## NSF Offers Concrete Technology Workshop

The National Science Foundation has awarded the NSF Center for Science and Technology of Advanced Cement-Based Materials (ACBM) a grant to conduct an Undergraduate Faculty Enhancement (UFE) Workshop. The goal is to improve the capabilities of faculty at two- and four-year colleges to teach concrete technology from a materials science approach in their materials courses taught to civil engineering undergraduate students. Entitled, "Teaching the Materials Science, Engineering, and Field Aspects of Concrete," the program will be held on July 25-30, 1993 at Northwestern University, Evanston, Illinois.

The program will be offered in two parts: Part 1 Teaching Workshop (Summer 1993) will offer 40 faculty from across the nation the opportunity to participate in a five-day workshop designed for teaching the materials science, engineering, and laboratory and field aspects of concrete. The topics include: cement manufacture, hydration, microstructure, mechanical properties and fracture mechanics, durability, and new materials and developments. Both theory and extensive hands-on experiences will be included in the workshop. Part 2 Follow-up Evaluation (Summer 1994) will provide a two-day conference to assess the impact of the teaching program on the participants and their students, and examine future educational initiatives. The program is designed to highlight the importance of the relationships between classroom teaching, including laboratory research and evaluation, and field aspects of concrete construction, including technology transfer.

Application deadline is **April 15, 1993.** Applicants will be informed of the decision by April 30, 1993. Application requests and materials information can be received by writing to ACBM Outreach Coordinator, ACBM Center A-130, Northwestern University, Evanston, IL 60208-4400, or by calling (708) 491-8925. Requests can also be faxed to (708) 467-1078.



## Alfred University's SHS Institute Signs Pact with Krakow's Institute of Materials Science

Alfred Univeristy's Institute for Self-Propagating High-Temperature Synthesis (SHS) has signed an agreement with the Institute of Materials Science in Krakow, Poland, to research and study SHS, trying to understand how it works and how to control it. SHS is the process of forming new materials by igniting mixtures of metal powders. The energy of the reaction produces the new material quickly, compared to traditional manufacturing processes. The research will also involve applied studies, where scientists will try to develop new materials that can be made by SHS.

Roman Pompuch, director of the Krakow Institute, signed the agreement while visiting Richard M. Spriggs, director of the Center for Advanced Ceramic Technology at Alfred.

This collaboration combines Krakow's 10 years of SHS research knowledge with

Alfred's sophisticated equipment and analytical, theoretical, and computing capabilities, which the Polish researchers otherwise have limited access to. Terms of the agreement call for periodic exchanges of information, along with annual visits between the institutes.

James McCauley, dean of the New York State College of Ceramics at Alfred University, created the SHS Institute about two years ago. He and Spriggs served as its first directors until Gregory Stangle, assistant professor of ceramic engineering, was appointed to the position last year.

SHS is already being used in commercial processing. Many of these applications involve making new powders by combining starting powders. The powders are then formed into the final product. According to Stangle, the real advantages of SHS processing will come when starting powders can be formed into the final product, without an intermediary powder step.

This has already been done on a limited basis in the Alfred laboratory. Stangle feels that if they can understand and, in turn, slightly modify the process, then they will be able to produce the final ceramic part in the desired shape directly, without firing.

## Silicon Crystal Growth Observed on the Atomic Level

A research team headed by Shigeyuki Hosoki at Hitachi, Ltd.'s Central Research Laboratory have succeeded in using a scanning tunneling microscope to observe silicon growth on the atomic level, including the sequential addition of atoms, thereby paving the way for a greater understanding of these processes. The procedures for observing the changes occurring on the surface of a heated specimen with a tunneling microscope are as follows.

**Specimen preparation.** When heating a specimen to promote crystal growth, the piezoelectric element which controls the probe's motion is vulnerable to heat and sometimes becomes inoperable at temperatures exceeding 300°C. It is therefore vital to prevent the temperature of the piezoelectric element from being raised due to the heated specimen. This is achieved by minimizing the power consumption by making the specimen as thin as about 0.1mm, enabling it to be amply heated with less electricity. The thickness is about one-fourth that of the specimens usually observed with STM.

**Fixation of the field of vision.** As the observation probe approaches the heated specimen for observations inside the microscope's field of vision, a phenomenon called "temperature drift" occurs, making fixation in the field of vision quite difficult. To cope with this problem, a piezoelectric element of duplex construction has been developed. It comprises a piezoelectric element that tracks the movement in the field of vision to enable continuous observations of specific specimen domains by counteracting movements that occur in the field of vision. Another piezoelectric element controls the motions of the probe for scanning specific observation domains. This fundamental development has made it possible to compensate for the movement of specimens while enabling continuous observation of specific visual domains.

**Acquisition of high-speed images over a wide field of vision.** To make direct observations of changes occurring on the surface of a specimen, it is most important to acquire STM images as quickly as possible. Thus, in order to lower the magnification ratio as much as possible to enable the observation of a broad visual range (since there is no way to predict the exact spot where crystal growth will be initiated, and there is a high probability of silicon atoms jumping between the specimen and the probe), the probe approaches the sample as closely as 1 nm. In addition, the image must be very clear to enable crystal growth observations on the single-atom level. Up to now more than 30s has been required to meet these conditions by existing techniques. Hitachi, however, has succeeded in acquiring images with double the number of scanning lines than before, making it possible to observe the state of crystal growth on silicon substrate surfaces in 15s intervals.

By applying these new techniques, the researchers have succeeded in making observations as individual atoms are added. In this case, 12 surface atoms were observed as the basic reconstructed surface structure. It also became clear for the first time that these surface atoms form in a unit of a single adsorbed atom with several substrate atoms. The reconstructed structure is made up of three layers—adatoms, stacking faults, and dimer atoms—on the $1 \times 1$ substrate.

The application of this new technology and the clarification of the mechanism of silicon crystal growth may pave the way for the establishment of sophisticated technology enabling atom-by-atom crystal growth. The new technology is also expected to further expedite research on new advanced devices featuring high working speeds, large-scale integration, and low power consumption, which are 10–100 times greater than their existing counterparts.

F.S. Myers

## Gas Plasma Treatment Improves Composites

By applying a relatively new technique to composite materials, Cornell University fiber scientists believe they have found a way to improve composite materials used in products—from bone implant cement to hockey sticks.

The scientists show that the adhesiveness of high performance polyethylene fibers can be enhanced with a technique called gas plasma treatment.

Adapting the same methods used to reinforce concrete with fibers, Cornell researchers have improved acrylic-based bone cement used in joint replacement surgeries by minimizing its chances of cracking. Acrylic-based bone cement is the most commonly used nonmetallic implant material in orthopedics. Each year about 10 percent of the metallic implant surgeries of the hip, knee, ankle, elbow, and wrist joints are repeat operations because the prostheses have either loosened or the cement has cracked, causing severe pain.

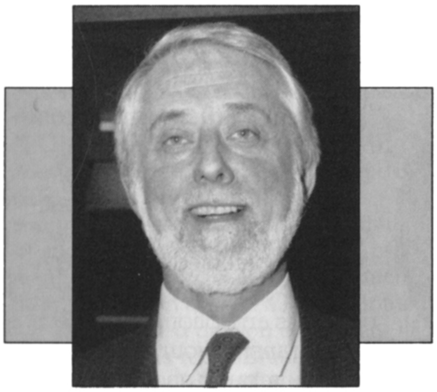
As a fiber scientist with a special interest in strengthening concrete, Peter Schwartz, professor of textiles and apparel in Cornell's College of Human Ecology, worked with former fiber science graduate student Debra Hild to apply the fiber-reinforcing techniques to bone cement. Hild now is a senior engineer at Monsanto Chemical Co. in Pensacola, Fla. They describe their work in the *Journal of Adhesion Science Technology* (1992) and in an article to appear in the *Journal of Materials Science: Materials in Medicine.*

Schwartz and Hild chose ultrahigh-strength polyethylene fibers to toughen the cement because polyethylene is strong and is approved for use in the human body. These fibers, however, have poor adhesive properties. Using carbon dioxide, nitrogen, and argon gas plasmas, the scientists improved the fiber-reinforced cement's adhesion, flexing strength, and reinforcing effect. They also improved its fracture toughness sixfold. The technique involves exposing the fibers to a gas plasma, which triggers chemical reactions on the fibers' surface; as a result, the chemical properties of the surface can be altered.

Schwartz is also using plasma treatments on other high-performance fibers, such as Kevlar, PBZT and graphite fibers, to modify their surface properties. Of particular interest is his use of plasma treatments to form a polymer layer in composite material. This strengthens the bonds between the composite material's fibers and matrix, thus enhancing the integrity and performance of the composite materials.

## LeComber Remembered for Important Contributions in Amorphous Semiconductors

**Peter G. LeComber,** professor and head of the Department of Applied Physics & Electronics & Manufacturing Engineering at the University of Dundee, Scotland, and a physicist internationally recognized for his work on the physics and applications of amorphous semiconductors, died suddenly on September 9 at the age of 51, a tragic loss for British science and for his many friends on both sides of the Atlantic.



LeComber earned his PhD degree from the University of Leicester under Walter Spear, who became his life-long friend and collaborator. LeComber did postdoctoral work for two years in the United States and returned to Britain when Spear was appointed to the Harris Chair of Physics at the University of Dundee. Lecomber joined the department as lecturer. Initially, the two scientists researched noncrystalline solids, establishing a laboratory at Dundee specifically to study amorphous semiconductors. By the mid-1970s, the team had recognized the unique electronic properties of amorphous Si as a thin film in a glow discharge, and its applied potential. Their 1975 breakthrough, showing that the electronic properties of amorphous Si and Ge could be controlled over wide limits by doping in the gas phase, opened up the possibility of thin-film junction devices (e.g., large-area solar cells) which subsequently led to worldwide industrial developments. LeComber, with his scientific ability, infectious enthusiasm, and fine sense of humor, played a vital part in maintaining the momentum of the Dundee team over two decades.

During the 1980s, Lecomber's interests focused on new applications of amorphous Si and their development in collaboration with industrial and government laboratories. Two highly successful projects from this work will always be associated with his name. The first—the amorphous Si thin-film transistor—arose from earlier field effect studies on the material, and led eventually to the commercial development of liquid crystal displays. For this contribution, LeComber was one of the recipients of the 1988 Rank Prize for Optoelectronics. The second fascinating device development was the amorphous Si memory junction, investigated jointly at Dundee and Edinburgh Universities and at the B.P. laboratories at Sunbury. The junction is an electronically nonvolatile memory element which, in terms of speed, retention time, and stability, compares favorably with existing crystalline memories. The first paper on this work by LeComber and colleagues was awarded the 1981-82 Maxwell Premium of the IEE. Such memory elements have recently been applied to an artificial neural network, carried out in collaboration with British Telecom.

Over the course of his career, LeComber produced more than 170 scientific papers, many published jointly with a wide range of collaborators and research students. He was elected to fellowship in the Royal Society of Edinburgh in 1983 and received the 1984 Duddell Medal and Prize of the Institute of Physics. In 1986, LeComber was promoted to a personal chair, and more recently succeeded Spear to the Harris Chair. During the past few years, he served on SERC Committees and devoted much time and travel to organizing the International Conference on Amorphous Semiconductors and to Materials Research Society meetings.

Despite his distinguished record, LeComber was not a "research dominated" physicist. He was a gifted teacher and his lectures were clear, meticulously prepared, and often amusing. He spent much time helping and encouraging undergraduate and postgraduate students. When the Physics and Engineering Departments of Dundee University were merged in 1987, LeComber became the first head of the new department. He dealt in a capable, fair, and effective way with the many administrative and personal problems that arose.

It is some consolation that LeComber lived to receive the greatest honor of his scientific career—election to the Royal Society in 1992.

W.E. Spear

## Uranium Enrichment Demonstration Completed

The Department of Energy (DOE) completed a uranium enrichment demonstration in the Uranium-Atomic Vapor Laser Isotope Separation (U-AVLIS) program by

Lawrence Livermore National Laboratory (LLNL). The U-AVLIS technology is a process for the enrichment of uranium for use in nuclear power reactors. The technology has the potential for significantly reducing the cost of separating uranium isotopes, and hence reducing the cost of electricity produced from nuclear energy.

The Uranium Demonstration System (UDS) at LLNL was operated continuously for 112 hours and processed over one ton of uranium. Preliminary analysis of results indicates that the demonstration met the objectives of the test plan and confirmed the designed enrichment performance capabilities of the AVLIS process in plant-scale equipment.

The UDS was designed to provide cost, performance, and engineering data required to make a decision on deploying an AVLIS production plant. The system utilizes full-scale, engineering-prototype uranium separator and laser systems. This and previous enrichment demonstrations should allow accurate projections of enrichment performance in a production plant. Operation of the AVLIS equipment has also provided data on equipment lifetime, as well as refurbishment and other operating costs. The program will now focus on follow-on activities to gather further operational and reliability data on subsystems and to decrease component costs.

The U-AVLIS program has been under development since the early 1970s by the staff of LLNL and Martin Marietta Energy Systems.

## New Technique Used to Produce High-Quality Graphite

A new technique to produce a high-quality graphite block has been commercialized by Matsushita Electronics Parts Co. Ltd. Matsushita says that this graphite is useful for constituting optical components for x-ray or neutron optics, such as a monochrometer of a filter.

The technology was originally developed by Susumu Yoshimura in the Ogata Fine Polymer Project of the ERATO program of the Research Development Corporation of Japan (JRDC). After completion of the project JRDC commissioned Matsushita to commercialize the technology.

In the production method, macromolecular films of polyimide are heated to 1,000°C in an inert gas to carbonize the films. After further heating the material at 3,000°C under pressure, it is kept for several hours at temperatures of 3,000°C or more in order to make the crystalline face extremely smooth.

The performance as a monochrometer of the thus-made graphite is equal to the highest grade graphite made by conventional production methods, including vapor phase growth of carbon from cracked hydrocarbons followed by stress annealing. Further, the volume is increased to 12 cm square by 1 cm thick, six times greater, and the production time has been reduced by 75%.

In the standard devices designed to absorb x-rays and neutrons, highly-ordered thermolytic graphite has been used. However, since thick graphite with a large surface area can be obtained by the new method, the method is expected to be useful for increasing the efficiency of various types of analytic devices.

F.S. Myers

## Civilian Radioactive Waste Management Program Announces Two International Agreements

The Department of Energy's (DOE) Office of Civilian Radioactive Waste Management (OCRWM) has signed new international agreements with Sweden and Spain.

DOE and the Swedish Nuclear Fuel and Waste Management Company (SKB) have agreed to carry out joint experimental and analytical development activities related to the disposal of spent nuclear fuel and high-level waste, utilizing the Hard Rock Laboratory located on the island of Aspo, Sweden. The work performed under the agreement will enable the OCRWM program to gain direct access to SKB's experience and expertise, assure that the appropriate technology, procedures, and instrumentation are available if required during U.S. site characterization activities, and will give scientists access to additional research facilities not readily available in the United States. The work performed under this agreement will help develop and refine technologies used in support of the Yucca Mountain Site Characterization Project.

The agreement between DOE and the Spanish National Waste Management Company (ENRESA) establishes mutually beneficial activities, including the characterization of geological formations, disposal in geological formations, repository design and operational issues, transportation issues, and surface and subsurface storage of radioactive wastes.

The SKB activities are linked to a master agreement between DOE and SKB, cover- [illegible] nagement that was most recently extended for five years in 1990.

## Methods Developed to Join Metals at Lower Temperatures

Osamu Ohashi of the National Research Institute for Metals, under the Science and Technology Agency (STA), has found that metals can be joined at substantially lower temperatures than were previously possible, by heating the surfaces in a vacuum before putting them into contact. When a metal is heated in a vacuum, contamination on the surface, such as oxygen and carbon, disappears and sulfur, an impurity from the base material, segregates to the surface. Then, when the surfaces are brought together, the sulfur diffuses away from the new interface. The bonding temperature is reduced to the temperature at which the sulfur diffuses into the base metal.

For example, in joining titanium materials, a temperature of 750°C is necessary when using the conventional diffusion joining method. This temperature can be reduced to 650°C by taking advantage of the sulfur film. When joining copper or stainless steel materials, previous temperatures of 800°C can be reduced to 300°C and 650°C, respectively. It is expected that the joining of other metals can be performed at lower temperatures and stress than was previously possible. The sulfur segregates to the surface even for super pure iron with only 1 ppm sulfur.

The conventional diffusion joining method involved applying heat and pressure to diffuse the surface films into the materials and then bringing them into contact with each other. In such cases the joining surfaces cannot be well controlled, and the high temperature (often more than 1,000°C) and pressure have disadvantages, such as the deterioration of the materials. The application of diffusion joining is therefore limited to materials such as titanium, in which it is easy for the oxide film to diffuse into the base material.

The new low-energy joining technology, however, controls the surface composition and crystalline orientation, using an ultrahigh-vacuum joining device and Auger analysis to monitor the surface composition. While examining the conditions of joined surfaces at the atomic level, Ohashi found that the sulfur film plays a role in reducing the joining temperature. Although the sulfur film is a thin layer of single atoms, it restrains the adsorption of carbon, oxygen, and other gases that prevent joining. While the sulfur segregates to the surface of the unjoined metals, it diffuses away from the newly created interface when the surfaces are joined. Because the sulfur layer is so thin, it can easily diffuse from the joining interface into the matrix and effectively disappear, resulting in a reduction of the joining temperature.

In other research, Tadatomo Suga and others at the University of Tokyo developed a new technology by taking a hint from the fact that cleaned surfaces are easily bonded. According to his technology the surfaces to be joined are irradiated with argon beams of comparatively low energy (1–1.8kV) to remove oxides and other adsorbates. The surfaces are then brought into contact under low pressure and are bonded momentarily at room temperature. It has become possible to use this technology at room temperature to join high-strength ceramics such as silicon nitride and/or superconductive ceramics with metals. This technique is expected to be applied to joint electronic parts having a high density, as well as fine pitch and LSI circuits.

F.S. Myers

## AT&T Develops Lead-Free Brass Alloys

AT&T was granted a U.S. patent for a family of lead-free brass alloys that could eliminate the problem of lead leaching into water from brass plumbing fixtures. The new alloys were developed by John Plewes and Dominic Loiacono, researchers in AT&T Bell Laboratories' Metallurgy and Ceramics Research Department. This advance has significant environmental implications.

"Replacement of leaded brass by these new lead-free alloys not only will address lead toxicity concerns in potable-water fixtures, but also will eliminate lead contamination in foundry sands and exposure to lead fumes during manufacture," Plewes said. "All are issues of growing concern at many manufacturing facilities."

In the new alloys, the lead is replaced with bismuth and small amounts of other elements to make alloys that are manufacturable and economical substitutes for leaded brass. The innovation received a 1992 R&D 100 Award from *R&D Magazine* as one of the most significant technical innovations of 1991.

Previous industry attempts to use bismuth as a lead substitute in brass failed. Even minute amounts of bismuth in these alloys severely embrittled them, rendering them useless in manufacture. The inventors of the new alloys solved that problem by using bismuth with minute amounts of other elements.

Kearny Smelting and Refining Corp., in Kearny, New Jersey, prepared some samples for evaluation. "We processed the material on a small commercial scale," said Michel Rothschild, president, Kearny Smelting. "We experienced no problems in melting or extruding the lead-free scrap material, and its machinability was excellent. In addition, we recycled the alloy several times, with no difficulties. This is important because everything we create gets recycled at some point."

AT&T's lead-free copper alloy technique is available through a licensing agreement. For further information, contact Leo Lin, AT&T Intellectual Property Division, 10 Independence Boulevard, Room 3B32, Warren, N.J. 07059, or call (908) 580-5952.

## Laser Method Detects Weld Defects as They Form

A University of Illinois researcher has devised a method to see liquid metal surface deformations in welds as they form. Ordinarily flawed welds cannot be detected as they form because they are obscured by hot metallic vapors generated by the welding process.

According to mechanical engineering professor Joyti Mazumder, the new technique is based on a simple premise. Light striking a mirror is reflected at an angle equal to the angle of the incoming light.

Mazumder and his research team used two lasers in the technique. Beams from a $CO_2$ laser were aimed to strike a metal perpendicularly, thus causing it to liquefy. Beams from a weaker argon laser then struck the molten metal—a forming weld—at an acute angle. The argon-laser beams bounced off at an angle equal to that at which they struck the metal. The reflected light was captured by a computerized camera, its zoom lens shielded from the intense heat by a perforated copper plate. A light filter was used to admit only the unique frequencies of the angled laser.

The angled laser light was emitted from optical fibers. The ends were secured to a bar that moved up and down, raising and lowering the beams, which traversed the forming weld. The camera registered any deflections in the beam caused by imperfections of a sloppy weld. The resultant electronic data provided researchers with quantitative data about the weld surface, while a qualitative image was continuously displayed.

The problem of determining exactly how a weld forms has perplexed scientists for more than a decade. In 1982, observations at Rocky Flats, a research site in Colorado, showed surprisingly that unavoidable sulfuric impurities in metal could cause heated materials to form keyhole shapes rather than flat mounds. In 1984, Mazumder observed that mixing heated metals would generate different microstructures even though the same amounts of the same materials were used each time. After 1986, many predictions were made as to what the liquid-air interface looked like.

## NSF Awards Grant to Establish Mechanics and Materials Institute at UCSD

To foster scientific collaborations in materials science and theoretical mechanics among academic, industrial, and governmental researchers, the University of California–San Diego has been awarded a five-year $5 million grant from the National Science Foundation to form an Institute for Mechanics and Materials.

Areas of interest include molecular and microstructural theories and experiments, computational methods, synthesis and processing, structural design, full-scale testing and forecasting needs, economic advantages, and purposes of new materials. While the Institute will not conduct extensive research per se, it will serve as an intellectual forum to spark the formation of new research groups.

The idea for the Institute resulted from a workshop sponsored by the NSF's Engineering Division, Program for Mechanics and Materials. The resulting report recommended the creation of an organization that would serve as a focus and liaison for a broad spectrum of research and researchers in theoretical mechanics and materials science.

Some of the formal activities at the Institute will include:

- Industrial liaison program—industrial visitors will be invited to UCSD to explore solutions to specific problems, in collaboration with university faculty and scientists;
- Workshops—two or three-day meetings focusing on particular research projects and industrial needs;
- Short courses—for topics that merit wider dissemination;
- Advanced education programs—open to doctoral students, postdoctoral fellows, faculty, and engineers from industry and the national laboratories;
- Think-tank meetings—long-term planning and priorities, as well as broad research objectives in mechanics and materials science;
- Outreach program—designed to foster communications among all sectors of applied mechanics and materials science communities, including professional societies, national laboratories, and governmental agencies.

Richard Skalak, professor of bioengineering at UCSD, will serve as the Institute's director. The Institute also will have four associate directors: Sia Nemat-Nasser, director of the Center of Excellence for Advanced Materials at UCSD; Robert J. Asaro, professor of applied mechanics and materials science; Gilbert A. Hegemier, director, Charles Lee Powell Structural Systems Laboratory; and Marc A. Meyers, professor of materials science.

## Laser Treatment Improves Strength, Durability of Surfaces

Los Alamos National Laboratory researchers report material surfaces can gain strength, durability, and friction resistance when treated with short pulses of ultraviolet laser light.

"Materials like metal absorb the ultraviolet light strongly, which heats the metal and even melts it," said Los Alamos materials scientist Tom Jervis. "This process can change a material's surface chemistry and surface microstructure in ways that are beneficial for many applications."

The process has potential applications in aerospace, in the fabrication of lightweight, heat-resistant engine parts, and in the development of structural components that slide easily without lubrication. In medicine, the process offers a new way of prolonging the life of medical prostheses, such as artificial hip joints, which corrode inside the body. At present, some manufacturers implant the surfaces of stainless steel prostheses with ions to retard the corrosive process and reduce friction. Using an excimer laser to resurface the steel is cheaper than ion implantation and the process can extend the life of the prosthesis, Jervis said.

By melting the surface of stainless steel with ultraviolet light and allowing it to resolidify, chromium present in the steel is driven to the surface where it improves the steel's resistance to corrosion.

Excimer lasers are commercially available and their competitive price and benchtop size make them appropriate for this technology. "An ion implanter costs about $1 million, an excimer laser about $75,000," Jervis said.

The process effectively treats metals and ceramics coated with metal, said Jervis. In the latter case, the metal and ceramic substrate mix during melting and form an alloy. "When a ceramic cracks, the cracks typically begin at the surface," Jervis said. "Creating a surface alloy with ultraviolet light can increase a material's toughness, while the material retains the lightness and heat resistance characteristic of a ceramic."

Compared to other resurfacing technologies, the process is fast. The researchers can treat 1.5 $cm^2/s$ of surface area, using ultraviolet laser pulses of 25 ns each.

Aerospace engineers can't lubricate mechanical systems designed for space with oil or grease because the oil evaporates in space. But many systems still require sliding parts. Jervis said the Los Alamos researchers have observed that some metallic surfaces treated with ultraviolet light not only harden, but they slide against each other four times more easily than nontreated surfaces.

Jervis presented a paper on this topic, coauthored by Michael Nastasi of Los Alamos' Ceramic Science and Technology Group and Juha-Pekka Hirvonen of the Technical Research Centre of Finland, on December 3 at the Materials Research Society's meeting in Boston. □