Materials Sciences in the Department of Energy

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Within the U.S. Department of Energy, in the Office of Energy Research, the Office of Basic Energy Sciences is responsible for supporting fundamental research in the natural sciences that is needed to accomplish the missions of the Department. The Division of Materials Sciences constitutes one portion of a wide range of research supported by the Office of Basic Energy Sciences. Other programs are administered by the Office's Chemical Sciences, Energy Biosciences, Engineering and Geosciences, Advanced Energy Projects, and Carbon Dioxide Research Divisions.

The Division of Materials Sciences traces its origin back to the Atomic Energy Commission's metallurgy and materials program of 1948. During its 39-year existence, the Division of Materials Sciences has been responsible for many significant discoveries and developments. Some examples of its more notable activities have been in neutron scattering, which has greatly aided our modern understanding of materials; radiation effects and defect structures; separation, preparation, and property measurements of individual rare earth elements which are used in lasers and as phosphors in television sets and computer display monitors; amorphous alloys which have started new areas of research and technology; and laser annealing combined with ion implantation now used routinely by the semiconductor industry. Yet the most important accomplishment has been the establishment and maintenance of a materials science effort of the highest quality. A measure of this accomplishment is the more than 8,000 publications in scientific and technical journals produced by this program during the last five years which have increased the understanding of materials phenomena and properties substantially. In this five-year time span, over 650 new scientists and engineers were trained in research programs at universities and the Department's laboratories.

Materials research requires interaction among many disciplines and the use of experimental facilities as simple as an optical microscope and as complex as nuclear reactors and synchrotron radiation sources. Both the people and the tools are needed to find generic solutions to technical problems, to tailor materials properties for ever more demanding uses, and to exploit discoveries wherever they may be made. For example, in fossil energy systems, high temperature corrosion is a serious problem in coal conversion plants. Although the promise of solar energy is substantial, use is limited primarily by the cost, performance, and lifetime of the materials involved. For energy storage, progress in advanced batteries is very dependent on understanding corrosion of the electrode materials. Ceramic components could be used to make more fuel efficient automobile engines; however, the behavior of ceramics is not understood well enough to make reliable parts. Applications involving ceramic high temperature superconductors will require solutions of many difficult materials problems.

Research in the Division of Materials Sciences is organized in four major categories corresponding to the major disciplines needed to solve the problems in energy systems and to provide support for major facilities: Metallurgy and Ceramics, Solid State Physics, Materials Chemistry, and Facility Operations.

In Metallurgy and Ceramics, research is conducted on the structure of materials, mechanical properties, physical properties, radiation effects, and engineering materials by materials scientists, metallurgists, and ceramists. The principal aims are to understand the relationship between the structure and properties of materials and to understand processing influences and phenomena that govern the defect, atomic, and microstructure of materials. In this category, researchers study, for example, fatigue properties of alloys, effects of processing parameters on the bulk structure properties of ceramics, the interaction of energetic radiation with materials, and the effect of welding parameters on weld structure and properties. Additional information regarding this program can be obtained by calling Dr. F.V. Nolfi, Branch Chief for Metallurgy and Ceramics at (301) 353-3428.

In Solid State Physics, physicists study the fundamental properties and theory of the condensed state of matter in the areas of neutron scattering, experimental and theoretical solid state physics, particle-solid interactions, and engineering physics. For example, researchers in this category study the magnetic structure of materials using neutrons, the modification of surfaces using ion implantation and laser annealing, the electronic structure of layers of atoms on surfaces using synchrotron radiation, and the mechanism of superconductivity in high-transition-temperature superconductors. Additional information regarding Solid State Physics can be obtained by calling Dr. B.C. Frazer, Branch Chief for Solid State Physics and Materials Chemistry at (301) 353-3426.

In Materials Chemistry, the principal areas of research are synthesis and chemical structure, polymer and engineering chemistry, and high temperature and surface chemistry. The objectives in this category are to understand the chemical behavior of materials and to synthesize new materials. Researchers in this category study, for example, synthesis and structure of ceramic and organic superconductors, molecular structure using x-ray and neutron crystallography, catalysts, and synthesis of high strength polymers. Additional information regarding Materials Chemistry can be obtained by calling Dr. R.D. Kelley at (301) 353-3426.

The Division of Materials Sciences also supports, wholly or partially, the operation of major facilities and is

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responsible for the development and construction of new, advanced research facilities needed to conduct modern materials research. Currently the major facilities supported are the National Synchrotron Light Source (NSLS) and the High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory, the Intense Pulsed Neutron Source (IPNS) at Argonne National Laboratory, the Los Alamos Neutron Scattering Center (LANSCE) at Los Alamos National Laboratory, Neutron Scattering at the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory, and the Stanford Synchrotron Radiation Laboratory (SSRL) at Stanford University. In addition, several smaller centers are supported, such as the National Center for Electron Microscopy at Lawrence Berkeley Laboratory and the Center for Microanalysis of Materials at the University of Illinois at Urbana-Champaign. Under construction is the 1-2 GeV Synchrotron Light Source at Lawrence Berkeley Laboratory, and in planning stages are the 6-7 GeV Synchrotron Light Source at Argonne National Laboratory and the Advanced Neutron Source at Oak Ridge National Laboratory.

The primary reason for the existence of these facilities has been to meet the needs of the Department of Energy and its predecessor agencies. However, through the years, the value of these facilities to the general scientific community has become increasingly evident, and they have been organized as user centers. Researchers from universities, industries, and government laboratories can use these facilities subject to the review procedures adopted by each center. Activities that can be done at commercially available laboratories are not appropriate for these centers. There are no charges for research that is not proprietary and is published in the open literature. Proprietary research may be done, but the full cost to use the facility is charged to the user. A recent survey showed that about 21% of the users came from Department of Energy laboratories, 48% from universities, 14% from industries, and the balance from other government laboratories, nonprofit research institutions, and foreign institutions. Although some of the outside users were supported in part by the Department of Energy, most received support from other sources.

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About 80% of the research supported by the Division of Materials Sciences is done at the Department of Energy laboratories. Research at these laboratories is generally done by large groups and has close ties with the major facilities and applied programs of the Department sited at the laboratories. Grants and contracts make up the other 20%, most involving grants to universities. A typical university grant involves a professor as principal investigator, graduate students, and often postdoctoral scientists. Grants usually run for three years and may be renewed if progress is satisfactory. Support for industry is provided both through the normal proposal route and through the Small Business Innovation Research (SBIR) program. The percentage of the budget supporting work at the Department of Energy laboratories includes the two university-based laboratories, Ames Laboratory at Iowa State University and Lawrence Berkeley Laboratory at University of California at Berkeley; therefore, support for university-based research is about 35% of the total when the university-based laboratories are taken into account. DOE laboratory funds also include support for the operation of the user facilities which provide substantial indirect support for both academic and industrial research. For reference, the total operating budget for fiscal 1987 was $154,455,000.

All the activities of the Division of Materials Sciences are described in detail in a document published annually. This document contains abstracts of each research project, funding levels, and descriptions of all of the user centers. The latest, *Materials Sciences Programs*, (DOE/ER-0348, September 1987), is available from the Division's office either by writing to the Division of Materials Sciences, U.S. Department of Energy, Washington, DC 20545, or calling (301) 353-3427.

Information regarding the grant program is contained in *Application and Guide for the Special Research Grant Program 10 CFR Part 605* (DOE/ER-0249), which is available from Acquisition and Assistance Management Division, Office of Energy Research, ER-64, U.S. Department of Energy, Washington, DC 20545. The solicitation for the Small Business Innovation Research Program is available from SBIR Program Manager, ER-16, U.S. Department of Energy, Washington, DC 20545. □

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