 0

DOE Contact - J. E. Copley, 304-291-4747
Energy Research Corporation Contact - L. Paetsch, 203-792-1460

The objective of this project is the improvement of anode creep resisance by filling the anode with lithium aluminate powders. Porosity can be improved by controlling particle synthesis and improving pressing and sintering methods. Catalysts are being developed for methane reforming in the anode compartment of the fuel cell. Also under development is a coating for separator plate materials which will meet the goals of over potential and resistance to corrosion and spalling after thermal cycling.

Keywords: Fuel Cells, Performance/Endurance, Catalysts, Coating

507. Alternative Molten Carbonate Fuel Cell Cathodes

FY 1986
$ 0

DOE Conatct - W. J. Huber, 304-291-4663
ANL Contact - R. D. Pierce, 312-972-4450

Various ceramic materials (e.g., Li_2MnO_3, $LiFeO_2$, and ZnO) are being evaluated as possible alternatives to NiO for the cathode material in molten carbonate fuel cells because in-cell migration of NiO has been found to be excessive for long-term operation.

Keywords: Fuel Cells, Ceramics

508. High Temperature Solid Oxide Electrolyte Fuel Cell Power Generation System

FY 1986
$ 0

DOE Contact - C. M. Zeh, 304-291-4265
Westinghouse Electric Corporation Contact - A. Jones, 412-256-1903

Diffusion studies to determine potential life limiting factors are underway.

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 DOE Materials Program for MHD is the development of materials applicable to the unique operating environment of coal-fired MHD systems. Program effort is primarily in the area of applied engineering development of MHD component materials.

The materials development effort is coordinated by the Pittsubrgh Energy Technology Center.

509. MHD Materials Development Testing, and Evaluation

FY 1986
$ 250,000

DOE Contact - L. Makovsky, 412-675-5814 (FTS 723-5814)
Avco (Contract No. DE-AC22-84PC70507) Contact - S. Petty, 617-381-4354

Avco has been involved in defining the thermal, electrical, chemical, and fluidynamic environment of electrode and sidewall materials and developing electrode, sidewall and insulator materials applicable to this environment. Service conditions include: temperature up to 2600°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 3 amp/cm^2, and sonic velocities.

Keywords: Ceramics, Electrodes, Insulators

510. <u>UTSI MHD Development Testing</u> <u>FY 1986</u>
$ 800,000

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

511. <u>Superconducting Magnet High Current Conductor Development and Testing</u> <u>FY 1986</u>
$ 50,000

DOE Contact - L. Makovsky, 412-675-5814 (FTS 723-5814)
Massachusetts Institute of Technology (Contract No. DE-AC22-84PC70512) Contact - P. Marston, 617-253-5722

The Massachusetts Institute of Technology is developing and testing a high-current conductor for larger-scale MHD magnets based on the concept of the internally cooled cabled superconductor (ICCS). An MHD focused, niobium-titanium technology base is being established. The existing niobium-tin technology base being developed for the fusion program provides a source of preliminary information that is being expanded and translated to the unique requirements for MHD magnets.

Keywords: Superconducting, Magnets, Conductors

<u>Instrumentation and Facilities</u>

512. <u>Argonne National Laboratory (ANL) Autoclave Testing</u>
<u>FY 1986</u>
$ 20,000

DOE Contact - C. A. Thomas, 412-675-5731 (FTS 723-5731)
ANL (Contract No. VAA-70-10) Contact - W. Swift, 312-972-5964

ANL has constructed an autoclave test facility to be used for long-term testing of materials to be used in the CFFF bottoming cycle.

Keywords: Autoclaves, Materials

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KEYWORD INDEX

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