Analyte Delivery System (BEADS), creates samples that can be used in biodetectors to quickly identify pathogens. BEADS cleans samples so that micro-organisms can be identified in places like food processing lines and water treatment plants. The system's sample preparation process can be used with existing detectors, which currently require a person to manually purify samples for identification. BEADS takes the person out of the process by using proprietary microfluidic systems and automated sample cleanup methods. It can be used in chemical, protein, nucleic acid or whole-cell detectors.

Award-winning Research

PNNL's innovative materials science research has garnered many prestigious awards. These include:

R&D 100 awards, presented by R&D magazine to the top 100 innovations each year:

- Catalysts for Engine Exhaust Treatment (2001)
- Ultra-Barrier Coatings (2000)
- PUMA Fiber Optic Neutron and Gamma Ray Detector (1999)
- Compact Microchannel Fuel Vaporizer (1999)
- MicroHeater (1999)
- SAMMS (1998)
- Multilayer Processes for Vacuum Deposition of Polymer Films (1996)
- High-Energy Corona (HEC) Reactor (1993)
- Ultrafine Powder Formation by Continuous Hydrothermal Synthesis (1993)
- Glycine-Nitrate Process (1992)
- Rapid Expansion of Supercritical Fluid Solutions (1988)

Federal Laboratory Consortium (FLC) Awards that recognize excellence in technology transfer:

- Engine Exhaust Aftertreatment (2003)
- Ultra-Barrier Coatings (2002)
- Superplastic Forming (2000)
- Plasma Enhanced Melter for Waste Conversion (2000)
- PUMA Fiber Optic Neutron and Gamma Ray Detector (1999)
- Vacuum Process for Manufacturing Lithium Polymer Batteries (1996)
- Glycine-Nitrate Process (1993)
- Advanced Decontamination Techniques (1985)

Partnerships

Collaboration with universities, other federal laboratories and industry is critical to our success in materials science research. Our partners in developing the DOE Center for Chemical Hydrogen Storage, for example, include several industrial companies, universities, and Los Alamos National Laboratory. SECA, the High-Temperature Electrochemistry Center (HiTEC), and the Zero Emissions Research and Technology Center are all key multi-institutional partnerships that support FutureGen, DOE's vision for an efficient fossil fuel plant that produces electricity and hydrogen while creating near zero emissions. As a national laboratory managed by Battelle, PNNL also collaborates with our counterparts at Battelle in Columbus, Ohio, in materials and in large-scale coatings and with the Battelle-managed Oak Ridge National Laboratory's materials programs.

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Materials Science at Pacific Northwest National Laboratory

Shaping the Way We Live

Materials have played a pivotal role in shaping modern society. Advances in materials drive economic, social and scientific progress and profoundly shape our everyday lives. Materials underpin major industries, steer global markets and are critical to national and economic security. Enhanced material performance and low-cost materials processing are essential to the U.S. Department of Energy's mission for increased efficiency in energy production and consumption and for the success of environmentally benign products.

From Science to Solutions

Breakthroughs needed to solve critical challenges in energy, the environment and national security don't happen overnight. Significant technologies that benefit society are built upon years of basic research. At Pacific Northwest National Laboratory, we integrate physical, chemical and biological sciences to predict and control the fundamental processes that drive all complex systems. Building upon our strong foundation in fundamental materials science, our researchers take innovative approaches to technology development and advancement by bringing together theory with experimentation.

Our "science to solution" approach, talented staff and state-of-the-art instrumentation make it possible to conduct robust and visionary materials research. PNNL's range of research related to solid oxide fuel cells is a hallmark example of our materials science activities. For nearly 15 years, we have investigated materials properties, chemistry and ceramic processing for fuel cells. More recently, however, we began building on this long history and expanding our capabilities to include designing, modeling and fabricating complete solid oxide fuel cell systems.

Innovation at Work

Materials science research at PNNL is a broad mix of basic research and applied programs designed to help solve problems for government and industry. Our materials scientists conduct research in:

- Advanced Ceramics
- Biomaterials
- Composite Materials
- Computational Mechanics
- Designed Catalysts
- Electronic and Spintronic Materials
- Glass Science
- Metal Forming and Joining
- Modeling and Properties Simulation
- Nanostructured Materials
- Optical and Photonic Materials
- Radiation Detection Materials
- Stress/Corrosion Research
- Structural Materials Performance

Providing the Science Foundation

PNNL's basic research in materials science—particularly in optical and photonic materials, stress and corrosion, biomaterials, nanostructured materials, and modeling and properties simulations—serve as the foundation for breakthroughs in materials development.

Advances in our ability to see, understand and manipulate materials at the nanoscale are particularly exciting and offer opportunities for scientific discovery as well as for designing materials with tailored or unique properties. PNNL's Nanoscience and Technology Initiative is investing major resources in manipulating structures at an atomic scale, enabling fundamental changes to the properties of materials and making possible new materials, chemistry and functions.

Several major facilities are available at the Laboratory for conducting basic research in materials science. The Interfacial and Nanoscale Science Facility (INSF), housed within the William R. Wiley Environmental Molecular Sciences Laboratory at PNNL, includes state-of-the-art equipment for vacuum film deposition, high-resolution surface and bulk characterization tools, and microfabrication and clean-room capabilities. Facilities also are available for material synthesis using thin film deposition and chemical synthesis, electron microscopy, ion beam processing and analysis, surface and bulk characterization and catalytic reaction.

Putting Materials to Work

Securing our Energy Future

Materials will play a key role in securing our energy future. Reliable and affordable fuel cells, for example, will be instrumental in providing clean energy for automobiles. PNNL is developing solid oxide fuel cell (SOFC) technology due to its leadership role in the Solid State Energy Conversion Alliance (SECA) Core Technology Program and several industrial programs. Researchers are working with industrial partners to develop and test advanced cell and stack designs, component materials and low-cost fabrication processes to accelerate the development of low-cost SOFC systems. The Laboratory's extensive knowledge base in materials synthesis, testing, design optimization, fuel processing and catalysis provides the foundation for solving the technical and economical challenges faced by SOFC system developers.

Materials also will be critical in enabling the development of hydrogen-powered vehicles, which would reduce both pollution and the need for foreign oil. PNNL, along with Los Alamos National Laboratory, will play a leadership role in a new national Center for Chemical Hydrogen Storage, one of DOE's centers of excellence aimed at enabling use of hydrogen-powered vehicles. Researchers will look at ways to improve the properties of chemical compounds currently known to hold hydrogen and to discover entirely new materials in which to store hydrogen.

Expertise in materials design and synthesis, thin film deposition, and modeling and testing of molecular structures and light-emitting devices will enable the Laboratory to make significant contributions in developing solid-state lighting technology that will transform the way we provide lighting to homes and buildings while reducing energy consumption. Using Organic Light Emitting Diodes (OLED) for solid-state lighting involves direct light emission from a semiconductor material rather than conventional thermal sources, such as the light bulb. Organic light emitting molecules may be applied as a coating or thin film.

As the U.S. attempts to move away from dependence on foreign oil and toward less polluting forms of energy, the ability to convert wasted heat into useful energy is becoming more important. In our country today, as much as 30 percent of the energy involved in many large-scale industrial processes is lost as waste heat. In the transportation sector, gasoline and diesel engines lose 35-40 percent of their fuel energy in waste heat, primarily in the exhaust. Scientists at PNNL are using nanoscale materials to create a thermoelectric device to harvest and recover waste heat from diesel and gasoline engines, exhaust systems and industrial processes, such as glass, aluminum and chemical manufacturing. Their goal is to achieve 20-percent efficiency that will make thermoelectric power generation using waste heat economically feasible.

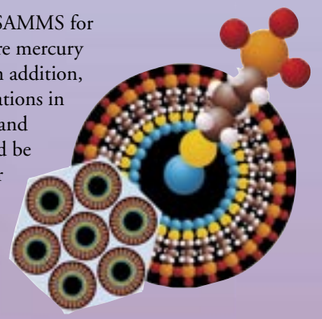
Cleaning Up the Environment

For decades, materials science research at PNNL has helped in developing technology to restore, protect and sustain the environment. This includes a major role in helping the DOE clean up legacy waste from nuclear weapons production and military and industrial activities.

Vitrification is a process that combines concentrated radioactive waste with glass-forming materials. The Laboratory's expertise in glass science has led to a formula for nuclear waste glass, known as "fast glass," that has been used to vitrify radioactive waste at DOE's Savannah River Site. Scientists at PNNL and the Savannah River Technology Center applied glass property models to develop a new frit or glass-forming material. This new formula, Frit 320, showed a melt rate 20 percent faster than the previous frit in small-scale melter tests.

Another environmental use of PNNL's materials expertise is the innovative SAMMS (Self-Assembled Monolayers on Mesoporous Supports) technology, a new class of materials that can remove metals and radionuclides from aqueous and organic liquids and gaseous streams. SAMMS integrates mesoporous ceramics technology first created by Mobil Oil Corporation with an innovative method for attaching "monolayers"—single layers of densely packed molecules—to the pore surfaces throughout the tiny grains of ceramic material. The molecules are custom designed to seek out mercury, lead, chromium and other metals and is available in powder form.

DOE is exploring the use of SAMMS for cleanup activities at sites where mercury contamination is prevalent. In addition, SAMMS has potential applications in industry, particularly mining and metal finishing, where it could be used to clean processing water and retrieve valuable metals present in waste streams.



Enhancing National Security

Materials research at PNNL is becoming increasingly important in developing technologies to detect nuclear, chemical and biological weapons. Growth in materials development, performance and characterization for national defense is anticipated at the Laboratory.

In the aftermath of the terrorist attacks on September 11, 2001, the need for radiation detectors is growing. These devices and other advanced technologies to detect clandestine nuclear materials or nuclear devices will require new materials.

PNNL's expertise in glass science in areas such as radiation damage effects and scintillators, as well as optical and photonic materials, such as non-linear optical properties, will be leveraged to help meet today's security needs, including detecting, identifying and analyzing nuclear materials and nuclear devices.

Solutions for national security, homeland security and counterterrorism also will depend increasingly on materials expertise in polymer chemistry, mineralization and nucleation chemistry, and biomaterials.

A technology developed at PNNL to automatically concentrate large volumes of soil, air or water samples into small, clean samples builds upon our biomaterials expertise. The Biodetection Enabling