Recently Announced CRADAs

Interstate Glass Distributors (Albuquerque, New Mexico) and **Sandia National Laboratories** (Albuquerque, New Mexico) signed a $130,000 agreement to perfect the design of a reusable plastic shipping container for automobile windshields.

Drexel University (Philadelphia, Pennsylvania), **Plasma Technology, Inc.** (PTI) (Santa Fe, New Mexico), and **Princeton Plasma Physics Laboratory** (Princeton, New Jersey) signed an agreement to study chemical reactions in PTI's high-temperature plasma reactor. The program is designed to investigate solid and gas/solids reaction mechanisms, carry out diagnostic measurements and develop a computer model to increase the understanding of PTI's reactors used to convert toxic wastes into energy and usable materials.

Sandia and UNM Eliminate Hazards in Production of Aerogels

A team of researchers from Sandia National Laboratories and the University of New Mexico (UNM) have found a way to produce aerogels at room temperature and pressure, thereby eliminating many of the hazards and the expense associated with conventional processing methods.

An aerogel starts out as a delicate three-dimensional framework made of clusters of molecules or particles linked together in a liquid medium. The linked clusters create a springy molecular mesh with thousands of pores filled with fluid. The liquid molecules help support the framework and hold the clusters in place.

The liquid must be removed from the mesh. Under normal conditions, capillary pressures generated by the liquid's evaporation cause the framework to collapse on itself. As the gel's interior walls are squeezed together, reactive molecules inside permanently bond, leaving a compressed, semiporous gel that is a fraction of its original volume.

By chemically modifying the interior surfaces of the mesh, the UNM researchers created a spongy framework that collapses during normal evaporation at room temperature and pressure, then springs back to its original form. To prevent the reactive groups inside the framework from bonding, the terminal hydroxyl groups in the mesh are capped of with nonreactive organosilanes that prevent bonding when compressed. When the pressure is released, the aerogel springs back.

The result is a dry, porous aerogel solid that can be as much as 98.5% air, which is useful in sensors and catalysis where a highly porous material can be used as a platform for other molecules.

The technique has been successful for both bulk and thin-film aerogel processing. Using a unique dip-coating method, the researchers have created aerogel thin films that spring back to as much as six times their compressed volume. By varying pre-processing factors such as dilution, aging, organic modification, heat

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treatment, and dip-coating conditions, the team can create an array of films with porosities from 10 to 98.5%, which opens a range of applications, particularly in the optics and acoustics fields.

While aerogels are good thermal insulators, researchers are interested in applying aerogels as invisible insulation, such as for use between window panes. "Creating a truly invisible aerogel would open up a whole new commercial market," said Sandia researcher Al Hurd. "The new technique stands a much better chance of meeting the needed optical properties, but there's still a long way to go."

Previously, the fluids were removed through hazardous methods that utilized high temperatures and pressures.

NSF Renews Funding for STCs

The National Science Foundation (NSF) has renewed funding for nine Science and Technology Centers (STCs), a program created in 1989 to support long-term collaborative research across disciplines and at the forefront of scientific frontiers. Four of the STCs involve materials research.

The University of California at Santa Barbara Center for Quantized Electronic Structures was granted $13,032,600 over five years. Scientists at this center make small structures using the natural properties of the materials to let electron boxes assemble themselves. Studies are exploring how these boxes can be used in optical and other innovative devices. Under the eduational outreach program, center scientists have created "QUESTboards," colorful hands-on modules for elementary and secondary students to explore circuits, electron flow, and transistors.

The University of Illinois, Champaign-Urbana Center for Superconductivity was granted $22,020,600 over five years. A consortium of the University of Illinois at Champaign-Urbana, the University of Chicago, and Northwestern University, this STC conducts research on high-temperature superconductivity. The center works in several critical areas of fundamental research, including MOCVD growth, materials synthesis, and structural and physical measurements.

The University of Rochester Center for Photoinduced Charge Transfer was granted $10,336,200 over five years. The University of Rochester STC, in collaboration with the Eastman Kodak Company and Xerox Corporation, study charge transfer. The links fostered by the center between students, university researchers, and industrial scientists encourage research in new basic science relevant to industry.

Virginia Polytechnic Institute Center for High Performance Adhesives and Composites was granted $8,988,000 over five years. The STC focuses on understanding and controlling how long adhesives and composites last. In particular, researchers seek to understand what happens near the surface when a polymeric resin contacts a metal, fiber, or other substrate, and how this area of intersection—the interphase zone—affects the resulting material's durability, damage tolerance, and safety. The worldwide printed circuit board industry has been one target for the center's work in thermoplastic toughening agents for thermosetting matrix resins. Materials created by combining the tougheners with cyanate ester monomers show up to three-fold better fracture toughness without compromising some other important properties.

T-Ray Spectroscopy Used for Imaging

AT&T Bell Laboratories scientists have demonstrated an imaging system that uses terahertz electromagnetic pulses (T-rays) to differentiate between various materials, chemical compositions, or environments.

The technology has a variety of potential applications from chemical-reaction analysis to materials inspection to profiling of doping and defects in semiconductors.

The researchers used laser pulses each lasting only 100 femtoseconds to generate, detect, and measure T-rays each lasting a picosecond. They transmitted the T-rays through various objects, using an imaging system of lenses and mirrors to focus the signals and to analyze changes in the T-rays as they passed through the objects.

They characterized the materials by measuring the amounts of distortion—from absorption, dispersion, and reflection—of the T-rays passing through to a detector. A digital signal processing unit processes the data and translates it into images that appear on a computer screen. The digital signal processor was programmed to recognize the characteristic shapes of transmitted waveforms and identify the particular material at the spot illuminated by the T-ray beam. This information was obtained for every pixel on each object.

Many compounds changed the T-rays in characteristic ways, due to absorption or reflection. Molecules and chemical compounds showed strong absorption lines that can serve as "fingerprints" of the molecules. Metals and other materials with high electrical conductivity were completely opaque to terahertz radiation. The T-ray imaging technique distinguishes between different chemical compositions inside a material even when the object looks uniform in visible light. Since most plastics are transparent to T-rays, this technique can be used on plastic packaging.

"This research is significant because, although terahertz time-domain spectroscopy has been done experimentally in the past, it has never been used in an imaging system," said David A.B. Miller, head of the Advanced Photonics Research Department at Bell Labs, Holmdel, New Jersey.

The Institute of Materials Recognizes Scientists for Outstanding Achievements

Recipients of the Institute of Materials' premier awards for 1995 are **Phillip Wright** of Sheffield Forgemasters, Ltd., who received the Bessemer Gold Medal for his contribution to the United Kingdom's metallurgical and manufacturing industries; **G.J. Lake** of the Malaysian Rubber Producer's Association, widely recognized as a leading expert on the failure of rubber and rubber products, was awarded the Colwyn Medal; **G.W. Greenwood** of Sheffield University was given the Griffith Silver Medal and Prize for contributions to the understanding of anelasticity, growth of fine precipitates, voids in solids, and gas bubbles in irradiated materials; and **Brian Wilshire** of University College Swansea, distinguished for numerous original contributions to the field of deformation and failure of metallic and ceramic materials at high temperatures, received the Platinum Medal.

The Charles S. Hatchett Award was given to **E.J. Palmiere, C.I. Garcia,** and **A.J. DeArdo** of the University of Pittsburgh for the paper, "Compositional and Microstructural Changes Which Attend Reheating and Grain Coarsening in Steels Containing Niobium" (*Metallurgical and Materials Transactions A, 25A*, 1994); and the Vanadium Award was given to **N. Ridley, S. Maropoulos,** and **J.D.H. Paul** of the Materials Science Centre, University of Manchester for the paper, "Effects of Heat Treatment on Microstructure and Mechanical Properties of Cr-Mo-3.5Ni-V Steel" (*Materials Science & Technology*, March 1994).

Z. Fan, P. Tsakiropoulos, and **A.P. Miodownik** of Surrey University received the Elegant Work Prize for the papers, "Yield Strength of Two Ductile Phase Alloys" and "Microstructural Characterisation of Two Phase Material" (*Materials Science and Technology*, October and December 1993); **J.G.P. Binner** of the University of Nottingham received the Holliday Prize for the development of microwave processing of ceramics from both a fundamental and applied point of view; **B.C.H. Steele** of Imperial College received the Kroll Medal and Prize for his contribution to the materials chemistry of ceramics systems and electronic materials; and **A. Donald** of Cavendish Laboratory in Cambridge, England received the Rosenhain Medal and Prize for her contribution to the field of materials science, spanning both metals and polymers.

Massalski Awarded Acta Metallurgica Gold Medal

The 1995 Acta Metallurgica Gold Medal has been awarded to Thaddeus B. Massalski, professor of metallurgical engineering in the Materials Science and Physics Department at Carnegie-Mellon University. The medal is an international award established in 1974 to recognize outstanding ability and leadership in materials research. Massalski is best known for his seminal contributions to the theory of the stability of alloy phases, discovery and description of massive transformations, formation of metallic glasses by rapid quenching from the molten state, and phase diagrams. The Acta Metallurgica Gold Medal is awarded annually by Acta Metallurgica, Inc.

Firouzi Receives Henkel Fellowship Award

Henkel Corporation announced the selection of Ali Firouzi, a doctoral candidate in chemical engineering at the University of California—Santa Barbara, as the recipient of the sixth annual Henkel Corporation Research Fellowship in Colloid and Surface Chemistry.

Under the fellowship, which is administered by the American Chemical Society's (ACS) Division of Colloid and Surface Chemistry, he will receive $20,000 per year for his final two years of doctoral study.

Firouzi's research proposal is titled, "Thermodynamic Principles of Silicatropic Liquid Crystal Self-Assembly." His investigation is to allow him to assess the validity of theoretical models of silicate-surfactant mesophase systems.

This work is expected to help provide insights into the phase behavior of silicate-surfactant liquid crystals. Potential applications include construction of zeolites or membranes with tunable pore size and morphology which can be used for separations and catalytic reactions.

NEW: Update Workshops Provide Materials Education Resources

NEW: Update's annual series of workshops will mark 10 years of accomplishments with NEW: Update 95. The objectives of NEW: Update 95 are to provide current information to participants on engineering materials technology through engaging in small group workshops at Oak Ridge National Laboratories on leading edge research in engineering materials technology; observing, evaluating, and obtaining a notebook of classroom demonstrations and laboratory experiments; and interacting with fellow educators and industrial specialists.

Past workshops have provided over 700 professors and teachers with update information and over 200 technical papers and experiments. The peer reviewed papers have been published and distributed to schools, colleges, and universities around the world. Beyond the workshops' techical sessions and publications, the NEW: Update activities have linked together a network of materials educators to provide many levels of support to materials science, engineering, and technology (MSE).

The host agencies of NEW: Update are the National Institute of Standards and Technology (NIST), NASA Langley Research Center, Oak Ridge National Laboratory, and Norfolk State University.

The experiments have been published as NASA and NIST publications and can serve as guides to faculty who are interested in useful activities for their students. The material was the result of years of research aimed at better methods of teaching materials science, engineering, and technology. The experiments were developed by faculty, scientists, and engineers throughout the United States. There is a blend of experiments on new and traditional materials. Uses of computers in MSE, experimental design, and a variety of low cost experiments were among the demonstrations presented.

Experiments underwent an extensive peer review process. After submission of abstracts, selected authors were notified of their acceptance and given the format for submission of experiments. Experiments were reviewed by a panel of specialists through the cooperation of the Materials Education Council. Authors received comments from the panel prior to NEW: Update 94, allowing them to make necessary adjustments prior to demonstrating their experiments. Comments from workshop participants provided additional feedback which authors used to make final revisions which were submitted for the NASA editorial group for this publication.

For more information about NEW: Update, contact James Jacobs, Norfolk State University, 2401 Corprew Avenue, Norfolk, VA 23504; phone (804) 683-8109; fax (804) 683-8215.

Mo_5Si_3B Developed for Use as High-Temperature Structural Material

Scientists at the U.S. Department of Energy's (DOE) Ames Laboratory have developed boron-doped pentamolybdenum trisilicide (Mo_5Si_3B), a material that holds up well at extremely high temperatures.

The material combines the oxidative stability of molybdenum disilicide ($MoSi_2$) and the resistance to creep of pentamolybdenum trisilicide (Mo_5Si_3).

The material $MoSi_2$ has often been considered for use as a high-temperature structural material. It has oxidative stability between 800°C and 1600°C and adequate mechanical properties at temperatures up to 1000°C. Above that, however, the creep rate is unacceptably high. In

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pure form, Mo_5Si_3 has adequate mechanical properties but less-than-desirable high-temperature oxidation resistance. If less than 2 wt% B is added to Mo_5Si_3, however, its oxidation resistance becomes as good as that of $MoSi_2$ and it retains the low creep rate of pure Mo_5Si_3.

Mo_5Si_3B has properties midway between those of a ceramic and a metal. It is electrically conductive and has high hardness compared to metals. Its strength in four-point loading tests is comparable to that of many cera7mics. In load-bearing applications where the material will be exposed to air, its upper temperature limit is higher than 1300°C. It would perform reliably at much higher temperatures in non-load-bearing applications.

According to Mufit Akinc, the Ames Laboratory scientist and Iowa State University professor of materials science and engineering whose group developed the material, Mo_5Si_3B could be used for high-temperature spray nozzles, ultra-high-temperature heating elements used in air, high-temperature ball or roller bearings, heat exchangers, and exhaust-system components. It might also be used as an oxidation and wear-resistant coating on other components.

Catalysis Shown on a Nanometer Scale

Scientists at the Molecular Design Institute of the Lawrence Berkeley Laboratory (LBL) demonstrated catalysis on a nanometer scale. Using an atomic force microscope, modified to function like an ultrafine-point pen for catalytic calligraphy, scientists with LBL and the University of California at Berkeley were able to create a reaction that changed the chemical composition of the surface of a material one molecule at a time.

Peter Schultz, a chemist with LBL's Materials Sciences Division and leader of the research team, said, "Atomic force microscopes have become important analytic tools in materials science and have been used to directly modify surfaces. However, this application has been limited by the complexity of the structures that can be fabricated. Discussions with the physicists convinced us that the potential for constructing novel nanostructures would be enhanced significantly if the resolution of the AFM could be combined with the wide array of catalytic transformations available in chemistry."

The researchers first created a self-assembled monolayer (SAM) of alkylazide molecules, an organic molecule that is capped with a crown of three nitrogen atoms collectively known as an azide. Next they deposited chromium onto the silicon tip of an AFM to make it adhesive and coated it with a layer of platinum.

Coating the AFM tip with platinum transformed it into an instrument for nanoscale catalysis. Samples of the alkylazide SAM were soaked with a hydrogen-containing solvent and then scanned with the AFM over an area measuring 10×10 μm^2. The idea was for the platinum coating on the tip to catalyze a reaction in which hydrogen atoms would be added to the azides to transform them into amines.

To prove their attempts at catalysis had been successful, the researchers added a fluorescent tag that binds to amines but not to azides. Under fluorescent microscopy, the scanned area became a glowing green square exactly where the tip had passed, demonstrating that a catalytic-tipped AFM can be used to precisely control where on a surface a chemical reaction occurs.

With the right choice of reactants and catalysts and adding on other molecules in the same manner they added the fluorescent tags, Schultz and his colleagues believe they could assemble a wide variety of complex nanostructures.

"Given the large number of heterogenous catalytic reactions involving the transition metal catalysts, our approach may provide a general strategy for performing chemistry on a nanometer scale," said Schultz.

Schultz said that even if the use of a catalytic AFM proves too slow to be a useful manufacturing process, it should still be a valuable research tool for investigating different aspects of the catalytic process, for example, helping scientists to identify how long a given catalyst must be in contact with specific reactants to produce a desired reaction.

Leica SEM Call for Micrographs

Leica SEM Users worldwide are invited to enter the 1995 Leica SEM micrograph competition. The micrographs can be accepted as either traditional photographic prints or TIFF images. Prizes will be awarded based on originality, quality, content, and preparation.

Frank Page from the Institute of Polymer Technology and Materials Engineering at Loughborough University, England, won the 1994 competition, with his micrograph of "Campylodiscus clypeus" taken on a LEICA S360.

All entries must be received by **August 31, 1995.** The winner will be announced at Leica's fourth joint International Image Analysis and Scanning Electron Microscope User Conference, October 2–5, 1995. For more information, contact Toni Williamson at Leica Cambridge, phone 011-44-1223-411411.

Flexible Molecular Lattice May Lead to Expandable Materials

Jeffrey Moore, a chemist at the University of Illinois at Urbana-Champaign, has produced solid materials that feature molecularly produced holes and channels, a framework from which flexible and expandable materials having unusual auxetic mechanical properties (negative Poisson's ratio) can be developed. The lattice network of atoms and molecules he describes is based on positively charged atoms of silver and symmetric molecules whose ends have the ability to bond to the silver atoms. These artificial molecular systems are considered critical in the evolving field of nanotechnology for developing dramatically improved electronic, surgical, and space applications.

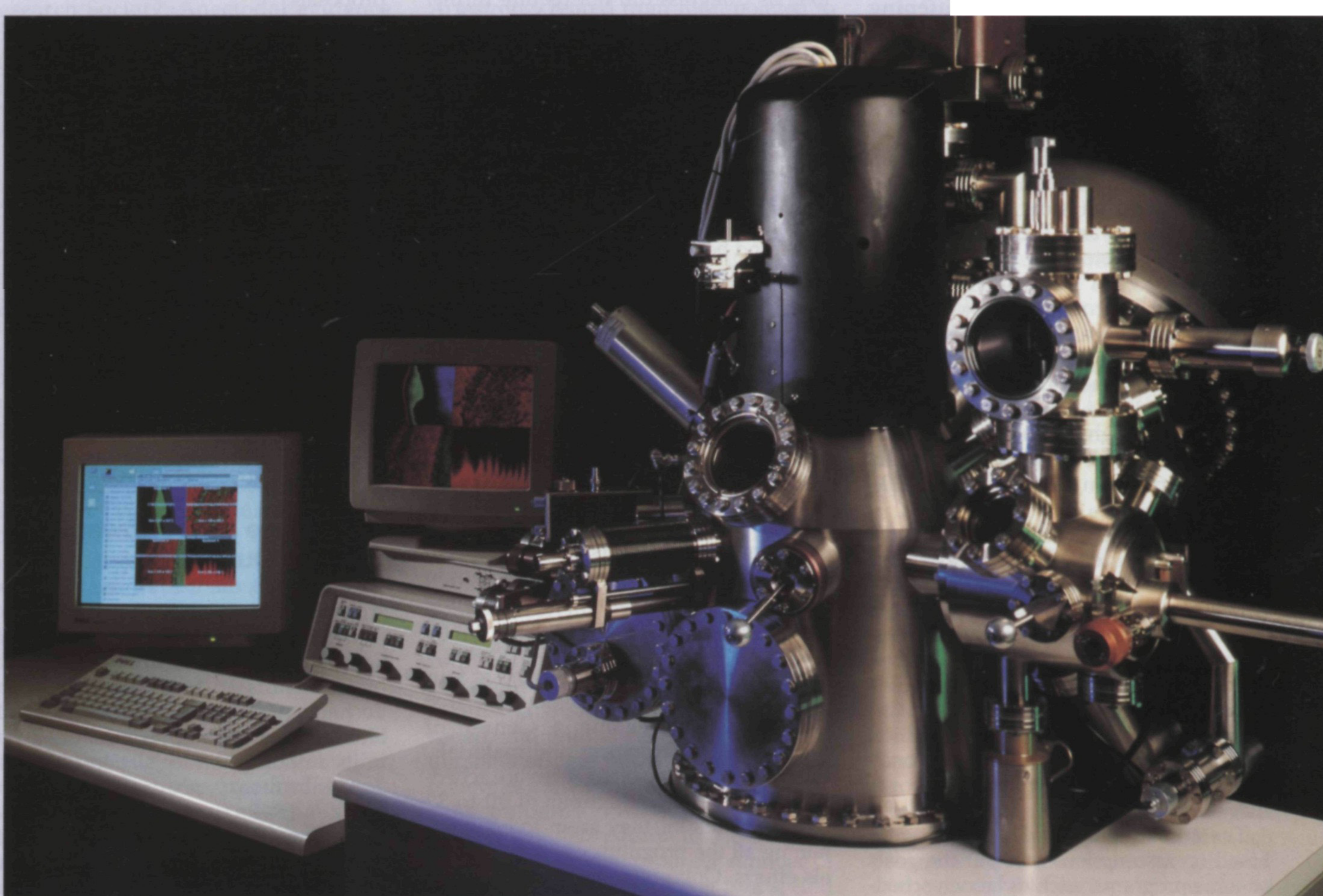
Moore said, "We identified a known inorganic mineral that had a structure that possessed all but one of the characteristics predicted to have unusual auxetic mechanical properties. The missing characteristic which we designed into our materials is open space in the solid—a rare commodity for the usual dense state of solid materials."

Moore and collaborator Stephen Lee, a chemist at the University of Michigan, replaced atoms in the mineral with molecules having the same symmetry and coordination characteristics. The larger molecules pry open the lattice, leaving behind large channels. These channels can serve as molecular-scale filters or provide a site for selectively performing chemical reactions, Moore said.

The pockets of open space also can permit unusual mechanical characteristics that depend upon atomic motion of the material. Referring to a theory for such a network published by Ray Baugh, authors talked about such a characteristic in which a material could respond like a hinge with its auxetic behavior. Moore said that almost no materials used currently exhibit auxetic characteristics, though reports have claimed that such materials could make unusual fasteners that would have solid material that expands when pulled out.

Moore's work foresees unprecedented flexibility in the design of materials with properties such as metallic conductivity, superconductivity, nonlinear optical behavior, and ferromagnetism.

Moore published his work in the April 27 issue of *Nature*. □



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