Periodic 3D Structures Prepared by Photolithography

Methods for large-scale production of micron-sized periodic structures are of great interest for the manufacture of photonic crystals, membranes, data-storage materials, and catalyst supports. Recently, Shu Yang and co-workers at Bell Laboratories, Lucent Technologies and Princeton University have demonstrated a photolithographic method for producing organic epoxy structures in an area larger than 1 mm in diameter. The structures have hexagonal, square, or fcc symmetries with periods of 0.9–8 μm. The symmetry and periodicity of the structures were templated by the interference pattern of continuous-wave (CW) laser radiation in the visible wavelength range. According to Yang, "the use of CW visible laser radiation results in a manufacturing speed and structure size advantages over two-photon infra red and pulsed ultraviolet interference photolithographic methods, respectively."

As described in the July issue of *Chemistry of Materials*, the researchers controlled the acid catalyzed polymerization of the Epon SU-8 epoxy monomer through the use of 2,4,5,7-tetraiodo-6-hydroxy-3-fluorene as the photosensitizing dye, diaryliodionium hexaflouroantimonate as the photoacid generator, and triethylamine (TEA) as the photoacid neutralizer. These reagents were mixed in tetrahydrofuran and spin-cast onto a cover glass to produce a solid 4–10-μm-thick resist film. The researchers initiated polymerization by irradiating the resist for 1 s with three or four non-coplanar beams of 514-nm Ar ion laser radiation to produce localized photoacids, and polymerization was chemically amplified when heating at 65°C. The triethylamine played a key role in the resist to neutralize the background photoacids and to increase the sharpness of the structure features. Following polymerization, the structure was washed with propylene glycol methyl ether acetate to remove the unexposed film, and dried in supercritical CO_2. Scanning electron microscopy was used to confirm the formation of the highly periodic structure of the specified size and symmetry.

The use of visible laser radiation in the photolithographic process resulted in higher substrate penetration efficiency and more even intensity distribution than UV radiation. This allowed for the production of larger structures and structures with fewer defects.

The number of defects was further reduced by the inherent stability of CW radiation. Visible radiation also allows CW lithography to be used on a wider range of substrates than does UV radiation. The researchers were able to alter lattice constants, porosities, and symmetry of the lattice by varying TEA concentrations, exposure times, laser intensities, beam orientations, and beam polarizations, and by using a laser mask.

GREG KHITROV

Polymer Molds Replicate Micropatterns to Ceramic Surfaces

Micropatterning of ceramic surfaces is becoming increasingly important in ceramic manufacturing. Micropatterned components make it possible to integrate more entities into a small area and the smaller size decreases the probability of failure for ceramic components. Micropatterned parts can be beneficial in fuel cells to increase the active surface area of dense components or for the fabrication of microchannels for effective gas distribution. Moreover, micropatterning enables the assembly of ceramic components into microelectromechanical systems (MEMS) fabricated with silicon-based technologies.

Using nonporous polymer molds, Urs Schönhozer and co-workers at the Swiss Federal Institute of Technology (ETH Zurich) successfully patterned ceramic surfaces with a feature resolution in the micrometer range. High-quality line patterns with an aspect ratio of 1 and a pitch of 3 μm were replicated. The details were described in an article published in the July issue of the *Journal of the American Ceramic Society*.

In the first experiment, the feasibility of replication was evaluated with powders of zirconia, cerium gadolinium oxide (CGO), and tin oxide. The researchers first cast poly(dimethylsiloxane) (PDMS) onto a 3 × 3 mm^2 master template of etched silicon grating. After curing, the PDMS molds were peeled off the master template. Suspensions of the ceramic powders (all with an average particle size of <0.3 μm) were cast onto the PDMS mold. After drying and sintering, 80% of the patterned ceramic surface area was defect-free. The pattern geometry was clearly resolved in all three sintered parts. No wear was observed on the master template following several production cycles.

In the second experiment, the researchers compared the pattern formation of alumina on various mold materials. They concluded that hydrophobic mold surfaces such as PDMS, high-density polyethylene (HDPE), and poly(tetrafluoroethylene-*co*-hexafluoropropylene resulted in excellent and almost identical pattern quality, while hydrophilic mode surfaces, such as plasma-treated PDMS and epoxy, caused a relatively poor pattern quality.

SHIMING WU

DNA Serves as Effective Metallization Template

The potential for DNA as a metallization template has been demonstrated by researchers from Technische Universität Dresden and the Università di Trieste, Italy. As reported in the August issue of *Nano Letters*, a research team led by Michael Mertig of Dresden found that Pt(II)•DNA adducts, which are complexes formed during incubation of DNA in a tetrachloroplatinate solution, may act as extremely efficient nucleation centers for metal cluster formation. Therefore, the balance between heterogeneous metal cluster nucleation on the biomolecular template and unwanted homogeneous nucleation of clusters in bulk solution can be controlled in a way that achieves selectively heterogeneous metallization. As a result, platinum cluster necklaces of unprecedented thinness and uniformity were fabricated with purely heterogeneous metallic growth on DNA. This biomolecular template-based technology represents a promising route for production of complex metal nanostructures.

The Dresden/Trieste group began the investigation with first-principles molecular-dynamics (FPMD) simulations to elucidate the molecular mechanism of platinum cluster nucleation on DNA templates. Using guanine (G) to represent a generic DNA base containing a nitrogen binding site, the Pt(II)•DNA adducts were modeled as either a partially hydrolyzed complex bound to guanine, $G{\cdot}PtCl_2\text{-}(H_2O)$ **[GP]** or by a fully hydrolyzed complex bound to two stacked guanines, $GG{\cdot}Pt(H_2O)_2$ **[GGP]**. In all cases, the researchers found that stable Pt dimers already formed after a single reduction step of a system containing a free Pt(II) complex and a Pt(II) complex covalently bound to DNA. As a basic result, they observed that the presence of nucleotide ligands results in the formation of Pt dimers with bonds that are stronger than dimers formed homogeneously. Furthermore, they hypothesized that the catalytic role of DNA may extend to future reduction–addition steps of cluster growth. The researchers inferred from calculated electron affinities that the metal dimers formed at DNA are expected to be preferred sites for further reductions, leading to easier incorporation of Pt atoms from solution.

Experimentally, DNA is "activated" by incubation in an aged K_2PtCl_4 solution. All possible metal-binding sites along the DNA become occupied when high complex-to-nucleotide ratios and long activation times, t_a, are employed. Dimethylamine borane is added after activation to reduce Pt(II) to metallic platinum. UV–visible spectroscopy was used to monitor the reduction kinetics. Transmission electron microscopy (TEM) and scanning force microscopy were used to analyze the products. Regular, continuous chains of nanoparticles, of 4-nm average diameter, form over the contour length of DNA in contrast to the large cluster agglomerates, of ~50-nm average diameter, that form in the absence of DNA. High-resolution TEM images of the nanoparticles show lattice-plane distances identical to bulk platinum.

The researchers showed that the metallization rate and the balance between heterogeneous and homogeneous nucleation can be controlled by varying t_a. An accelerated process and altered nucleation behavior results from increasing t_a. Vanishingly small activation times result in mostly homogeneously nucleated large clusters and a small number of small clusters on the DNA strands. Exclusively heterogeneous nucleation takes place after long activation times (~20 h). The researchers expect that heterogeneous cluster nucleation may be influenced by the DNA composition because it has been previously shown that the complexation kinetics is nucleotide-specific to a certain degree.

Mertig suggests that "strong donor ligands other than DNA, bound to metal ions before (or during) the reduction process to form organometallic complexes, may induce cluster nucleation in a similar way." Mertig expects formation of similarly nucleated platinum nanoparticles on proteins if heterocyclic amino acids are present.

STEVEN TROHALAKI

Thin Oxide Films Crystallized with Low-Temperature Anneals

Sangmoon Park and colleagues from Oregon State University, along with collaborators from ReyTech Corp. and Hewlett-Packard, reported their work on low-temperature thin-film deposition and crystallization in the July 5 issue of *Science*. Park and colleagues described their deposition and annealing techniques, which allowed for the creation of thin-film crystalline oxides for applications in displays, electronics, and energy storage. Typically, a high-temperature processing step is required to crystallize deposited amorphous films. This creates constraints to obtain desirable characteristics of the film while maintaining stability of the substrate, in addition to increasing the cost. By using a unique method of preparing the oxide powders by precipitation and hydrothermal dehydration, and depositing them using the successive ionic layer adsorption and reaction (SILAR) deposition method, the researchers have created amorphous films that crystallize under low-temperature hydrothermal annealing.

The oxide powders were created by dehydrating a hydroxo precipitate under hydrothermal conditions to form an anhydrous crystalline oxide. The SILAR process consists of repeated monolayer coatings of material and water rinsing until the desired film thickness is achieved. The samples underwent 700 cycles of ~0.1 M solutions and rinse baths for 10 s each by robotic control to obtain layer thicknesses of ~250 nm. The samples were then dehydrated for ~12 h. Films of several oxides, (Zn_2SiO_4, ZrO_2) and (MnO_2, Mn_2O_3), were deposited on Si_3N_4/Si and SiO_2/Si substrates, respectively, using the SILAR process, creating amorphous films. Low temperature (378–473 K) hydrothermal annealing in a sealed 23-ml Teflon-lined Parr reactor with 0.15 ml of water produced highly crystalline films, as determined by x-ray powder diffraction. Annealing the as-deposited films at higher temperatures (773–923 K) did not produce crystalline material in the case of Zn_2SiO_4, and produced alternate crystal forms for the remaining materials.

CHRISTINE RUSSELL

Glass-Ceramic Materials to Provide Broad-Band Light Sources

Active light-emitting fibers have multiple applications in photonics, particularly as lasers and amplifiers. The most widely used active fibers are formed from silica-based glasses doped with rare-earth ions. B.N. Samson and co-workers from Corning, Inc. have turned their attention to glass-ceramic fibers. Glass ceramics can be formed by suitable heat treatment of a glass, thus producing the growth of a crystal phase embedded in a glassy matrix. The crystalline phase in these fibers allows not only the use of rare-earth ions for light emission, but also the use of transition-metal ions due to their broad emission bands. In addition, the inherent broad absorption band of the metal transition ions expands the choice of pump wavelengths.

In the August issue of *Optics Letters*, the research team reported the performance of a fiber formed by gallate-rich aluminosilicate spinel nanocrystals (~10 nm in size) dispersed uniformly throughout a continuous silicate glass matrix and doped with nickel. The researchers studied the fluorescence spectra, including fluorescence lifetimes, and output power as a function of nickel doping density, heat treatment (crystallization), and optical pump power. The fluorescence spectrum pumped at 980 nm showed a broad-band emission that, for the optimized spectrum, has ~250 nm bandwidth (full width at half maximum [FWHM]) peaking at a wavelength near 1200 nm. The original glass matrix showed no measurable light emission. The shape and intensity of the band depends on the heat treatment. This result shows the clear advantage of using a nanocrystalline environment for the transition-metal ions, according to the researchers. The researchers also report the output of a codoped nickel and thulium ceramic glass fiber pumped by a single ytterbium fiber (1060 nm). This source provides a light source with 450 nm bandwidth (FWHM).

The researchers suggested that these broad-band sources could replace those formed by multiple edge-emitting sources. The research team is currently investigating many novel glass-ceramic systems containing doped crystals that cannot be made in single-crystal form, and the team believes that this research route will significantly expand the range of crystal hosts that can be investigated for potential applications.

ROSALÍA SERNA

Photo-Orientation of Mesostructured Silica Films at Large-Scale Levels Demonstrated

The preparation of mesostructured films with high orientation order at the macrolevel is emerging as a new area of technological and scientific interest. In particular, it is a key technology for developing novel sensors, micro- and optoelectronics, and separation devices, for example. A group of researchers from the Tokyo Institute of Technology and the Science University of Tokyo has discovered a method for the synthesis of macroscopically aligned mesostructured silica films using a hierarchical multiple transfer technique and photoinduced orientation. As reported in the July issue of *Chemistry of Materials*, Yasuhiro Kawashima and co-workers first performed the deposition of a photochromic layer (Az; photochromic unit: C_6H_{13}-C_6H_4N=NC_6H_4-O-$(CH_2)_{10}$-COO on polyvinyl alcohol) by the Langmuir–Blodgett method, followed by irradiation with linearly polarized light, which resulted in the re-orientation of the azobenzene chromophores to the orthogonal, that is, nonexcitable, direction with respect to the substrate. A spin-cast film of poly(di-*n*-hexylsilane) (PDHS) with a thickness of 60 nm was deposited onto the previous molecular layer. After sufficient crystallization of the PDHS spin-cast film, this film became highly optically anisotropic with a Si backbone aligned perpendicular to the photoaligned chromophore layer. In the last step, a mesostructured silica layer was formed on the photoaligned PDHS by polycondensation of tetraethoxysilane in the presence of an organic template. The researchers said that attempts to directly deposit the surfactant-templated silica onto the Az monolayer were unsuccessful because the conditions adopted for the siloxane condensation crucially damaged the orientation of the Az layer. The researchers removed organic surfactant molecules from the composite by using a recently developed "photocalcination" method achievable at room temperature.

With low-angle x-ray diffraction, the researchers confirmed a well-defined ordered structure and perfect in-plane orientation of mesochannels. The research team showed that the preferential orientation of photo-oriented mesochannels was parallel to the direction of light polarization. The researchers also proposed a way to obtain patterned films of mesoporous silica by the conventional photolithography technique. These experimental results provide the possibility of fabricating mesostructures on the microlevel.

ANDREI A. ELISEEV

News of MRS Members/Materials Researchers

Erich Bloch, a principal of The Washington Advisory Group, LLC, a distinguished fellow at the Council on Competitiveness, a former National Science Foundation (NSF) director, and an outspoken supporter of fundamental research in leading innovation, has received the **2002 Vannevar Bush Award** given by the National Science Board on May 7 in Washington, D.C., in tribute to his longstanding reputation in research and innovation, and his senior statesman status in science and engineering.

Rod Ewing of the Nuclear Engineering and Radiological Sciences and Materials Science and Engineering Departments at the University of Michigan has been named a **Guggenheim Fellow**. Guggenheim Fellows are appointed on the basis of distinguished achievement in the past and exceptional promise for future accomplishment. The 2002 Fellows include writers, painters, sculptors, photographers, filmmakers, choreographers, physical and biological scientists, social scientists, and scholars in the humanities. Ewing's Fellowship will support his work on a book that analyzes the impact of the nuclear fuel cycle on the environment.

Mihal Gross has been selected as a RAND/AAAS Science and Technology Policy Fellow for 2002–2003. She begins her term in Washington, D.C., in September. Gross expects her focus to be on policy issues related to nanotechnology, industrial competitiveness, and national innovation systems. She currently serves on the board of directors of the Materials Research Society.

Rolf Hummel has received the **2002 American Society for Engineering Education (ASEE) Southeastern Section Teacher Award**. The award was presented at the ASEE Southeastern annual conference, which was held in Gainesville April 7–9, 2002.

Kevin S. Jones has been chosen as the new chair of the Department of Materials Science and Engineering at the University of Florida. He will replace Reza Abbaschian who has served as chair for 16 years. Jones said he is looking forward to the challenges of the position and making his vision for the department a reality.

David King, the U.K. Government's Chief Scientific Advisor and a Fellow of the Royal Society, has been awarded the Society's **Rumford Medal** for his outstanding contributions to the fundamental understanding of the structure and dynamics of reaction processes on solid surfaces. Such reactions are important because of their significant applications in the creation of new compounds and materials.

Cora Lind joined Cornell University as a postdoctoral associate in the Department of Chemistry and Chemical Biology, after receiving her PhD degree from Georgia Institute of Technology. She writes research news for *MRS Bulletin* and the MRS Web site.

Christopher Matranga recently joined the U.S. Department of Energy National Energy Technology Laboratory in Pittsburgh, Pa., as a National Research Council postdoctoral research associate. He received his PhD degree in March from the University of Chicago, and contributes to research news for *MRS Bulletin* and the MRS Web site.

Gary L. Messing, professor and head of materials science and engineering at The Pennsylvania State University, was installed as president of the American Ceramic Society (ACerS) at the Society's annual meeting held in St. Louis, Mo.

Julie Nucci has been named as the European Union liaison for Max-Planck-Institut für Metallforschung in Stuttgart, beginning in September. She contributes to research news for *MRS Bulletin* and the MRS Web site.

Tim Sands has been appointed as the Turner Professor at Purdue University, where he will hold a joint position in the Schools of Electrical and Computer Engineering and Materials Engineering. He begins in September.

Shilpa Sankhe recently joined American Profol, Inc., Cedar Rapids, Iowa, as a prod-

Cohen, Somorjai Receive 2001 National Medal of Science

Credit: LBNL-Roy Kaltschmidt

Marvin L. Cohen

Credit: LBNL

Gabor A. Somorjai

Marvin L. Cohen and **Gabor A. Somorjai** of the University of California—Berkeley and Lawrence Berkeley National Laboratory have received the **2001 National Medal of Science**, the United States' highest science honor, in recognition of their pioneering scientific research. The medal was presented to the laureates on May 9 by President George W. Bush.

Cohen is known widely for the theoretical model he developed to describe how materials are put together on the atomic level. This model is used worldwide to calculate the properties of materials ranging from metals and semiconductors to superconductors, and has had a major impact on the semiconductor industry and the emerging field of nanoscience. Cohen has an unparalleled record of explaining and predicting properties of matter. Examples of his successful predictions are the first superconducting oxide (semiconducting) material, a host of new structural phases of solids, several new superconductors including silicon at high pressures, new compound nanotubes, and new classes of superhard solids.

As a leader in developing modern surface science, Somorjai established the molecular foundation of many surface-based technologies. His fundamental surface studies over the past 35 years have contributed to the understanding of surface structure at the molecular level, the bonding of adsorbates, and the concepts and ingredients responsible for the reactivity of surfaces that helped in the development of various surface technologies. Somorjai began the process of discovering the fundamental bases of heterogeneous catalysis, without which the chemical industry known today would not exist. The techniques he developed and the results he obtained bear on many surface features of broad technical importance such as adhesion, lubrication, friction, absorption catalysis, and other phenomena that depend on surface interactions.

Tomás Díaz de la Rubia Selected as LLNL Associate Director of Chemistry and Materials Science

Tomás Díaz de la Rubia

Tomás Díaz de la Rubia, who serves on the board of directors of the Materials Research Society, has been selected as associate director of chemistry and materials science (CMS) at Lawrence Livermore National Laboratory (LLNL). He replaces Hal Graboske, who announced his retirement earlier this year. In his new position, which he started in July, Díaz de la Rubia manages more than 520 chemists, chemical engineers, materials scientists, and physicists. The directorate is responsible for multidisciplinary research and technology development in support of the laboratory's missions in national security, energy and environment, and biotechnology. Díaz de la Rubia will also take the lead on the development of a high-quality work force and a sound infrastructure for the directorate.

Díaz de la Rubia joined LLNL in 1989 in a postdoctoral appointment. Subsequently, he served as a term scientist in the CMS directorate, a staff physicist, and as the Scientific Capabilities Leader for Computational Materials Science. In 2000, he was appointed Deputy Division Leader for Science and Technology in the Materials Science and Technology Division of CMS. He also held a concurrent position leading a team of CMS scientists who brought expertise to the National Ignition Facility (NIF) project. In 2001, Díaz de la Rubia became Materials Program Leader for NIF Programs, in addition to leading the Laser-Materials Interaction Investment area in CMS. He earned BS (1984) and PhD (1989) degrees in physics from the State University of New York.

Ewen, Woodall Receive 2001 National Medal of Technology

John A. Ewen

Jerry M. Woodall

John A. Ewen, president of Catalyst Research Corp. in Houston, and **Jerry M. Woodall** of Yale University have received the **2001 National Medal of Technology**, the United States' highest award for technological innovation. The **Dow Chemical Co.** (Midland, Mich.) has received the National Medal of Technology as a leading science and technology company. The company was cited "for the vision to create great science and innovative technology in the chemical industry and the positive impact that commercialization of this technology has had on society." The medals were announced on May 9 by President George W. Bush.

Ewen was cited "for his basic discoveries and inventions in the field of metallocene catalysis, which have revolutionized the production of polyethylene and polypropylene plastics, thereby enhancing American leadership and stimulating the growth of the entire industry." A catalyst chemist and inventor, Ewen discovered that rational changes to the molecular structures of these polymerization machines had profound effects on controlling the structures and physical properties of the macromolecules produced by them. Catalysts can now be confidently designed to yield polymers having a wide array of desirable properties for several specific applications.

Woodall was cited "for the invention and development of technologically and commercially important compound semiconductor heterojunction materials, processes, and related devices, such as light-emitting diodes, lasers, ultrafast transistors, and solar cells." Currently the C. Baldwin Sawyer Professor of Electrical Engineering at Yale, he has conducted pioneering research in compound semiconductor materials and devices over a career spanning four decades. Woodall has invented a number of electronic and optoelectronic devices seen ubiquitously in modern life, including the red light-emitting diodes (LEDs) used in indicators and stoplights; the infrared LED used in CD players, TV remote controls, and computer networks; the high-speed transistors used in cell phones and satellites; and the weight-efficient solar cell.

uct development engineer. She received her PhD degree from Clemson University in May, and writes research news for *MRS Bulletin* and the MRS Web site.

S.K. Sundaram (Pacific Northwest National Laboratory); **P.P. Woskov, J.S. Machuzak,** and **P. Thomas** (Massachusetts Institute of Technology); and **William E. Daniel Jr.** (Westinghouse Savannah River Co.) received the **Best Paper Award of the Nuclear and Environmental Division, the American Ceramic Society** for their article, "Millimeter-Wave Monitoring of Nuclear Waste Glass Melts—An Overview."

Jeffrey Wadsworth joined Battelle as a senior executive, focusing on helping build its broad technology and business base in government and commercial markets. His appointment became effective in early August. Wadsworth most recently has served as deputy director for science and technology at Lawrence Livermore National Laboratory.

Jane G. Zhu has recently joined the U.S. Department of Energy as a program manager in the Division of Materials Sciences and Engineering, Office of Basic Energy Sciences, Office of Science. The core research activities in her area include materials synthesis and processing, nanostructured and advanced materials, electron and scanning probe microscopy, epitaxial growth and interface structures, microelectronic and optoelectronic materials, correlation of microstructure and physical properties, ion beams for materials fabrication, corrosion science, and nonlinear optics.

The American Ceramic Society (ACerS) announced 2002 awards and honors:

Dennis W. Readey, the Herman F. Coors Professor of Ceramic Engineering at Colorado School of Mines and director of the Colorado Center for Advanced Ceramics; **Frederick F. Lange**, Alcoa Professor and chair of the Materials Department at the University of California at Santa Barbara; and **Manfred Rühle**, director of the Max-Planck-Institut für Metallforschung, Stuttgart, and a professor at the University of Stuttgart, have been named **Distinguished Life Members**; **Readey** also presented the **Sosman Lecture for the Basic Science Division**;

Eva Zeisel of New York and **Paul G. Shewmon**, emeritus professor of materials science and engineering at The Ohio State University, Columbus, have been named **Honorary Members**;

William W. Mullins (deceased) and **Gregory S. Rohrer** received the **Ross Coffin Purdy Award** for their paper, "Nucleation Barrier for Volume-Conserving Shape Changes of Faceted Crystals," published in the January 2000 issue of the *Journal of the American Ceramic Society*, p. 214;

Venkatraman Gopalan, an assistant professor of materials science and engineering at The Pennsylvania State University, received the **Robert L. Coble Award for Young Scholars**;

Larry L. Hench received the **W. David Kingery Award**; he is professor and chair of ceramic materials in the Department of Materials at Imperial College of Science, Technology, and Medicine, University of London; director of the Imperial College Centre for Tissue Regeneration and Repair; and co-director of the Imperial College Tissue Engineering Centre;

Duncan T. Moore, the Rudolf and Hilda Kingslake Professor of Optical Engineering and professor of biomedical engineering at the University of Rochester, presented the **Edward Orton Jr. Memorial Lecture** on "National Initiatives in Nanoscience and Technology: Challenges to Innovation in the United States";

Siegfried S. Hecker, senior fellow at Los Alamos National Laboratory, presented the **Frontiers of Science & Society—Rustum Roy Lecture** on "Issues Associated with Nuclear Proliferation from the Countries of the Former Soviet Union";

Yuichi Ikuhara (University of Tokyo), **Clive A. Randall** (The Pennsylvania State University), **Makio Naito** (Japan Fine Ceramics Center, Nagoya), **Akira Ando** (Murata Mfg. Co. Ltd., Kyoto), and **Duane B. Dimos** (Sandia National Laboratories) received the **Richard M. Fulrath Awards**;

William M. Carty, associate professor of ceramic engineering and director of the Whiteware Research Center, Alfred University, received the **Karl Schwartzwalder-Professional Achievement in Ceramic Engineering (PACE) Award**;

James W. McCauley, Fellow at the Army Research Laboratory, presented **NICE's Arthur L. Friedberg Memorial Lecture** on "Design-Based Approach to Ceramics Research";

David E. Clark, professor and head of the Materials Science and Engineering Department, Virginia Polytechnic Institute and State University, received **NICE's Arthur Frederick Greaves-Walker Award**; and

Rajendra K. Bordia (University of Washington), **Nancy E. Bunt** (Lafarge Aluminates, Paris), **Margaret L. Carney** (Schein-Joseph International Museum of Ceramic Art), **Wai-Yim Ching** (University of Missouri—Kansas City), **Tsu-Wei Chou** (University of Delaware), **Seshu Desu** (University of Massachusetts, Amherst), **Duane B. Dimos** (Sandia National Laboratories), **Arturo Domínguez-Rodríguez** (University of Seville, Spain), **Peter Greil** (University of Erlangen, Germany), **Kazuyuki Hirao** (Kyoto University), **Hideo Hosono** (Tokyo Institute of Technology), **Todd L. Jessen** (U.S. Department of Defense, Washington), **John Kieffer** (University of Michigan, Ann Arbor), **Doh-Yeon Kim** (Seoul National University), **Richard A. Lowden** (Oak Ridge National Laboratory), **Alexander J. Marker III** (Schott Glass Technologies, Inc., Duryea, Pa.), **Steve W. Martin** (Iowa State University), **Arvid E. Pasto** (Oak Ridge National Laboratory), **Pradeep P. Phulé** (University of Pittsburgh), **Jennifer Wang Posda** (New Jersey Commission on Science & Technology, Flemington), **Kenneth H. Sandhage** (The Ohio State University, Columbus), **Jeffrey D. Smith** (University of Missouri—Rolla), **Yao Xi** (Xian Jiaotong University), and **Curtis E. Zimmer** (Sauereisen Inc., Pittsburgh) have been named **Fellows**.

The Chinese Institute of Engineers/USA Society (CIE/USA) announced the **2002 Asian American Engineer of the Year Award**:

Special recognition was given to **Leo Esaki**, Nobel Laureate (1973), who received the **Distinguished Scientific and Technology Award**; and

Chang-Lin Tien, former chancellor of the University of California—Berkeley, who received the **Distinguished Lifetime Achievement Award**.

The award of the year was given to **Shawn-Yu Lin** (Sandia National Laboratories), who has made a broad range of pioneering advances in the field of photonic crystals;

Raymond Ng (Sandia National Laboratories), who manages the engineering design services and electronic data interfaces with the production facilities in the National Nuclear Security Administration's Nuclear Weapon Complex; and to

Alwin Tsao (Texas Instruments), who has been a key contributor to the development of leading-edge complementary metal oxide semiconductor process technologies for over the past nine years.

The Institute of Physics (IOP) announced 2002 awards and honors:

Sir Martin Wood (Oxford Instruments) received the **President's Medal**; his founding of Oxford Instruments as a spin-out from Oxford University, visionary at the time, has led to the creation of whole industries in Oxford and elsewhere in the world; he is a polymath, an entrepreneur, and a true champion of science;

Penelope Jane Brown (Institute Max van Laue—Paul Langevin, Grenoble) received the **Guthrie Medal and Prize** for her outstanding contribution to the field of neutron scattering, especially in the area of polarization phenomena in scattering;

John Bernard Pethica (Oxford University) received the **Holweck Medal and Prize** for his contributions to the field of nanometer- and atomic-scale mechanics;

S.R.P. Silva (University of Surrey) received the **Charles Vernon Boys Medal and Prize** for outstanding contribution to experimental physics in the development of electronic materials for advanced device applications, particularly in carbon-based electronics;

Federico Capasso (Bell Laboratories) received the **Duddell Medal and Prize** for his contributions to engineering materials and solid-state devices, in particular the invention and demonstration of the quantum cascade laser;

John Andrew Scholfield (University of Birmingham) received the **Maxwell Medal and Prize** for his outstanding contributions to the physics of highly correlated systems, particularly his efforts to develop novel experiments that reveal the underlying physics of emergent phenomena in materials;

Polina Bayvel (University College London) received the **Paterson Medal and Prize** for her contributions to theoretical and experimental research in fundamental aspects of nonlinear fiber optics and their understanding and application in optical communication systems and networks; and

Maurice Sidney Skolnick (University of Sheffield) received the **Mott Medal and Prize** for his major contributions to the understanding of excitons, defects, and interaction phenomena in semiconductors.

The Optical Society of America (OSA) announced 2002 awards and honors; the awards ceremony will take place at the 2002 OSA Annual Meeting in Orlando, Florida, on October 1:

Arthur H. Guenther (University of New Mexico) will receive the **David Richardson Medal** for pioneering contributions and continued leadership in the study of laser-induced damage of optical materials, and for exemplary guidance in enabling the infrastructure for technical optics development;

Pallab Bhattacharya (University of Michigan, Ann Abor) will receive the **Nick Holonyak Jr. Award** for fundamental contributions to the development and understanding of quantum-dot lasers and other quantum-confined photonic devices;

Sanford A. Asher (University of Pittsburgh and Carnegie Mellon University) will receive the **Ellis R. Lippincott Award** for pioneering the development of UV Raman methods and demonstrating their applications to vibrational spectroscopy in analytical, biophysical, and materials chemistry; and

Charles V. Shank (Ernest Orlando Lawrence Berkeley National Laboratory) will receive the **Charles Hard Townes Award** for the development of ultrashort lasers from the near-IR to x-rays, and their application to condensed-matter problems in chemistry, physics, and biology.