

Research Activity:**Nanoscience Centers**

Division:

Materials Sciences and Engineering

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Portfolio Description:

This activity supports construction and the subsequent operation of Nanoscale Science Research Centers (NSRCs) at DOE laboratories that already host one or more of the BES major user facilities. Nanotechnology is the creation and use of materials, devices, and systems through the control of matter at the nanometer-length scale, at the level of atoms, molecules, and supramolecular structures. Nanoscience and nanotechnology will fundamentally change the way materials and devices will be produced in the future and subsequently revolutionize the production of virtually every human-made object. Nano-science will explore and develop the rules and tools needed to fully exploit the benefits of nanotechnology. Each NSRC will combine state-of-the-art equipment for materials nano-fabrication with advanced tools for nano characterization. The NSRCs will become a cornerstone of the Nation's nanotechnology revolution, covering the full spectrum of nano-materials and providing an invaluable resource for universities and industries.

Unique Aspects:

Nanoscale Science Research Centers were recommended by the NSTC Interagency Working Group on Nanoscale Science, Engineering, and Technology (IWGN) as part of DOE's contribution to the National Nanotechnology Initiative (NNI). The NNI proposed significant increases in this Nation's investment in nanotechnology in order to ensure a competitive position in this rapidly developing field of science and technology. European nations and Japan are already heavily committed to this field of research, which promises to revolutionize technology in the 21st century. The most recent example is the planned construction of a large center for Micro and Nanotechnology near Grenoble at a projected cost of about \$300M. Grenoble is a major research center in Europe where the European Synchrotron Radiation Facility (ESRF) and the Institut Laue-Langevin (ILL) neutron source are localized. The importance of collocation of NSRCs with facilities for x-ray and neutron scattering was also recognized by the IWGN. Hence, the Basic Energy Sciences program will play a major role in the NNI through the establishment of NSRCs affiliated with major BES scientific user facilities already sited at the DOE national laboratories, particularly the synchrotron radiation light sources, the neutron scattering facilities, and the electron beam microcharacterization facilities..

NSRCs will provide unique scientific and engineering capabilities not available in any of the parallel programs sponsored by other government agencies. For example, the National Science Foundation will sponsor research programs in nanoscience at universities, but such programs will be limited in scope and size and will not be comparable to the large-scale facilities in Europe or Japan. Three NSRCs are being planned by BES to cover the diverse aspects of nanoscience and to leverage existing DOE facilities. These centers were selected after an intense peer-review process. The proposed centers will be located at Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory and Los Alamos National Laboratory / Sandia National Laboratories.

Each Center will combine state-of-the-art equipment for materials nanofabrication with advanced tools for nano characterization. The purposes of NSRCs are as follows:

- Advance the fundamental understanding and control of materials at the nanoscale regime.
- Provide an environment to support research of a scope, complexity, and disciplinary breadth not possible under traditional individual investigator or small group efforts.
- Provide the foundation for the development of nanotechnologies important to the Department of Energy.
- Provide state-of-the-art equipment to in-house laboratory, university and industry researchers and optimize the use of national user facilities for materials characterization employing electrons, photons, and neutrons.
- Provide a formal mechanism for both short- and long-term collaborations and partnerships among DOE laboratory, academic, and industrial researchers.
- Provide training for graduate students and postdoctoral associates in interdisciplinary nanoscale science, engineering, and technology research.

Relationship to Others:

This activity will have strong interaction with all BES programmatic research performed at national laboratories and academic institutions. A significant fraction of the research will use the collocated synchrotron radiation light sources and the neutron scattering facilities. BES continues as a member of the NSTC Interagency Working Group on Nanotechnology to coordinate activities across the government. In addition, individual NSRCs have strong working relationships with academia, industry, state-sponsored nanoscience activities, and one another.

Significant Accomplishments:

This activity is presently in Project Engineering Design stages.

Mission Relevance:

The mission of the Office of Science is “To advance basic research and the instruments of science that are the foundations for DOE’s applied missions, a base for U.S. technology innovation, and a source of remarkable insights into our physical and biological world and the nature of matter and energy.” The Nanoscale Science Research Centers provide a unique opportunity for a major advance in carrying out that mission.

Scientific Challenges:

Scientific Challenges: Preparing for the challenges of this new millennium requires strategic investments that will help our nation develop a balanced R&D nanotechnology infrastructure, advance critical research areas, and nurture the scientific and technical workforce of the new century. The nanotechnology research and development is a top priority for the future. In response, DOE has taken the initiative of constructing three NanoScience Centers at LBNL, ORNL and SNL/LANL with the following project goals: (1) to attain a fundamental scientific understanding of nanoscale phenomena, particularly collective phenomena; (2) to achieve the ability to design and synthesize materials at the atomic level to produce materials with desired properties and functions; (3) to take full advantage of major user facilities, and (4) to develop experimental characterization techniques and theory/modeling/simulation tools necessary to drive the nanoscale revolution.

There are a large number of scientific challenges, all of which involve the collocation of disparate disciplines in order to fabricate and assemble nanosized components. One of the most challenging scientific problems is interfacing hard and soft matter, i.e., the world of electronic and structural materials with the world of biomaterials. These centers will employ advanced experimental and theoretical tools to tailor and control the functionality (e.g., detection ability and sensitivity), compatibility, performance, and integration of materials at this interface.

Construction Challenges: The major challenges are associated with the schedule of design and construction required in order to achieve successful completion of the project. To be most timely, the NSRCs should be completed by FY06.

Funding Summary:

Dollars in Thousands

	<u>FY 2002</u>	<u>FY 2003</u> <u>Request</u>	<u>FY 2004</u> <u>Request</u>
Construction – Other Project Costs	1,160	100	400
Project Engineering and Design	3,000	11,000	3,000
Center for Nanoscale Materials, ANL	0	0	10,000
Center for Nanophase Materials Sciences, ORNL	0	24,000	20,000
The Molecular Foundry, LBNL	0	0	35,000
Center for Integrated Nanotechnologies, SNL/LANL	0	0	29,850
TOTAL	4,160	35,100	98,250

Projected Program Evolution:

The initial stages of this program are associated with the design and construction of the Nanocenters at three National Laboratories: LBNL, ORNL and SNL/LANL. In addition, it is necessary to develop a well balanced and fair user program for this new type of National Laboratories facility. Scientific utilization and programmatic integration in the National Laboratories is prerequisite for successful operation in the near future of these Nanoscale Science Research Centers.

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