NMR Used for Environmental Restoration

Researchers at Pacific Northwest Laboratory are using a suite of nuclear magnetic resonance (NMR) spectrometers to research molecular problems related to environmental restoration. NMR is being used to examine catalytic conversion of environmental toxins to study the physical integrity of materials used for waste storage. Researchers are using NMR to determine how carbon tetrachloride is destroyed when it is converted to methane catalysts that can destroy a wider range of contaminants. Paul Ellis, head of the Department of Energy's Environmental Molecular Sciences Laboratory (EMSL) conducting the research at Pacific Northwest Laboratory, said that more research is needed to test the applicability of the methods. According to the scientists, EMSL catalysis research would have applications wherever toxic materials are used, including energy, petrochemical, fuel and plastics production or manufacturing sites.

Vertical-Cavity Surface Emitting InGaAs Laser Yields High Efficiency

A team of researchers led by Kent Choquette, Kevin Lear, and Richard Schneider in Sandia National Laboratories' Center for Compound Semiconductor Technology demonstrated a 53% electrical-to-optical power conversion efficiency from an indium-gallium-arsenide vertical-cavity surface emitting laser (VCSEL) operating at 980 nm. In contrast to the conventional semiconductor laser that emits light from the edge of a cleaved wafer, a VCSEL emits light perpendicular to the wafer surface, rendering it easy to fashion into densely packed arrays of lasers on a single chip.

The researchers used a series of advances in the design and growth of the multilayered device heterostructures, combined with a "selective oxidation" fabrication technology to realize the low electrical resistance and high optical and electrical confinement needed to achieve the high efficiency.

VCSELs are fabricated by sequentially layering atoms of semiconductor materials on a substrate. The center layer is the light-emitting optical cavity, and the surrounding layers are mirrors. Electrical charges approaching from the mirror layers above and below get trapped and recombine in the cavity to emit light. The mirrors reflect the emitted light, which is amplified in the central layer, to produce the laser beam.

The selective oxidation approach involved embedding specially designed layers of aluminum-gallium-arsenide in the VCSEL structure during the growth process. This is followed by the formation of mesas by dry etching. The layers were oxidized to form an aluminum oxide aperture that defined the current injection path for the VCSEL device as well as providing an enhancement to the optical confinement of photons in the device. The collective effects of the low electrical resistance combined with the oxide aperture resulted in the high operating efficiency of the devices.

https://doi.org/10.1557/S0883769400044791 Published online by Cambridge University Press

ORNL Develops Self-Lubricating Coating for Engine Parts

A self-lubricating composite coating that could make engine and other moving parts last longer has been developed at Oak Ridge National Laboratory (ORNL).

The self-lubricating coating may be used for high-speed bearings, piston rings, cylinder linings, valve guides, and other parts in jet and internal combustion engines. Coated samples from ORNL are now being tested at the General Electric Company's Aircraft Engines Division in Cincinnati, Ohio.

ORNL's Metals and Ceramics Division staff members Woo Lee, Peter Blau, postdoctoral scientist Y. Bae, and Ted Besmann developed a composite coating made of titanium nitride, a hard, wear-resistance material at high temperatures, and of molybdenum sulfide, a solid lubricant. Electron micrographs of the composite coating show that separate grains of the solid lubricant are dispersed near the surface of the titanium nitride coating.

To make the coating, the researchers used chemical vapor deposition (CVD). In this process vapors or gases are allowed to flow over a heated substrate, react, and form a solid coating.

The researchers simultaneously deposited the desired materials in gaseous form on substrates such as silicon and graphite. Then they deposited the composite coating on a titanium alloy used for parts in engines.

"To make the coating for a titanium alloy substrate," Besmann said, "we flowed several gases at a temperature of 800°C and low pressure into a reactor containing the heated substrate. To get the best coating composition, we varied the composition of the gases, which included molybdenum hexafluoride, hydrogen sulfide, ammonia, and argon that carried the titanium organometallic vapor into the reactor."

Besmann said that solid lubricating films of molybdenum sulfide have been deposited on moving parts, but the lubricant tends to be worn away quickly. The composite coating developed at ORNL increases the sliding life of the molybdenum sulfide lubricant by incorporating it in a hard material. Besmann said that CVD could be used to develop a low-wear, low-friction composite coating.

SBIR Update

Labsphere, Inc. (North Sutton, New Hampshire) was awarded an $80,000 Phase I contract from the Manufacturing Technology Directorate of the U.S. Air Force Wright Laboratory (Dayton, Ohio) to develop a system to nondestructively measure and characterize surface roughness of polished semiconductor wafers and oxide layers deposited on the wafer surface.

Potomac Photonics, Inc. (Lanham, Maryland) has been awarded a Phase II contract of $600,000 from the National Aeronautics and Space Administration to develop a laser micromachining workstation for the rapid manufacture of diffractive optics.

QUEST Integrated, Inc. (Kent, Washington) has received a Phase I grant from the National Science Foundation to study sonochemical routes for the synthesis of nanosize ceramic powders.

Essential Research, Inc. (Cleveland, Ohio) has been awarded two $70,000 grants from the National Aeronautics and Space Administration. One grant is for the development of components for a thermophotovoltaic (TPV) generator that produces electricity from heat. The other is for the purpose of growing high-quality, indium phosphide thin films on germanium substrates.

https://doi.org/10.1557/S0883769400044791 Published online by Cambridge University Press

NRL Licenses Diamond-Based Electronic Device Patents to DMC

The Naval Research Laboratory (NRL) and Diamond Microelectronics Corporation (DMC) signed a patent licensing agreement granting DMC a partially exclusive right and license to use NRL inventions in the fields of high-performance, diamond-based electronic devices, including high-current, high-power switches, RF amplifiers, flat panel displays, and gamma-ray detectors. According to Pehr E. Pehrsson of NRL's Chemistry Division, the agreement will enable researchers to remove performance-degrading contaminants from the surface of semiconducting diamonds, and to selectively etch damaged subsurface carbon created by ion implantation, which permits detachment of an undamaged surface diamond layer, which can be used as a seed for further growth by chemical vapor deposition.

Gold Nanowires Exhibit Insulating Properties

Researchers at the Georgia Institute of Technology and the Universidad Autonoma de Madrid in Spain have reported the results of experimental and supercomputer-based simulations of electronic transport and mechanical elongation in ultrathin metallic wires.

In the March 24 issue of *Science* the researchers reported that under certain conditions, the ability of the nanowires to conduct electricity declines to the point that they resemble insulators. Conductance of such atomic-scale gold wires depends on their length, lateral dimensions, the state of atomic order and disorder, and the elongation mechanism of the wires.

To study the phenomena, researchers at the Universidad Autonoma de Madrid created tiny nanowires by bringing the tip of a scanning tunneling microscope (STM) near a gold surface and applying an electrical voltage, or by pushing the tip into the surface, and then retracting the tip to carry away gold atoms in the form of tiny wires between 50 and 400 Å in length.

The researchers studied electrical conductance as they pulled the tip away from the surface, elongating and eventually breaking the nanowire. The experimental measurements were correlated with predictions obtained from molecular dynamics simulations performed by the Georgia Tech research group.

"The simulated elongation process reveals a mechanism exhibiting periodic oscillations of the pulling force," said Uzi Landman, director of Georgia Tech's Center for Computational Materials Science. "These oscillations reflect the atomic-scale mechanisms of elongation, which proceeds layer-by-layer as stress accumulates up to a certain limiting value. After that point, relief of the stress occurs through the formation of a new layer and a corresponding reduction in the diameter of the wire."

The elongation process is also reflected in the conductance of the nanowires.

The wire current varied in a stepwise manner as the wire narrowed. "We saw that the jumps in the conductance occurred with a periodicity of about the interlayer spacing in the wire," Landman said. "Moreover, the conductance changed in each stage in steps whose height was one or two times the conductance quantum, a measure of electrical resistance in very small conductors."

The conductance measurements revealed a repeating pattern in which the conductance exhibited dips corresponding to enhanced degrees of disorder in the wires during elongation. The increases in the conductance subsequent to each of these dips was correlated with a restoration of a higher degree of order in the elongated wire. Such a repeating pattern manifested itself as the thickness of the wire dropped below five to 10 atoms.

In wires between 50 and 400 Å in length, the researchers

https://doi.org/10.1557/S0883769400044791 Published online by Cambridge University Press

observed nonlinear dependence of the electrical resistance as a function of the voltage across the wire. As the length of the narrow wires increased, the conductance decreased and ultimately the wires behaved more like insulators than metallic conductors.

"While at a fixed point of elongation, wires that are short (less than 50 angstroms) showed linear and regular ohmic characteristics, but the nature of the resistance trace changed as the wire became longer and more narrow, going through a stage in which the wire looked very much like a semiconductor," Landman said. "Eventually, the very long wires—up to 150 or 200 Angstroms—began to appear insulating."

Based on the observations, the group developed a formula for the nonlinear behavior of the resistance of the long wires and related it to a phenomenon known as Anderson localization.

Establishment of Mexican National Research Foundation Announced

In an effort to enhance the Mexican government's ability to make sound decisions on matters involving science, technology, and public health, the Mexican Academy of Scientific Research announced the establishment of the Fundacion Nacional de Investigacion (Mexican National Research Foundation).

The Mexican National Research Foundation, independent of the Mexican government, will be the working arm of the Mexico National Academies of Science, Engineering, and Medicine. In conducting its work, the Mexican organization will form committees of expert scientists who volunteer their time to examine issues of importance to Mexico and to prepare reports on their findings, conclusions, and recommendations.

The idea for the Mexican Research Foundation arose from a study of Mexico City's water supply, undertaken by Mexican and American scientists and organized by the U.S. National Research Council (NRC). The ground-water study recommended a range of action on issues of public health, water-demand management, conservation, and recycling. The modernization report, a collection of individually authored chapters prepared in cooperation with the U.S. NRC, explored how science and technology could promote long-term economic growth. Mauricio Fortes, president of the Mexican Academy of Science, said, "The process used by the U.S. Research Council—that of bringing together volunteer experts to study an issue exhaustively and then issuing a report of conclusions, findings, and recommendations—could be extremely useful in helping to inform the debate over issues of science, technology, and medicine in Mexico."

Sandia, AT&T Develop Ultraviolet Lithography Tool for 0.1 Micron Features

Sandia National Laboratories and AT&T Bell Laboratories have developed a new laboratory research tool which can print integrated circuit features 0.1 μm in width, which is five times smaller than currently found in mass-produced chips.

The lithography tool uses extreme ultraviolet light, which is reflected with mirrors coated with special multilayers. The mirrors must be atomically smooth.

The new tool relies on resists that are sensitive to this particular wavelength of light, which are in development. Also, researchers use a stage that aligns the wafer between each step using frictionless magnetic levitation.

Fiber-Optic Sensor Developed to Detect Radioactive Contaminants

Researchers at Pacific Northwest Laboratory (PNL) developed a sensor that can detect, on site, radioactive byproducts of uranium-238 and strontium-90 left over from nuclear power generation and weapons development. The BetaScint sensor relies on tiny fiber-optic strands.

The sensor consists of 0.5–1.0 mm-thick plastic fibers mixed with fluorescent compounds. The fibers scintillate when they contact highly energized beta particles produced by radionuclide decay. "As the beta particles travel through the fiber, the fibers glow. We look at the intensity of that light to quantify the level of strontium and uranium in the surface of the soil," said Alan Schilk, who leads the PNL development team. The light is translated into electrical current, which is transmitted to a portable computer where the data is read and stored. PNL is looking for industrial partners interested in licensing the sensor.

Epoxy Resin Formulation Made Electron-Beam Curable

Researchers at the Oak Ridge Centers for Manufacturing Technology (ORCMT) at the Oak Ridge Y-12 Plant, in cooperation with several industrial partners in a Cooperative Research and Development Agreement (CRADA), have advanced the formulation of epoxy resin systems capable of being cured (crosslinked) by ionizing radiation. The process incorporates epoxy resin systems that have been modified to render them electron-beam curable. Exposing these mixtures to a high-energy electron beam initiates rapid curing of these resin systems.

The specific formulations developed have yielded polymer matrix composites having high glass-transition temperatures. Electron-beam curing can be achieved at low, ambient, or high temperatures as compared to heat-cured systems that typically require processing temperatures of 250–350°F (~120–180°C). The thermomechanical properties that result are as good as or better than those of heat-cured systems but without drawbacks such as long cure times, high-energy consumption, and residual-thermal stresses in the composite part.

Further optimization of these resin systems is currently being performed for specific aircraft, aerospace, and defense applications.

Recently Announced CRADAs

Sandia National Laboratories (Albuquerque, New Mexico), **Superconducting Core Technologies** (Golden, Colorado), and **Electrotechnical University of St. Petersburg** (Russia) initiated the first CRADA signed as part of the Industrial Partnering Program (IPP), a government- and industry-funded R&D program that links U.S. Industry with research capabilities in the former Soviet Union, to improve microwave communications, including cellular phone technologies.

Los Alamos National Laboratory (Los Alamos, New Mexico), **Oregon Medical Laser Center at Providence St. Vincent Medical Center** (Portland, Oregon), **Palomar Medical Technologies, Inc.** (Beverly, Massachusetts), **Oregon Health Sciences University** (Portland, Oregon), and **Oregon Graduate Institute of Science and Technology** (Beaverton, Oregon), under a three-year agreement, are developing computer simulations to better understand the interaction between laser energy and blood clots to improve the procedure of laser thrombolysis.

https://doi.org/10.1557/S0883769400044791 Published online by Cambridge University Press

Los Alamos Researchers Develop Laser Scissors for Textile Industry

Los Alamos National Laboratory researchers developed a laser cutting system that can cut entire fabric patterns in less than one second. They use an ultraviolet excimer laser focused through a series of lenses and a holographic filter to cut the fabric. The laser exposes the fabric to intense ultraviolet light through a holographic-patterned filter to cut the material in the desired shape. The holographic filter concentrates the ultraviolet light around the pattern.

The Alexander von Humboldt Foundation Announces Awards

The Alexander von Humboldt Foundation of Bonn, Germany, provides opportunities for international research collaboration. The Foundation's North American Office in Washington, D.C. distributes information on the research programs to North American scholars.

The Foundation recently awarded the Humboldt Research Award for Foreign Scholars to **Hai-Lung Dai** (University of Pennsylvania) whose specific area of research is in interface chemistry; **John Gladysz** (University of Utah) and **Craig Hill** (Emory University) who both work in anorganic chemistry; **Marvin Ross** (Lawrence Livermore Laboratory) who works in physical chemistry; and **Richard Schrock** (Massachusetts Institute of Technology), who specializes in organic chemistry. The recipients are to spend 4 to 12 months conducting research at German institutions.

The Foundation selected **A. Paul Alivisatos** (University of California) and **Sean P. Frigo** (University of Wisconsin), who both specialize in physical chemistry, and **Andrei Tokmakoff** (Stanford University), whose specific area of research is in spectroscopy, to receive a research fellowship for a long-term collaborative research project in Germany.

Under the Foundation's Feodor-Lynen Fellowship program, the following American scientists, whose general field of research is in chemistry, received funding for a German postdoctoral researcher: **Robert Bau** (University of Southern California—Los Angeles), **A. Welford Castleman, Jr.**, (The Pennsylvania State University), **Sow-Hsin Chen** (Massachusetts Institute of Technology), **Frank A. Cotton** (Texas A & M University), **Robert H. Grubbs** (California Institute of Technology), **Josef Michl** (University of Colorado), **George A. Olah** (University of Southern California), **Kenneth N. Raymond** (University of California—Berkeley), and **Peter J. Stang** (University of Utah). □

https://doi.org/10.1557/S0883769400044791 Published online by Cambridge University Press