1998 MRS Fall Meeting Presents Broad Spectrum of Current Materials Research

The multidisciplinary nature of the 43 symposia as well as clustering of symposia into broad categories proved to be a success at the 1998 Materials Research Society Fall Meeting held in Boston from November 29–December 4. The Meeting spread across the Boston Marriott, the Westin Hotel, both at Copley Place, and the Sheraton Boston Hotel, chaired by Clyde Briant (Brown University), Eric Chason (Brown University), Howard Katz (Lucent Technologies), and Yuh Shiohara (ISTEC). It set a new attendance record of 4,580 with 3,866 papers presented in both oral and poster sessions. The Meeting included Nobel Laureate Richard E. Smalley (Rice University) giving the plenary talk relating to Buckytubes, U.S. Representative Vernon Ehlers and the Director of the U.S. National Science Foundation Rita Colwell at the International Union of Materials Research Societies Forum on international collaboration regarding materials research, and several NASA astronauts and representatives of the International Space Station. It was also clear from this meeting that materials research is making significant forays into nontraditional materials research areas including medical materials and biomaterials. This was self-evident from Larry L. Hench's Von Hippel address on Bioglass™.

Plenary, Award Talks, and Symposium X Presentations for the Nonspecialist

Both the plenary speaker Nobel Laureate Richard E. Smalley of Rice University and the Von Hippel Award recipient Larry L. Hench of the Imperial College of Science, Technology, and Medicine in London cast their presentations with an outlook for the importance of materials in the next millennium. Smalley, in his talked entitled, "Buckytubes: New Materials and New Devices from Carbon," said that the population is growing at a significant pace and it is important to make sure that the lives of everyone are improved to an equivalent high standard. He asserted that carbon materials may hold the key to this. Indicating that a nanotube is simply a graphene sheet wrapped around, he described the structure as very high strength along its plane and wrapped to form nanotubes which enhances the strength and versatility of the material. He showed various ways in which these buckytubes can be modified. Future applications include continuous fullerene fibers and cables, oriented fullerene fiber membranes, and random fullerene fiber tangles. Electronic applications using fullerenes are a major future possibility.

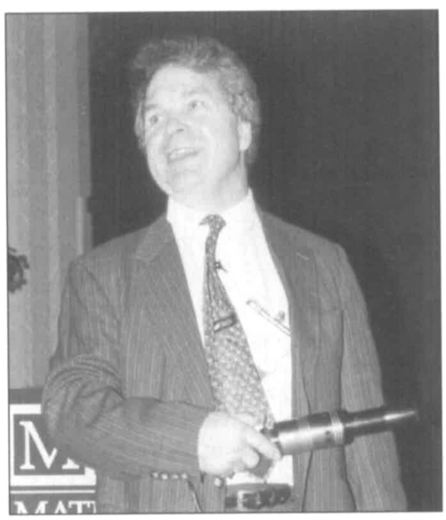
Hench, in his talk entitled, "Medical Materials for the Next Millennium," highlighted Bioglass™, a material that he invented. Hench also referred to long life expectancies over the next century, and emphasized the need for artificial prosthetic implants. He said that these parts will need to be made from materials that are not only compatible with bone and human tissue but will also need to bond closely. Bioglass™, developed in the late 1960s, was found to bond with bone very well. Moreover, in 1980 it was discovered that Bioglass™ bonds very well to soft tissue and is the only synthetic material to do so. One current application of the material is as a replacement for the middle ear, particularly in children. The future looks very promising with possible applications in dental applications such as fillings. The major goal is regeneration of tissue and bone and Bioglass™ has been shown to stimulate growth of new bone material. Hench ended his talk with a video clip from CNN showing a story about a girl who was deaf since childhood but who regained her hearing after a Bioglass™ middle ear was implanted.

H. Eugene Stanley of Boston University gave the David Turnbull Lecture on "Unsolved Mysteries of Water in Its Liquid and Glass Phases." He showed that the glassy phase of water provides clues to understanding water in its liquid phase. Linus Pauling recognized that the

*Von Hippel Award recipient **Larry L. Hench** of the Imperial College of Science, Technology, and Medicine in London gave his presentation on Thursday, December 3 at the 1998 MRS Fall Meeting in Boston on "Medical Materials for the Next Millennium," in which he highlighted Bioglass™, a material that he invented.*

distinguishing feature of H_2O compared to other seemingly similar materials was the preponderance of hydrogen bonds. "It's a hydrogen bonded gel with a very, very short bond life," Stanley recounted, "and therefore, water doesn't behave like jello, but because the bond life is typically a picosecond, one can pour water and it flows just like any other liquid." He pointed out that living systems are able to survive even when the water inside them is metastable, namely supercooled. But below about -38°C, the temperature of homogeneous nucleation, all forms of water are stable only in solid, crystalline phases. He focused on what he called "no-man's land" between that temperature and roughly 80 degrees lower, where water is stable and even metastable only in its solid crystalline phases. He then described a narrow window of 10 or 20 degrees in which water is liquid again, although very viscous, and finally, a region in which water exists in the glassy phase. Venturing into these phase fields is important to understanding the anomalies of water that give it its unique and useful properties. Stanley described several kinds of experiments and simulations to approach this "no-man's land," in particular, trying to gain an understanding of a second critical point found somewhere near -50°C, where the liquid phase apparently separated into two distinct phases, a low-density and a high-density phase. Neutron experiments can be used to approach from one direction. These studies are done by tuning the pressure to a point just above the critical pressure and gradually decreasing the temperature to see what the structure does. Another approach nears the critical point from both sides, allowing for interpolation. The diffusion coefficient can be measured in the ultraviscous liquid phase while heating it up to the crystallization temperature, which demonstrated that the data in this ultraviscous region fit with a single smooth curve. A third approach involves studying the metastable extensions of the melting curves of the 14 kinds of high-pressure ice. One measures the temperature as a function of the pressure. Compression melts the existing phases and the temperature responds a little bit. This is called compression-induced melting. One can map all the metastable melting lines this way, and the ultimate outcome is the complete equation of state.

The 1998 MRS Medal was presented to William L. Johnson of the California Institute of Technology. His talk was on the science and technology of bulk glass-forming metallic alloys. Johnson reviewed the history of metallic glasses starting with the first liquid metal (Au-Si) that was vitrified. He recounted how David Turnbull had worked on undercooling and nucleation in metals and predicted that raising the glass transition temperature relative to the melting point would lead to homogeneous nucleation so that metals would form glasses. The rate of homogeneous nucleation becomes very rapidly small as one approaches a reduced glass transition of about two-thirds. Johnson described the need to "frustrate" the process of crystallization, which is aided by the complexity of the system and the need for multiple components. There are polymers that are so frustrated that they never crystallize on any laboratory time scale. Allied Signal in the 1970s commercially developed a continuous process for manufacturing metallic glass sheets. Now "bulk" ingots can be cast of centimeter diameter and inches long. Thicker samples were developed by finding materials that would go metallic with slower cooling rates. Atomic mobility is orders of magnitude less in an undercooled liquid than in a pure melt and so undercooled liquid metals can be used as a medium for studying liquid metal behavior since it is possible to keep them in the undercooled state long enough to do measurements on a laboratory scale. This is an area not easily accessible previously because crystallization kinetics intervened and obscured the results. That has a big impact on the understanding of nucleation kinetics and expands the opportunity to study diffusion in the region. Beyond the interesting science of metallic glasses, they also have useful properties. They are strong, they have a very large elastic limit, and can support double the tension or bending of ordinary commercial crystalline materials. Dislocations cannot move, so the materials have a very high strain limit, but failure is still plastic. Near the failure point, adiabatic heating caused by the flow takes over and causes local softening and the shear completely localizes. This is an abrupt transition from homogeneous flow to localized shear bending. Edited transcripts of the award talks will be published in a future issue of *MRS Bulletin*.



In Symposium X at the 1998 MRS Fall Meeting in Boston, ***H. Eugene Stanley*** *of Boston University gave the David Turnbull Lecture on the mysteries of water in its liquid and glass phases.*

Symposium X, Frontiers of Materials Research, commenced on Tuesday, December 1, with a presentation by Christine Sloan from General Motors on challenges and opportunities for materials science in the automotive industry. She described various possibilities for the use of new materials in the automobile industry. While lightweight materials are clearly advantageous for fuel efficiency, the major factor is the cost. Environmental effects also need to be considered. Sloan outlined various important points to be considered such as integration of parts and function, and the use of composite materials. The most important aspect for the future is the creation of a knowledge base of materials properties as a function of the formation process and geometry. Other major areas for materials in automobiles include powertrain challenges, catalysts for emission control, and materials recycling.

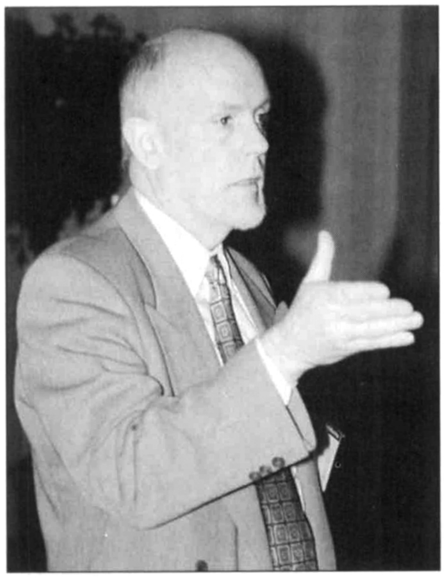
ACRONYM KEY

ADP: atomic displacement parameters
ANL: Argonne National Laboratory
BNL: Brookhaven National Laboratory
CMC: ceramic matrix composite
CMR: colossal magnetoresistance
CRT: cathode ray tube
CVD: chemical vapor deposition
CWRU: Case Western Reserve University
DLC: diamondlike carbon
DRAM: dynamic random-access memories
ESA: European Space Agency
GE: General Electric
HTS: high-temperature superconductor
IBAD: ion beam assisted deposition
IC: integrated circuit
JPL: Jet Propulsion Laboratory
LANL: Los Alamos National Laboratory
LED: light-emitting diode
MBE: molecular beam epitaxy
MEMS: microelectromechanical system
MIT: Massachusetts Institute of Technology
MLED: molecular light-emitting diode
MOVPE: metalorganic vapor-phase epitaxy
MSIBD: mass-separated ion beam deposition
NASA: National Aeronautics and Space Administration
NIST: National Institute of Standards and Technology
PLD: pulsed laser deposition
PVD: physical vapor deposition
QWIP: quantum well infrared photodetectors
R&D: research and development
RABiTS: rolling-assisted biaxially textured substrates
RPI: Rensselaer Polytechnic Institute
SEM: scanning electron microscopy
SNL: Sandia National Laboratories
SWNT: single-walled nanotube
TEM: transmission electron microscopy
TPV: thermal photovoltaic
TST: transition-state theory
UC: University of California
UCD: UC Davis
UCLA: UC Los Angeles
UCSB: UC Santa Barbara
ULSI: ultralarge-scale integration
uv: ultraviolet
UVA: University of Virginia

David Bishop of Bell Labs, Lucent Technologies presented a talk on microelectromechanical systems (MEMS). MEMS are unique in design and functionality since they are tiny, inexpensive, and can be fabricated using IC techniques. Bishop also indicated that MEMS will become the "new physics machine shop." These devices were foreseen by the physicist Richard Feynman as early as 1959. Bishop showed numerous examples of MEMS devices including a mechanical antireflection switch, a microscopic hinge demonstrating the three-dimensional nature of these devices and self-assembly, a MEMS microphone, and movable micromirrors. Various other devices included small electric motors, a microsteam engine, and a microlock for weapons. Bishop also showed a video of a MEMS optical switch in operation. Bishop concluded his presentation by predicting that the 21st century will be the era of micromachines.

Jeffrey Wadsworth of Lawrence Livermore National Laboratory gave a Symposium X talk on the experiences of LLNL with industrial partnering. Wadsworth talked about the historical evolution of LLNL from its original mission as a pure nuclear weapons laboratory to its current more diverse activities including significant materials research. Wadsworth said that LLNL has specified three major areas for the organization: materials, lasers, and computation. Presently LLNL is building up numerous industrial and other partnerships to facilitate the transfer of technologies developed at the laboratory that are deemed to have industrial applications and that could be of value to society. One example is the AVLIS—Atomic Vapor Laser Isotope Separation—which has been adapted by U.S. Enrichment Corporation. This partnership is worth $120 million per year. Wadsworth presented several examples of technologies that have been adopted by industry or that are in the process of being adopted.

Robert Marianelli of the U.S. President's Office of Science and Technology Policy touched upon various aspects of science and technology policy issues from the Clinton administration's viewpoint. Additional information can be obtained at website www.whitehouse.gov/ostp/.



*Nobel Laureate **Richard E. Smalley** of Rice University gave the plenary address of the 1998 MRS Fall Meeting in Boston on Monday, November 29 on "Buckytubes: New Materials and New Devices from Carbon."*

Technical Symposia

Structural Materials

A cluster of symposia emphasizing structural materials included J, K, M, and NN. Both symposia J and K covered different aspects of computational materials science. Multiscale modeling was the topic of Symposium J addressing the synthesis of strategies for length or time scales for materials modeling. The hierarchy of methods used in the analysis of plasticity using dislocation theory was one of the focus areas. Processes were investigated such as dislocation nucleation at crack tips by coupling finite element methods with dislocation dynamics codes wherein dislocation segments serve as fundamental degrees of freedom. Computation of rates of activated processes were covered in Symposium K. New methods for computing rates of activated processes, new techniques for simulating activated dynamics of complex materials and applications were covered. The use of quantum chemistry in conjunction with transition-state theory to predict rates and mechanisms of chemical reactions at surfaces was discussed by several researchers. New understanding of transport in nonporous solids was also described which has potential applications for separation science.

Symposium M focused on various aspects of fracture and ductile versus brittle behavior of materials. The strength of the Symposium was its success in bringing together various communities working in this field including physicists, engineers, and materials scientists. G.R. Odette (UCSB) gave a keynote presentation on attempts by his group to integrate various fracture theories, specifically for judging reliability of steels for nuclear reactors. T. Foecke (NIST) gave an overview on his forensic investigation of material from the *Titanic*, particularly concerning theories of rivet failure.

Symposium NN addressed the important present-day concern of the aging of engineered systems with a focus on airworthiness of aircraft. The Symposium was designed to provide a forum for exchange of information between practitioners and researchers in the structures, materials, and nondestructive inspection committees spanning a broad spectrum of disciplines. Presentations mainly focused on materials aspects and structural integrity of airframe and other primary structures, and engines.

Semiconductors

Several symposia focused on various aspects of semiconductors. An overview of fundamental aspects of strain-driven formation of islands and lateral composition modulations in heteroepitaxy was provided in Symposium B, Growth Instabilities and Decomposition During Heteroepitaxy. One topic of increasing interest is self-ordering of islands into two- and three-dimensional lattices. Good examples of controlled formation of ordered three-dimensional "crystals" of PbSe islands in a PbEuTe matrix were shown.

Symposium C covered Surface and Interface Structure and Dynamics of Materials. A nearly complete atomistic understanding of the mechanisms controlling surface structure and film growth appears to be emerging. One recurring theme in the Symposium was the importance of SPM for dynamic observations of surfaces or growing films. For example, sequentially recorded SPM images were combined to observe motions of individual adatoms for measurement of diffusivities and interaction energies by F. Besenbacher (Aarhus).

Symposium F, Microcrystalline and Nanocrystalline Semiconductors, was the fifth in a series of MRS symposia on this topic. New optical and biological applications in addition to traditional themes were presented. The fabrication of passive optical elements made from nanostructured semiconductors is one of the emerging areas. The use of nanocrystalline materials in medicine- and biology-related applications was demonstrated, such as the use of luminescent quantum particles for biological tagging and counting.

GaN and related materials have almost become a mainstay of MRS meetings and were the subject of Symposium G. The Symposium program included a tutorial by M. Shur (RPI). A panel discussed high-temperature electronics in Japan and the United States, based on a report by a study group. S. Nakamura of Nichia Chemical Industries announced the imminent commercialization of blue laser diodes.

Infrared semiconductors materials and devices were the topic of Symposium H that blended together narrow-bandgap semiconductors and infrared devices. One focus topic in the Symposium was semiconductor lasers emitting at wavelengths >2 μm. Infrared detectors used in imaging focal plane arrays were also well covered in various sessions. R. Higashi from Honeywell described uncooled, micromachined, microlobometer imaging arrays.

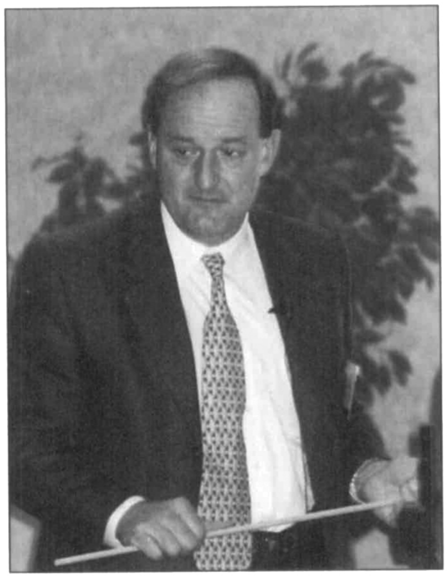
Microstructural Processes in Irradiated Materials was the topic of Symposium N, the third in a series held every two years. The emphasis was on radiation effects in all materials. Various presentations included irradiation-induced medium range order of Si and novel phases including oriented nanoparticles in semiconductors and ceramics, as well as the report of production of diamond (to a small extent) during swift heavy ion irradiation of graphite.

Oxides

Symposium O covered ferroelectric thin films, including piezoelectrics for micromachines and actuators, pyroelectric and piezoelectric sensors, various types of memories, and microwave frequency devices. Among the various topics discussed, P. Clem (SNL) talked about the development of pyroelectric imaging devices with the capability to sense a change in pixel temperature as small as 0.05°C by fabricating Ta-doped PZT pixels over an aerogel of SiO_2.

Various aspects of magnetic oxides and oxide-based devices were covered in Symposium P including materials aspects of fabrication of magnetic oxide-based heterostructures. Various topics included spin-polarized tunneling, which is of interest for ferromagnets due to the potential of tunnel junction devices as field sensors. CMR systems include perovskites and layered manganites and cobaltites, ruthenates, ferrites, spinels, garnets, and pyrochlores. The field of spin polarization phenomenon in CMR manganites appears to be maturing though the effect seems to vanish at room temperatures.

Symposium Q focused on various materials issues relating to HTS. Several new techniques to fine-tune HTS properties, in particular relating to boundaries and interfaces, and improving stability were presented. Large area YBCO films were reported as were advances in IBAD and RABiTS, both of which have the potential to lead to large area YBCO-coated conductors.



MRS Medalist **William L. Johnson** of the California Institute of Technology gave his presentation on the science and technology of bulk glass-forming metallic alloys at the 1998 MRS Fall Meeting in Boston.

Device Fabrication and Processing of Materials

The topic of Plasma Deposition and Treatment of Polymers was covered at an MRS Symposium for the first time in Symposium Y. One of the areas discussed was plasma treatment of biomaterials focusing on how biological entities interact with plasma-treated polymeric surfaces. Plasma treatments for electronics and optics were also covered. The issue of adhesion promotion on polymer surfaces by plasma pretreatments were discussed in several talks including those by F. Arefi-Khonsari (Paris) and R. Lamendola (Bari).

MEMS devices were the focus of Symposium AA covering new materials, processing, and properties of materials at the MEMS size scale. One example of the type of work presented was an on-chip surface micromachined single-edge notched beam fabricated from polysilicon. Electrostatic actuation was used to initiate and study crack propagation.

New Areas, Functional Organic Materials, Medical

Optical data storage and processing continues to grow in importance as evidenced by Symposium T. A majority of the papers reported on holographic storage particularly using polymeric materials. T. Bieringer (Bayer) talked about the development of a new class of photoaddressable polymers that exhibits a large change in the refractive index upon exposure, a 10× greater change than previously observed, which would enable the recording of significantly more holograms in a given volume and with higher efficiency.

The interdisciplinary field of supramolecular science is comprised of researchers from organic chemistry, metal-coordination chemistry, surface chemistry, crystal engineering, biochemistry, and materials science, and was the topic of Symposium U covering a range of organic and organic/inorganic hybrid systems. New developments were reported in a number of areas including chemical sensors, molecular recognition, and functional polymers including dendrimers and nanoscale devices. Several systems have the ability to store, transduce, or transmit information at the molecular or supramolecular level. For example, T. Swager (MIT) reported sensing properties of new conjugated polymers in which an ordered array of sensor sites can amplify electronic signals when the guest molecules bind to receptor cavities. S. Stupp (Illinois) discussed large asymmetric supramolecular assemblies of macromolecules, which are large nanoscale objects.

Polymeric drug delivery systems and devices were covered in Symposium GG. One example is the development of new polymeric bile acid sequestrants, presented by W. Mandeville (GelTex Pharmaceuticals), which have applications as cholesterol lowering agents. Another example was presented by D. Trommeshauser (UCSB) who described vesosomes, sized aggregates of unilamellar vesicles attached to each other through the interaction between streptavidin/avidin and biotin anchored in the membrane. These materials have the potential to be encapsulants for various water or lipid soluble drugs.

Continuing Topics

Interaction of phase and defect microstructures in metallic alloys was the subject of Symposium L, a critical issue for structural materials. The goal of the field is to use the understanding of phase and defect evolution to yield microstructures with superior properties. Modeling of microstructural evolution has made significant advances with the use of more sophisticated mathematical tools, as shown by several presentations. Experimental techniques continue to validate modeling studies. One elegant example presented was the study of the effects of applied and internal stresses on microstructure and precipitation behavior of a nickel intermetallic compound in some binary nickel alloys.

Carbon Nanotubes, Fullerenes, and Related Carbon Materials was the topic of

Two of the 1998 Materials Research Society Fall Meeting chairs, Yuh Shiohara from ISTEC (left) and Eric Chason from Brown University, go over meeting details.

Symposium S. Various advances were reported including an approach to solubilize shortened carbon SWNTs into common organic solvents by J. Chen (Kentucky). R.E. Smalley (Rice) gave the plenary talk at the meeting and reported on the success in spin-coating SWNTs solution onto a substrate. University of Pennsylvania scientists presented results on encapsulation of C_{60} molecules in SWNTs.

Symposium Z highlighted thermoelectric materials which have applications in small-scale refrigeration and power generation. A number of new materials and concepts were presented. Several studies on a family of materials called skutterudites were reported. This was the first material to show Slack's concept of a phonon glass and electron crystal. Another group of open cage structure materials called clathrates were also discussed.

Symposium DD covered Solid-State Chemistry of Inorganic Materials, the second in a series for materials ranging from intermetallics to insulating oxides. An example of the type of topic discussed is the work on distorted-perovskite oxides of the formula $Se_{1-x}Te_xCuO_3$ ($0 < x < 1$) presented by M. Subramanian (DuPont) where all the Cu is in the +2 oxidation state. The material is a single phase showing a ferromagnetic-antiferromagnetic crossover coincident with a Cu-O-Cu angle of 127°.

Solid State Ionics, the topic of Symposium EE, is of current technological interest for electric-based transportation for the development of advanced materials capable of storing high-energy and for providing high-power when needed. The Symposium covered advanced lithium batteries, as well as synthesis of novel transition metal oxides, ionic and electronic conductive polymers, insertion and intercalation compounds, and carbonaceous materials. Materials aspects of ambient and high-temperature solid-state fuel cells and sensors were also covered.

Recent developments and progress in Advanced Catalytic Materials were presented in Symposium FF. Noteworthy topics include new synthetic methodologies for control of porosity and surface area, monolithic materials, and combinatorial methods applied to catalysis (in a joint session with Symposium CC). A reverse emulsion technique in which sol-gel chemistry is carried out in water droplets suspended in oil for preparing high surface area hexa-aluminates was reported. These are used in catalytic combustion of natural gas. Ceramic foams have been commercialized as filters for molten metals but are now eliciting interest as catalyst supports and were discussed in two talks.

The 40th anniversary of NASA was commemorated in Symposium JJ, Materials in Space-Science, Technology, and Exploration. A tutorial on space materials preceded the Symposium. Several aspects of materials in space were explored including space power, near-earth space environment, and the exploration of Mars. Other highlights included a panel discussion focused on the user microgravity community and a keynote session featuring astronaut payload specialists.

For further details about the technical content of the meeting, read the following symposium summaries and see the published proceedings.

Ideas on Island Evolution Nucleated

(See MRS Proceedings Volume 534)

Symposium B, Growth Instabilities and Decomposition During Heteroepitaxy, provided a dynamic overview of the fundamental aspects of strain-driven formation of islands and lateral composition modulations.

Within the context of SiGe/Si (001) heteroepitaxy, the debate continues as to whether observations of static island sizes and morphological coexistence result from thermodynamics or kinetics. The relative importance of energetic effects due to surface stress are also controversial. Fluctuating subcritical Ge/Si island nuclei were directly observed in the tunneling microscope, emphasizing the importance of moving beyond continuum linear stability theories. Continuum simulations that include surface energy and elastic anisotropy appear promising as a tool to evaluate various aspects of island evolution.

Determination of a comprehensive picture of island evolution is more difficult in compound semiconductors due to the high strains and complex chemistry. In nearly strain-symmetrized III-V superlattices, highly regular lateral modulations in composition are observed. The coupling between surface morphology and composition is being vigorously investigated both in the laboratory and in theory. Understanding the role of the superlattice in this process will continue to be an active area of research.

Self-ordering of islands onto two- and three-dimensional lattices is a topic of increasing interest (along with self-assembly of island sizes). The combined effects of elastic repulsion, elastic anisotropy, and strain-selected island nucleation are being manipulated both experimentally and theoretically. Spectacular examples were shown that demonstrate the controlled formation of well-ordered 3D "crystals" of PbSe islands in a PbEuTe matrix.

Symposium Support: American Xtal Tech., TLI Enterprises Inc., SVT Assoc., NSF, and Bede Scientific

Film Growth Atomistics Fall into Place

For scientists studying the structure and dynamics of surfaces and interfaces (Symposium C) this is an exciting period. Advances in both theoretical and experimental techniques have developed to the point that a complete atomistic understanding of the mechanisms controlling film growth and surface structure is emerging.

One theoretical challenge that received much attention is the prediction of surface structure based on first principles. A number of theoretical talks demonstrated an impressive level of agreement between calculations and experiments, discussing the structures of single-crystal surfaces as well as heterostructures and surface alloys. Topics addressed range from predictions of surface relaxations by J. Xie (LANL) to the thermodynamics of a classic adsorbate system discussed by C. Stampfl (FHI—Berlin).

Improved models describing the formation and relaxation of two-dimensional islands as well as three-dimensional morphologies were presented by J. Evans (Iowa State) and D. Kandel (Weizmann Inst.), respectively.

The importance of using scanning probe microscopes in a dynamic way was a recurring theme in this Symposium. A number of speakers have shown how "movies" assembled of sequentially recorded STM images can be used to measure fundamental physical quantities controlling the dynamic properties of surfaces or growing films. F. Besenbacher (Aarhus) used this method to track the motions of individual adatoms, allowing the measurement of diffusivities as well as interaction energies. Step edges on surfaces can act as diffusion barriers and several speakers discussed the important impact of such barriers on surface morphology evolution. STM movies from W.W. Pai (ORNL) and M. Giesen (IGV—Juelich) illustrated how step-edge barriers can be suppressed through the concerted motion of adatom islands. Using an STM to monitor the thermal motion of defects in strained films, K. Pohl (SNL) was able to measure experimentally the elastic forces between nanoscale surface defects.

Symposium Support: ELMITEC GmbH, Omicron, Thermodynamics Lab., and Blake Industries.

The year 1998 marks the 25th Anniversary of the Materials Research Society. In celebration, MRS created a time capsule to be opened by the 50th president of the Society. Holding the time capsule are (left to right) 1998 MRS Treasurer Alan Hurd (Sandia National Laboratories), 1983 MRS President Harry J. Leamy (University of North Carolina), 1998 MRS President Robert J. Nemanich (North Carolina State University), and 1999 MRS President Ronald Gibala (University of Michigan).

Hyperthermal Beams Spur Film Growth and Processing

One of the major themes of Symposium E, Film Growth and Processing Using Hyperthermal Beams, was the differences in the nucleation behavior, surface morphology, roughness, and crystallinity of thin films that are deposited from energetic beams in comparison with those created by thermal beams.

T. Michely (Aachen, Germany) emphasized the importance of the impacts of individual energetic atoms in the growth of Pt thin films, and said that reductions in film roughness are largely due to energetic atoms' ability to modify step structure and/or remove adsorbates bound to steps. H. Atwater (Caltech) presented results of Monte Carlo simulations of PLD of silicon films, and showed that through such modeling the different influences of the pulsed deposition flux and its hyperthermal energy distribution can be evaluated separately. The results indicate that smoothing due to surface displacements can more than compensate kinetic roughening due to the pulsed flux, so that PLD films are expected to be smoother than those grown by a continuous thermal flux (e.g., MBE) under well controlled experimental conditions.

J.R. Engstrom (Cornell) described the use of neutral supersonic beams to grow Si and Ge films and the effect of beam parameters on growth morphology and selectivity. High selectivity for Si growth on Si but not on SiO_2 is obtained at low incident energy and low temperatures and selectivity is enhanced by atomic hydrogen, which greatly extends the incubation period on SiO_2. Surface morphology/roughness is governed by the beam angle of incidence, with either a rectangular groove or triangular pyramid morphology (caused by shadowing) obtained on (001) or (111) Si, respectively, for high (approaching grazing) angles of incidence.

T.A. Friedmann (SNL) described the use of energetic carbon species produced by pulsed laser ablation to grow hydrogen-free amorphous carbon films that contain a high fraction of four-fold bonds and consequently have diamondlike properties. Although the energetic deposition process produces high residual compressive stresses that limit the film thickness, brief annealing at 600°C was shown to produce bond rearrangements that completely relieve the stress while retaining most of the diamondlike characteristics. A model for the stress relaxation process, involving thermal activation over a distribution of energy barrier heights, has been developed by J. Sullivan (SNL). H.C. Hofsass (Konstanz—Germany) described the use of MSIBD to study the nucleation and growth mechanisms of nanocrystalline or amorphous nitride and carbide films, with special emphasis on cubic BN (c-BN) and B_xC. The MSIBD experiments are carried out at ion energies ≤8 keV, for which the atomic rearrangements described by a cylindrical thermal spike or other subplantation model dominate over the ion implantation (TRIM modeling) that occurs at higher energies. Although MSIBD usually produces highly stressed films, its advantage is that film composition and deposition parameters (ion energy, species, charge ratio, and dose) are easily varied so that a broad range of property-composition relations can be studied. Hofsass pointed out the existence of well-defined thresholds of deposition temperature and ion energy for the formation of c-BN, and said that these are in reasonable agreement with model calculations. In a related talk, A. Kolitsch (Forschungszentrum Rossendorf, Germany) described the use of BN/TiN multilayers to relieve stress and to prevent thicker films from peeling off.

J. Greene (U. of Illinois) described new experiments in which low-energy mixed ion and neutral beams have been used to control the mosaicity, preferred crystalline orientation, and microstructure evolution of polycrystalline metallic (Al, Cu, Ti) and nitride (ScN, TiN, $Ti_{0.5}Al_{0.5}N$) layers deposited on SiO_2. Greene showed that by using well-characterized beams containing low-energy ions as well as a generally high ion/neutral flux ratio the adatom mobility can be varied over a wide range and highly oriented films grown on SiO_2, with the degree of orientation approaching epitaxial growth in some cases. Strain-induced and kinetic roughening also were shown to be strongly suppressed by the use of low-energy ions.

Symposium Support: Commonwealth Scientific Corp., Lambda Physik, Epion, Neocera, Ion Tech., ORNL, Techscience, and Terada Shokai.

DoD and NSF Provide Information on Materials Research Support

The U.S. Department of Defense held a seminar on "Materials Research Support at DoD" on Tuesday, December 1 at 5:30 p.m. Various aspects of research funding opportunities at the department were described by DoD representatives. Among the speakers was Robert J. Trew, Director of Research within Defense Research and Engineering, whose area covers materials, physics, chemistry, biology, electrical engineering and electronics, computer engineering and science, mathematics, environmental sciences, and aerospace. He is also responsible for science, mathematics and engineering education, policy for grants, cooperative agreements, and executing the University Research Initiatives and other research efforts administered by the Office of the Secretary of Defense.

The National Science Foundation held a seminar on "Materials Research Support," conducted by Tom Weber, Director of the Division of Materials Research at NSF, and a number of program managers. One of the thrusts of the presentation was the Fast Lane Project, an all-electronic web-based avenue for submitting research funding proposals as well as reviewing proposals and other interactions. The NSF website is located at www.nsf.gov and the Fast Lane website is accessible at www.fastlane.nsf.gov.

Optical and Biological Applications Added to Scope of Nano- and Microcrystalline Semiconductors

(See MRS Proceedings Volume 536)

In addition to the now traditional themes of synthesis, structure, and optoelectronic properties of nano- and microcrystalline semiconductors, properties leading to new optical and biological applications were reported in Symposium F.

In the area of synthesis, techniques have emerged for the production of nanoparticles with narrow size distributions and more well-behaved electronic properties. Wet chemical techniques to build core-shell structures (a nanoparticle of one semiconductor coated with a thin layer of a material having a larger bandgap) have yielded more chemically robust materials with higher photoemission quantum yields. Solution and gas phase methods to synthesize Si and Ge nanocrystallites have also been perfected. Chemical techniques have also been brought to bear on the modification of semiconductor interfaces, and many contributions described chemical reactions to functionalize or stabilize nanocrystalline materials. The interest in producing stable materials with narrow size distributions stems from the desire to design longer-lived electroluminescent devices and to impart specific functionality to the material for sensor, micromachine, or photonic applications.

Earlier symposia have focused on electroluminescent devices made of nanocrystalline and porous silicon. High efficiency electroluminescent devices that operate at visible wavelengths are desired for display applications. Steady progress has been made in this area, and a porous Si device with an electroluminescence efficiency above 1.1% was reported in the Symposium. Although the efficiencies are improving, long-term stability of these devices is still a problem. Communications applications require devices that emit at wavelengths in the near infrared, and a room-temperature device incorporating an emitting Er species in a nanocrystalline Si matrix was reported. Along with these more familiar optoelectronics themes, several new properties and applications of nanocrystalline materials were represented.

One emerging theme involves the fabrication of passive optical elements made from nanostructured semiconductors. Multilayer structures can be used to artificially narrow the broad emission band from Si nanocrystallites or other emissive species to very narrow linewidths, providing a convenient means of fabricating devices with tunable optical properties. It has been found that multilayered structures such as Bragg reflectors can be easily synthesized by pulsed electrochemical corrosion of silicon. The porous silicon layers produced display a periodic porosity which provides the required optical characteristics. Such structures are currently of interest for applications in optical filtering and switching, and for silicon-based lasers.

Application of nanocrystalline materials to biology and medicine is another emerging theme that was explored in the Symposium. Properly prepared luminescent quantum particles were reported to have characteristics for biological tagging and counting experiments superior to conventional fluorescent molecules. Highly sensitive biological sensors based on a chemically modified porous Si etalon structure were also reported. Finally, in vivo studies of bulk and porous Si showed that their soft tissue biocompatibility is comparable to Ti, a well-established biomaterial.

Many contributions on microcrystalline semiconductors were concerned with the development of efficient solar cells. The recent fabrication of efficient (>10%) solar cells from microcrystalline TiO_2 films (the Graetzel cell) were discussed in several presentations, and crucial elements of microstructure and surface chemistry were explored. Although the initial TiO_2 cells were liquid junction devices, progress toward the development of an efficient all solid-state device was presented. New syntheses and studies of ternary phase semiconductors of interest for solar cell applications were also presented.

A significant number of contributions reported observations of new properties of microcrystalline and nanocrystalline semiconductors. The coming of age of high-sensitivity near-field and far-field spectroscopic microscopy as an analytical tool has yielded some fascinating results on nanoparticles. Intermittent emission (blinking) phenomena from nanocrystallites seems to be a general trend; such observations were reported on group IV and II-VI materials. The intermittency is thought to be related to carrier trapping events at the nanoparticle interfaces. Unusual nonlinear optical properties and magnetic effects were reported for several systems. One of the more surprising observations was that nanocrystalline porous Si layers can emit a strong ultrasonic signal under an applied bias. The effects of size on the structural properties (lattice dimensions as well as microstructure) of nanocrystalline materials were also covered.

Symposium Support: NEC, British Telecom Labs., and Hitachi.

*The **student mixer** of the 1998 MRS Fall Meeting gave students an opportunity to interact and network with other students. The mixer also provided a forum for interaction among various MRS student chapters.*

Imminent Commercialization of Blue GaN Laser Diode Announced
(See MRS Proceedings Volume 537)

Symposium G began with a tutorial by M. Shur (RPI) on GaN-based electronic and photonic devices and the opening plenary session included the announcement by S. Nakamura (Nichia Chemical Industries) that commercialization of blue laser diodes is imminent. H. Morkoc provided an overview of electronic properties and device technologies and the role of piezo-related effects. Processing issues were covered by I. Adesida (etching techniques) and S. Lau (contacts). Bulk growth of GaN at high pressures and temperatures was reviewed by S. Porowski (High Pressure Research Center, Warsaw), who showed the high structural quality of this material and of epitaxial overlayers. The role of piezoelectric and pyroelectric phenomena was reviewed by Shur, who showed the very important role these play in heterostructures. Subsequent sessions on laser diodes and spectroscopy, epitaxial lateral overgrowth, theory, defects, bandstructure, uv detectors, light-emitting diodes, quantum dots, processing and rare-earth emission were extremely well-attended, as were two poster sessions. Another highlight was a panel discussion on high-temperature electronics in Japan and the United States, consisting of a report on these activities by members of a study group that visited many facilities in Japan over the summer under the auspices of U.S. Office of Naval Research.

Symposium Support: ARO.

Infrared Lasers and Detectors Examined

Symposium H on Infrared Materials and Devices brought together researchers working in the interrelated fields of narrow bandgap semiconductors and infrared devices. A wide spectrum of semiconductor materials (including III-V, II-VI, Pb-Salts, and Ge) were represented.

A large portion of the Symposium focused on semiconductor lasers emitting at wavelengths >2 μm. Papers presented by C. Gmachl and A. Tredicucci (Bell Labs) summarized the status of intersubband, quantum cascade devices. Several papers described interband, Sb-based lasers. Advances in high power, optically pumped lasers were described by H. Le (MIT Lincoln Labs), J.R. Meyer (Naval Research Lab), S.S. Pei (Houston), and R.M. Biefeld (SNL). Papers presented by T.F. Boggess and M.E. Flatte (Iowa) summarized their experimental and theoretical studies of Auger recombination and laser gain in Sb-based active regions. Several papers were also presented which proposed novel Pb-salt and II-VI heterostructure lasers.

The topic of several sessions was infrared detectors, used in imaging focal plane arrays. R.E. Higashi (Honeywell) described uncooled, micromachined, microbolometer imaging arrays. Other papers addressed issues relevant to cooled, photodiode and photoconductor detectors. P. Mitra (Lockheed Martin Vought) and R.D. Rajavel (Hughes) presented invited papers which described progress in the growth of HgCdTe focal plane arrays by MOVPE and MBE, respectively. S.D. Gunapala (JPL) summarized recent developments in QWIPs. J. Schmitz and F. Fuchs (Franhofer Ins.) described high detectivity, type II photodiodes.

A session discussed TPV technology. TPV systems utilize 0.8–0.4 eV bandgap solar cells to convert photons emitted from a hot radiator into electrical power. G.W. Charache (Lockheed Martin) presented an overview of TPV engineering and performance.

Computational Materials Science is a Multiscale Challenge
(See MRS Proceedings Volume 538)

An emerging theme in computational materials science is that of multiscale modeling as reflected in Symposium J, Multiscale Modeling of Materials. Though such models are not new (their origins can be traced to early attempts to explain macroscopic phenomena on the basis of underlying molecular interactions), the topic has taken on a new sense of urgency recently. This is in large part due to the recognition that brute force computational approaches often fall short of allowing for the direct simulation of both the characteristic structures and temporal processes found in real materials.

The key element in multiscale models is a synthesis of strategies aimed at addressing either particular length or time scales. One recurring theme in the Symposium was the hierarchy of methods that can be brought to bear on the analysis of plasticity using dislocation theory. A. Needleman (Brown) and B. Devincre (Onera) illustrated the coupling of the finite element method with dislocation dynamics codes in which dislocation segments serve as the fundamental degrees of freedom, allowing for the investigation of processes such as dislocation nucleation at crack

Entering the World of Materials the Fun Way

Tom Rockwell, one of the designers of the Materials Research Society's interactive displays, works on concept drawings for future displays. The bulletin board is flanked with "concept drawings" contributed by attendees of the 1998 MRS Fall Meeting in Boston.

During the 1998 Materials Research Society Fall Meeting in Boston, meeting attendees met in the Interactive Display room to brainstorm ideas for future traveling displays. The Polage (left), entitled "Matters," is a collage of images that plays with polarized light and "Testing Titanic" (right) is a Charpy impact tester.

Watch polarized light transform materials into applications....Crack open the mystery of how the Titanic and other ships failed....Take a turn with interstitial diffusion. These are some of the ways to learn about materials through a new medium to the Materials Research Society—through hands-on interactive displays.

An added accent to the 1998 MRS Fall Meeting was a set of three handcrafted interactive displays designed for and usually resident in the lobby of the MRS Headquarters building in Warrendale, Pennsylvania. They were developed in 1998 with input from a task force of MRS members to add a materials accent to the headquarters building that was completed August 1997. The displays were transported to Boston so that Fall Meeting attendees could receive some direct benefit from them, could test them, give their feedback, and help set the course for expansion of this project. This project has been transferred to the MRS Academic Affairs Committee where the effort has moved into preparing a proposal for a full-scale traveling exhibit that would travel to science centers around the United States. These displays are designed to be educational for people of all ages and for scientists and nonscientists alike.

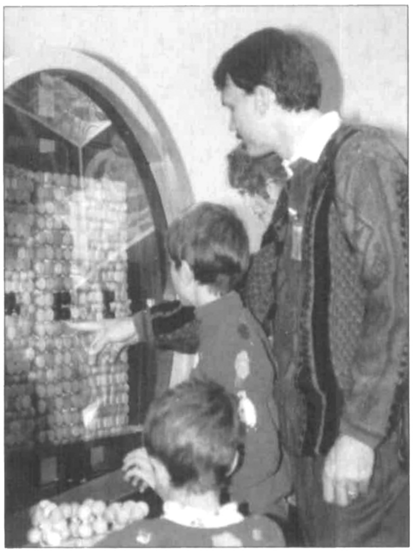
A piece of artwork called Polage, which is a collage of images that plays with polarized light, depicts nine materials on the microscopic scale such as pearlite, polyethylene, and integrated circuits, when observed with the unaided eye. Placing a polarizer in front of the display and rotating it causes the images to transform into colorful views of applications related to the microscopic materials first observed, such as a steel bridge, plastic toys, and a computer. Attendees waiting to pick up their preregistration badges caught a few glimpses of the Polage while in line. This art piece entitled "Matters" was designed and fabricated by Austine Wood-Comarow, an artist in Las Vegas, Nevada.

Another hands-on display is called "Testing Titanic," which is a Charpy impact tester used to test toughness of materials by the same method that samples recovered from the Titanic ship were tested for brittleness. Samples of aluminum and steel alloys were available to place in the tester, then the user cranks up a heavy mallet which is released by pushing a button—sending the hammer through the sample. The sample is recovered for fracture surface analysis and the energy absorbed by the sample is recorded. As an additional focal point of the exhibit, several rivets and pieces of hull steel from the original Titanic were displayed, with photos and descriptions of the materials properties and behavior.

The third exhibit demonstrates diffusion. It consists of a big wooden wheel frame with glass sides containing wooden balls stacked in body-centered cubic, face-centered cubic, and hexagonal close-packed crystal structures. Turning the wheel releases a cascade of ball bearings, which trickle down through the wooden crystal structures, thus modeling interstitial diffusion and revealing the easier diffusion in the bcc structure, due to its more open architecture. Written descriptions and photographs of applications of diffusion and hand-held models of the various crystal structures complete the picture of the action and importance of diffusion. The Titanic and the Diffusion displays were designed and built by Tom Rockwell and Eric Huther (Painted Universe Productions, Ithaca, New York).

During the Fall Meeting, visitors to the MRS Interactive Displays room posted dozens of ideas for future displays, which

Continued next page.



Former Materials Research Society Secretary Kevin Jones shows his family the diffusion exhibit, one of the three materials-related interactive displays developed by MRS and showcased at the 1998 MRS Fall Meeting in Boston.

Continued from previous page.
designer Tom Rockwell incorporated into a "concept drawing" showing what a full science exhibit could look like. The concept, which was presented to the MRS Council at the end of the week, included a central climbing structure with human-sized polymer chain ladders, crystal structure jungle gyms, nanotube slides, and zeolite tunnels, so children can literally get into materials. Around the outside, the concept drawing shows rooms with modules on structures, properties, and processing. Displays of applications would be interwoven throughout the exhibit, and an entrance hall would bring participants through a brief history of materials developments.

MRS members are encouraged to give their input on the existing and future interactive displays by contacting MRS Interactive Displays, c/o Betsy Fleischer, Materials Research Society, 506 Keystone Drive, Warrendale, PA 15086, USA; phone 1-724-779-3004 ext. 521; fax 1-724-779-8313; or e-mail fleischer@mrs.org. Help is sought to develop ideas and designs for future displays; to gather information and materials to produce displays; to contribute materials, equipment, or services; and to help secure funding for continuation of this effort.

tips. J. Broughton (Yale) described a similar "handshaking" between molecular dynamics and the finite element method which has the benefit of allowing for atomic resolution where needed, such as near a crack tip, with a degree of freedom savings associated with the continuum mechanics treatment of regions that are remote from the crack tip.

In addition to the challenges posed by problems with multiple spatial scales, many problems can also involve a disparity in temporal scales. A. Voter (LANL) discussed various computational schemes for overcoming the limitations imposed by short time steps in the molecular dynamics setting. An alternative scheme for confronting the challenge of simulating processes involving multiple time scales is that of kinetic Monte Carlo models as described by D. Srolovitz (Michigan) and others.

Symposium Support: LLNL.

Computation of Activated Process Rates Balances Long-Time Simulations and Atomic-Scale Details

Symposium K on Computation of Rates of Activated Processes featured a variety of theoreticians focused on the challenge of achieving long-time simulations of materials while accurately retaining atomic-scale detail. For many applications, overcoming this challenge means computing the rates of activated processes governing structural evolution. Although TST provides the theoretical framework for computing the rates of these processes, practical implementation of TST is still a major challenge for many systems. Three major thrusts of the Symposium were on new methods for computing rates of activated processes, new techniques for simulating the activated dynamics of complex materials, and applications. New methods were presented for calculating the rates of activated processes in materials such as disordered solids, solids undergoing structural transformations, and liquids. Several talks focused on techniques to accelerate molecular-dynamics simulations of activated processes—which can typically cover only nanosecond times—to the microsecond-second time range. Also, theoretical developments were presented for describing the dynamics of activated processes in complex systems. Many applications in this Symposium were in modeling surface phenomena. Several talks highlighted the use of quantum chemistry, in combination with TST, to predict the rates and mechanisms of chemical reactions at surfaces. A few authors went one step further by incorporating this information into powerful kinetic Monte Carlo simulations to predict the long-time behavior in a collection of reacting molecules. A number of talks focused on rate processes in epitaxial thin film growth, such as atom and cluster diffusion on surfaces, and deposition dynamics. Also receiving considerable attention was activated dynamics near grain boundaries in solids. Also, several participants presented new results in understanding transport in nanoporous solids, with applications for separations in the chemical industry.

Superior Properties Sought Through Coupling of Phase and Defect Evolution

The problem of how concentration, stress, phases, and defects interact is of key importance for structural materials. In the area of phase transformations and microstructures, considerable progress has been achieved using lattice and continuum models with sharp or diffuse interfaces.

In the area of defect microstructures and plastic instabilities, there is an improved understanding of both equilibrium and non-equilibrium aspects of dislocation patterning (using, e.g., the "reaction-diffusion" approach with symmetry-breaking transitions in dissipative systems far from equilibrium, mesoscopic numerical simulations using the Peach-Koehler equation, and strain-gradient plasticity) which define the performance of structural materials.

While the techniques to describe phase and defect transformations are very different, both types of changes can occur simultaneously when processing real-life materials (e.g., recrystallization and grain growth are accompanied by the redistribution of dislocations on grain boundaries, and a small addition of an alloying element can change dislocation microstructure tremendously).

The goal of Symposium L, Interaction of Phase and Defect Microstructures in Metallic Alloys, was to bring together specialists in the fields of phase and defect microstructures in order to discuss experimental and modeling techniques that can be applied to obtain microstructures with superior properties, with special emphasis on coupled problems of phase and defect evolution.

The mathematics of microstructural evolution becomes increasingly sophisticated. The formalism of time-dependent Ginzburg-Landau equation is applied both for analysis of phase transformations and for better understanding of dislocation structures. New trends and developments in partial differential equations and in the calculus of variations can be successfully applied to the study of thin films, fracture, damage, optimal design, and microstructures. Mathematical problems in triple junction descriptions using different approaches are much better understood now. Mesoscopic phase-field simulations can be successfully complemented by first principles calculations of thermodynamic properties of diffuse interphases. Sophisticated finite-element techniques are now available for the analysis of microstructural images and extraction of meaningful information from them including distribution of microscopic stresses around microstructural features, stress concentrators, and reliability estimates which can be related to such stress distributions.

In the field of plastic instabilities, earlier attempts to use a phenomenological reaction-diffusion approach to understand length scales associated with dislocation structures (e.g., ladder structure of persistent slip bands, cells, and mazes), coarse slip bands, microscopic shear bands, Luders and Portevin-LeChatelier bands, are now further developed to introduce length scale(s) into plasticity theory using mechanics- and physics-based ideas of lattice incompatibility. This incompatibility is characterized by a certain gradient of the elastic deformation gradient field, and this measure can play a natural role in a nonlocal theory of crystal plasticity. Important attempts to introduce the concepts of strain percolation theory into dislocation patterning have been initiated. Statistical techniques to characterize dislocation microstructures (including the concepts of fractal geometry and noise-induced transitions) have been further successfully developed. The effects of cross-slip on dislocation patterning in fcc metals have been studied in detail and are much better understood now. Atomistic studies of dislocations have achieved a considerable level of sophistication as it was demonstrated by the computational studies of effects of stress and hydrogen on a dislocation lock in nickel. These important contributions form the basis for multiscale modeling and understanding of "real-life," commercial alloys, thus providing hope that a holistic modeling, rather than completely empirical, approach to alloy and material product design is indeed feasible.

In the area of phase microstructures, coherent phase transformations in a random field of lattice defects have been successfully studied. This included martensitic transformations in metals, ferro-elastic and ferro-electric transformations in ceramic materials. Elegant modeling techniques involving the time-dependent Ginzburg-Landau equations clearly demonstrated that the thermodynamics, kinetics, and the microstructure may be qualitatively altered by the coherency strain in the presence of randomly distributed defects. Phase-field simulation techniques have been applied to understand the nature of martensitic transformations in Fe-Mn-Si shape memory alloys. Elegant experimental work was presented which illustrated the effects of applied and internal stresses on microstructure and precipitation behavior of a nickel intermetallic compound in some binary nickel alloys.

Overall the Symposium has clearly demonstrated the need for continued efforts—experimental, modeling, and theoretical—to work on the development of coupled formalism to describe phase and defect microstructures in structural materials. The other, especially important, goal is to bridge the gap between a significant progress in the development of theory and experimental work on selected (typically binary) alloy systems, on the one hand, and our clear lack of ability to implement this valuable knowledge to create new (multiphase multicomponent) materials with enhanced properties in industrial environment, on the other hand.

*Volunteer **Coral Baglin**, often seen at the Information Booth at Materials Research Society meetings, receives a plaque and MRS paperweight as an MRS Presidential Recognition "in special appreciation of her positive spirit and the gracious and friendly help she has generously provided to countless members through her many years of volunteer service at MRS Meetings." Baglin has volunteered at 11 meetings. She has a PhD degree in nuclear physics and is part of the research staff at Lawrence Berkeley National Laboratory.*

Range of Perspectives Gathered on Fracture from Atomic to Titanic Dimensions

(See MRS Proceedings Volume 539)

Scientists and engineers from many diverse disciplines are making dramatic progress in, or calling for more effort in, several aspects of the fracture of materials as well as the ductile/brittle transition. Research in these areas is carried out in diverse research communities, and unfortunately communication among the different groups is limited. For instance, fracture research carried out within the ceramics community might well be presented at a ceramics meeting, which is not typically well-attended by statistical physicists. Likewise, computer simulation work on fracture done by physicists might be published in *Physical Review* and not seen by members of the engineering community. The primary strength of Symposium M on Fracture and Ductile vs. Brittle Behavior—Theory, Modeling, and Experiment was that it attracted participation from theorists as well as experimentalists from the physics, engineering, and materials science communities.

The primary themes of the Symposium were basic fracture theory and how fracture concepts can be applied to understand why and when a component will mechanically fail. Notable keynote speakers included G.R. Odette (UCSB), who applies and integrates various fracture theories in connection with the reliability of steels that comprise nuclear reactors, and T. Foecke (NIST), who provided a fascinating review of his ongoing forensic investigation of rivet failure in the Titanic.

An ongoing issue with fracture, and one of the primary reasons it still is as little understood as it is today, is that the actual fracture process is controlled by many fundamental processes that occur over a diverse range of length scales, including atoms pulling apart from one another just ahead of a crack tip, and at the opposite end of the spectrum, plastic deformation that occurs several microns or millimeters away from a crack tip. Theorists continue to tackle methods by which a comprehensive understanding of fracture can be obtained. Speakers in this area included D.M. Lipkin (GE Corp. R&D), A.S. Argon (MIT), and J. Broughton (Yale).

Symposium Support: ARO, Air Force Office of Scientific Research, NIST, and ONR.

Irradiation Brings Improvements and Degradation to Microstructure

(See MRS Proceedings Volume 540)

Symposium N on Microstructural Processes in Irradiated Materials was the third in a series of symposia held every

Poster sessions were held in all three hotels (Marriott, Westin, and Sheraton) during the 1998 Materials Research Society Fall Meeting in Boston.

two years. The purpose of the Symposium was to bring together researchers working on different materials systems so that similarities and differences in radiation effects could be compared. Radiation can produce dramatic improvements or degradation in the properties of materials, and an understanding of the microstructural changes which occur during irradiation is critical for the development of predictive models. This Symposium focused on the microstructural changes which occur in solids during irradiation with ions, electrons, neutrons, gamma rays, and x-rays. Materials covered included metals, intermetallics, semiconductors, insulators, and superconductors. A joint session on modeling was held with Symposium J, and a concurrent session on radiation effects in waste materials was held with Symposium QQ.

Several presentations summarized recent highlights in understanding radiation effects in semiconductor heterostructures. Other presentations addressed the medium range order of amorphous Si and novel phases (including oriented nanoparticles) that can be induced by irradiation of ceramics and semiconductors. The production of diamond during swift heavy ion irradiation of graphite (albeit at low efficiency) was reported in one presentation. Steady progress in the understanding of radiation effects in nuclear waste materials (such as amorphization and bubble formation) was evident in a number of presentations. A significant increase in the number of presentations on irradiated metals compared to previous symposia in this series shows a rekindled interest in the physics of anisotropic diffusion of point defect clusters in metals, along with increased emphasis on radiation hardening of metals in the fission and fusion energy research fields. A computer simulation study reported that surface effects can significantly enhance the production of vacancy clusters in irradiated metals for displacement cascades located up to 20 nm from a free surface.

Symposium Support: EPRI and ORNL.

Ferroelectrics Focus on Memories and Other Electronics Applications

(See MRS Proceedings Volume 541)

Symposium O on Ferroelectric Thin Films covered a broad spectrum of fundamental and applied topics including piezoelectrics for actuators and micromachines, pyroelectric and piezoelectric sensors, microwave frequency devices, and several memory types.

Use of the built-in or remanent polarization of ferroelectrics for integrated circuit nonvolatile memories presents challenges in the fabrication and integration of ferroelectric and electrode materials. For memories using lead zirconate titanate (PZT) ferroelectrics, substantial progress was reported by D. Wouters (IMEC) in maintaining good properties while thinning the PZT to achieve a reduction of the switching voltage to below 1.5. This is important because of the trend to lower memory operating voltages. Several authors reported progress in reducing the process temperatures for PZT capacitors. Of these reports, among the most visually dramatic was that by T. Tatsumi (NEC) who showed a SEM of a PZT capacitor stacked over a contact plug to an underlying aluminum metallization line. The PZT was deposited by MOCVD at a deposition temperature of 440°C. Progress has been limited in reducing the process temperature requirements for a competing ferroelectric material, strontium bismuth tantalate (SBT). However, J. Kudo (Sharp) reported successful development of a bottom electrode structure (IrO_2 over a TaSiN diffusion barrier over a polycrystalline silicon contact plug) which was capable of withstanding the 700°C SBT crystallization. Interestingly, a different electrode material (platinum) was used as the top electrode. In addition to the fabrication challenges, the reliability and degradation mechanisms of ferroelectric thin films were widely reported.

The high dielectric constant of ferroelectrics has made them attractive as a potential replacement for silicon oxide based capacitor dielectrics in DRAMs. With continued scaling of DRAMs the use of ferroelectric materials is expected to become advantageous in the next few years. The leading candidate is barium strontium titanate (BST) which in thin film form has a dielectric constant of several hundred. D.E. Kotecki (IBM) reviewed BST for DRAM applications. Even with the high dielectric constant of BST, it will be necessary to use three-dimensional capacitor geometries at the giga-bit generations contemplated for production. Kotecki reported on MOCVD BST deposited over a Pt cylinder or postbottom electrode. A barrier of TaSiN was used between the Pt and an underlying polycrystalline silicon contact plug. In another invited paper, T. Horikawa (Mitsubishi Electric) also gave an overview of BST DRAM technology. The basic capacitor geometry was similar; however, the bottom electrode structure materials were different with Ru over a TiN/Ti diffusion barrier. Both speakers identified key integration issues such as (1) oxidation of the barrier, and (2) degradation of BST properties on exposure to hydrogen such as the forming gas anneal that is typically used near the conclusion of processing of silicon-based integrated circuits. The dielectric constant of thin film BST is substantially lower than that of crystalline BST. S.K.

Meeting attendees at the 1998 Materials Research Society Fall Meeting in Boston take the opportunity to discuss their needs with some of the 400 exhibitors who showcased products in booths at the Marriott and Westin hotels.

Streiffer (ANL) discussed the influence of microstructure on the dielectric properties of BST. He reported that mechanical strain, excess titanium, and an interfacial capacitance effect all contribute to the reduction of the dielectric constant of thin film BST.

The large pyroelectric effect in ferroelectrics makes them of interest for use in infrared imaging devices. Especially of interest are uncooled imaging devices for consumer applications such as security and night-time driving vision. P.G. Clem (SNL) reported on the development of pryoelectric imaging devices with the capability to sense a change in pixel temperature of as little as 0.05°C. This was achieved by fabricating Ta-doped PZT pixels over an aerogel of SiO_2 which has very low thermal conductivity. The use of the aerogel provides a more robust system than the air bridges previously used.

Symposium Support: Motorola, SNL, and Samsung Adv. Inst. of Tech.

Complex Oxides Exhibit Magnetoresistive, Magneto-Elastic, and Magneto-Optic Effects

Symposium P on Magnetic Oxides and Oxide Devices covered various aspects of this exciting research area, from fundamental physics issues to practical materials science issues related to fabrication of magnetic oxide-based heterostructures. The focus was on basic and applied research involving complex oxide materials that exhibit magnetoresistive, magneto-to-elastic, or magneto-optic effects as well as other oxides that have device potential. These included CMR materials such as doped perovskite and layered manganites and cobaltites, ruthenates, ferrites, garnets, spinels, and pyrochlores.

Spin-polarized tunneling issues were examined from the viewpoint of spin-polarized photoemission spectroscopy (J. Park, BNL), the behavior of both CMR tri-layer tunnel-junctions (J. Sun, IBM), and CMR oxide-superconductor heterostructures (A. Goldman, Minnesota), and from low-field magnetoresistance (J. Evetts, Cambridge). Regrettably, the spin polarization essentially vanishes at room temperature, suggesting that the possibility of a conventional junction-based field sensor operating near 300 K seems doubtful. Nonetheless, research into the critical area of lattice-strain effects on thin-film heterostructures is crucial to any future thin-film application of these magnetic oxides. To that end, the latest developments in this area were presented both from the experimental (S. Ogale, Maryland and C. Eom, Duke) and the theoretical (H. Roder, LANL) perspective. Novel ferromagnetic materials systems were examined (H. Ohno, Tohoku and T. Ono, Keio) as was charge ordering behavior in CMR compounds (B. Raveau, CNRS; T. Tomioka, JRCAT; and C. Chen, Lucent). Local structure (D. Louca, LANL) and the influence of laser light on charge-ordered CMR systems (M. Fiebig, Tokyo) were also examined. The influence of domain walls on bulk properties (A. Kent, New York) and the imaging of these structures was also discussed (A. Marshall, Stanford). A joint session on oxide electronic devices was held in tandem with Symposium O that examined the progress made to date in the area of low-field magnetoelectronics (R. Ramesh, Maryland) and ferroelectric oxide heterostructures (C. Ahn, Geneva).

Symposium Support: LANL, JRCAT, Microceramics, and Neocera.

High-Temperature Superconductor Properties and Processes Refined

In Symposium Q on High-Temperature Superconductors—Materials Challenges, new techniques were reported to fine-tune HTS properties, particularly concerning boundaries and interfaces, and improving stability of the HTS materials in ambient and operating condition. On the basic issues, tricrystal-pairing symmetry was reviewed and provided clear evidence for d-wave order parameter symmetry.

Flux dynamics and the status of flux pinning in HTS was reported and reviewed. The effects of twin boundaries in YBCO where the refinement of twin spacing and twin domain can lead to flux pinning was systematically demonstrated on the melt textured samples with different amounts of 211. Pinning centers of Pb-doped Bi-2212 was reviewed and sorted out by systematic study of resistivity anisotropy, microstructures, and critical current.

Large area (20 cm × 20 cm) YBCO film with high quality was reported. IBAD and RABiTS both have made incremental progress toward large area YBCO coated conductor development. Several DOE-funded wire projects and Japan's wire and cable projects were reviewed. Good progress on Bi-2212, and 2223 were reported. An equal amount of Bi- activities versus Y-123 activities toward wire development were presented at this meeting. One activity related to Hg-HTS involves the development of high quality thin film using Tl-HTS as a structure precursor by Hg/Tl replacement annealing. Another is the development of a way to reduce cost for HTS conductors by coating Hg-1223 thick film on Ni substrate.

Symposium Support: IBM T.J. Watson Research Center, ISTEC, Texas Center for Superconductivity, and ONR.

Synthesis to Device Modeling Encompassed in Organic, Electronic, and Photonic Materials

Symposium R on Organic Electronic and Phototonic Materials and Devices encompassed a wide range of subjects from synthetic procedures for organic and polymeric compounds to device modeling and circuit performance. Many talks described the details of chemical structure, physical phenomena, and device operation. Some of the highlights of the Symposium included the use of combinatorial techniques to efficiently screen materials and LED device structures by a group from the University of Bayreuth, Germany. Several talks were devoted to the understanding of the beneficial effects of thin layers of materials such as lithium fluoride at the interface between the cathode and the electron transporting layer in MLEDs. Contributions to this subject were made by groups from the University of Arizona, Phillips University, and Yamagata University. A group from IBM T.J. Watson Research Center reported organic transistors with operating voltages less than 5 V, while a group from Bell Laboratories reported charge carrier mobilities as large as 100 cm^2/V s for pentacene single crystals at cryogenic temperatures. Other highlights of the Symposium included talks on organic-based microcavities in the strong coupling regime (Sheffield) and active matrix poly-Si/conjugated polymer LED displays (Cambridge/Seiko-Epson). Several groups reported on relatively efficient photodiodes/solar cells with active materials that range from organic single crystals to polymer-based composites.

Symposium Support: HP, Sanyo, Nissan Chemical Industries, Dai Nippon Printing Co., and IMES.

Carbon Nanotubes Move from Chemistry to CRTs

In Symposium S on Carbon Nanotubes, Fullerenes, and Related Carbon Materials, J. Chen (Kentucky) reported the development of an approach to solubilize shortened single-walled carbon nanotubes into common organic solvents. Both ionic (charge transfer) and covalent solution-phase chemistry with concomitant modulation of the SWNT band structure were demonstrated. Solution-phase near-infrared spectroscopy was used to study the effects of chemical modifications on the bandgaps of the SWNTs. Reaction of soluble SWNTs with dichlorocarbene led to the first example of solution-phase functionalization of the nanotube walls.

Nobel Laureate R.E. Smalley said in his plenary session that his group in Rice University has been able to spin-coat the SWNTs solution into a suitable substrate. They are trying to use these individual tubes as seeds to grow longer nanotubes with certain catalysts.

A group of scientists from the Institute of Metal Research in China and MIT reported a novel CVD method to grow SWNTs. These SWNTs have larger diameters than previous PLV and electric arc preparations. The addition of thiophene was found to be critical in promoting the growth of SWNTs.

Scientists from the University of Pennsylvania used high-resolution TEM to show that C_{60} molecules were encapsulated in SWNTs. Some C_{60} molecules are observed as self-assembled chains with nearly uniform center-to-center distances and resemble a nanoscopic peapod. The endofullerenes coalesce into longer capsules under the action of the electron beam.

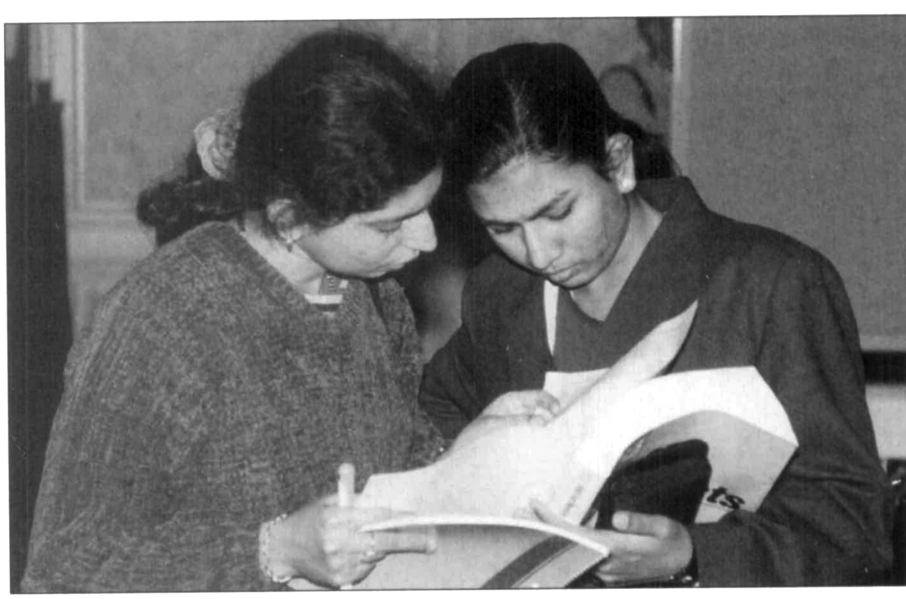
Y. Saito at Mie University in Japan demonstrated a prototype CRT equipped with field emitters composed of multi-walled carbon nanotubes. The fabricated CRTs are lighting elements, which can be assembled to form a giant outdoor display. Stable electron emission, adequate luminance (>1 × 10^4 cd/m^2) and long lifetime (>10,000 h) were demonstrated. The CRT lighting elements presented are the first practical products utilizing carbon nanotubes on an industrial scale.

Symposium Support: Carbolex.

Photoaddressable Polymer Shows Huge Refractive Index Charge

Over two-thirds of the papers in Symposium T on Recent Progress in Optical Data Storage & Processing dealt with materials for holographic storage with the vast majority discussing polymeric materials. These materials, suitable for read-only (ROM) and write-once-read-many (WORM) storage are expected to be the initial market entry points for this technology. Erasable materials, such as gated recording in $LiNbO_3$, still need more development, especially in reducing the laser power densities required for recording. The big surprise at the Symposium came from a newcomer to the optical storage arena, Bayer of Germany. Famous for aspirin and other pharmaceuticals, we were unprepared to hear from T. Bieringer of their research into materials for conventional optical and holographic storage.

They reported on the development of a new class of photoaddressable polymer (PAP) that exhibits a huge change in refractive index n = 0.4, upon exposure—this is 10 times greater than any previously reported change and may enable the recording of significantly more holograms in a common volume or the recording of higher efficiency holograms. This material has enormous potential for increasing holographic storage capacity into the terabyte regime. At the same time, the large n has potential for gray-scale recording in conventional optical storage. Storage of multiple bits in one location, rather than



Researchers review the abstract book, deciding which talks to attend at the 1998 Materials Research Society Fall Meeting in Boston.

just a binary 1 or 0, can increase capacity so that a single CD-sized disk can contain 30–40 Gb.

The strength and depth of the research efforts at Lucent Technologies was evident in three excellent papers presented on photopolymers for holographic storage (M.L. Schilling, L. Dhar, and M. Schnoes). Significant progress was reported in solving the difficult problem of dimensional stability, that is, the shrinkage of the polymer matrix upon exposure. Shrinkage as low as 0.1% has been achieved by the Lucent team whereas many other polymer materials exhibit shrinkage as large as 5%—a situation that greatly limits storage capacity. They also reported recording densities of 48 bits per micron (the metric used in holographic storage); this is equivalent to 30 Gb/in^2. This is significant when compared with conventional magnetic recording that is now shipping 5.5 Gb/in^2 and has achieved 11.7 Gb/in^2 in the laboratory.

Finally, in the one nonstorage paper in the Symposium, N. Zheludev of the University of Southhampton, United Kingdom, reported on the application of the huge optical nonlinearity of a fiber-gallium interface to a high contrast all-optical gate. Nonlinearities that are 14 orders of magnitude higher than optical glass can operate with only a few milliwatts of laser power over a broad range of wavelengths.

Graduate Students Receive Gold and Silver Awards

The Materials Research Society initiated the Graduate Student Gold and Silver Awards at the 1998 Fall Meeting in Boston. During an awards ceremony on Thursday, December 3, the Graduate Student Award finalists each received either a silver or a gold award. The **Gold Award** recipients are **Marc A. Baldo** (Princeton University); **Derrick T. Carpenter** (Lehigh University); **John R. Harper** (Texas A&M University); **Bryan D. Huey** (University of Pennsylvania); **Byeongwon Kang** (University of Kansas); **Daniel L. Polis** (University of Pennsylvania); **Gwenaëlle Rousse** (Université Paris-Sud); **Jeffrey S. Sullivan** (University of Wisconsin—Madison); **Madeline Torres-Lugo** (Purdue University); **Anton Van der Ven** (Massachusetts Institute of Technology); **Brian D. Wirth** (University of California—Santa Barbara); **Stanislaus S. Wong** (Harvard University); **Andrey Zarur** (Massachusetts Institute of Technology); and **Mingqi Zhao** (Texas A&M University).

The **Silver Award** recipients are **Rong Bai** (Brown University); **Michael V. Braginsky** (University of Pennsylvania); **Dmitriy S. Chekmarev** (The University of Chicago); **Xiaohua Chen (Cinti)** (Georgia Institute of Technology); **Xing Chu** (Carnegie Mellon University); **John M. DeLucca** (The Pennsylvania State University); **Lawrence H. Friedman** (University of California—Berkeley); **Alexander Hartmaier** (Max-Planck-Institut für Metallforschung—Stuttgart); **Jaemo Im** (Northwestern University); **Catherine Klapperich** (University of California—Berkeley); **Young Joo Lee** (State University of New York—Stony Brook); **Ju Li** (Massachusetts Institute of Technology); **Charlene Lobo** (Australian National University); **Yoshiko Sakairi** (University of Tokyo); **Leonid E. Shilkrot** (University of Michigan); **Moonsub Shim** (The University of Chicago); **Vera N. Smolyaninova** (University of Maryland); **Jay F. Whitacre** (University of Michigan); **Eva M. Wong** (The Johns Hopkins University); **William S. Wong** (University of California—Berkeley); and **Yiping Zhao** (Rensselaer Polytechnic Institute).

The 1998 Materials Research Society Fall Meeting Gold Award recipients.

Noncovalent Interactions Key to Supramolecular Science

Supramolecular science has emerged over the last decade as an interdisciplinary field with roots extending into organic chemistry, metal-coordination chemistry, crystal engineering, surface chemistry, biochemistry, and materials science. A key topic in supramolecular science is the study of noncovalent interactions, so molecular components must have specific functionality (information) encoded into their structures. Symposium U on Organics with Supramolecular Structure and Function concerned issues of supramolecular and materials science of a wide range of organic and organic/inorganic hybrid systems. Several important developments were presented in the areas of noncovalent synthesis, molecular recognition, chemical sensors, functional polymers including dendrimers, thin film architectures, layered structures, and nanoscale devices. Many of the systems discussed were designed to allow information to be stored, transduced, or transmitted at the molecular/supramolecular level.

Crystal engineering of new materials included manganoporphyrin-based magnets in which electron acceptors (e.g., tetracyanoethylene) link the metal centers into chain structures (J. Miller, Utah). Intricate supramolecular architectures based on tetrathiafulvalene derivatives (rotaxanes, belts, and cages) constructed by virtue of intermolecular charge-transfer interactions were described by J. Becher (Odense). Related multicomponent systems were shown to have applications in prototype supramolecular devices using light-driven or electrochemically controlled processes (D. Fitzmaurice, Dublin, and V. Balzani, Bologna). The importance of hydrogen bonding in regulating the association of small molecules was emphasized in several lectures. Porous supramolecular frameworks were also described. Synthetic chemistry inside multiporphyrin cages was presented by J.K.M. Sanders (Cambridge). The power of metal-directed self-assembly was illustrated by W. Hosseini (Strasbourg) in the synthesis of coordination networks:

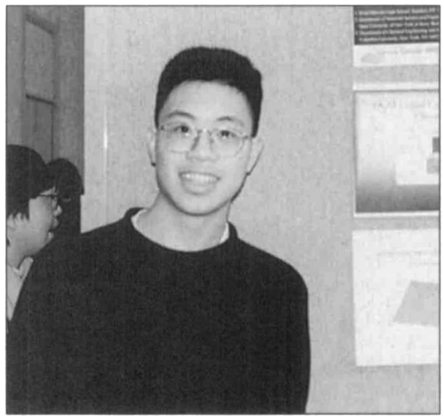
the dimensionality (one-, two- , or three-dimensional networks) as well as the topology (linear, helical) can be tuned by judicious choice of ligand and metal. Extended graphite-related organic materials were described by K. Mullen (MPIP, Mainz), including the synthesis and properties of shape-persistent dendritic polyphenylenes. V. Percec (CWRU) described the synthesis and properties of an array of polymeric structures including dendrimers and linear polymer/dendrimer composites, some of which are liquid crystalline. T. Swager (MIT) discussed sensing properties of some new conjugated polymers in which an ordered array of sensor sites are designed to amplify the electronic signal when the guest molecules bind to the receptor cavities. F. Wudl (UCLA) introduced new heteroacene materials for light-emitting devices.

Langmuir-Blodgett and metal-thiol self-assembly techniques were described by several speakers as a means of constructing functionalized monolayer and multilayer structures with remarkable molecular recognition or nonlinear optical properties. Large nanoscale objects, including large asymmetric supramolecular assemblies of macromolecules were reported by S. Stupp (Illinois). Interest in many of the systems presented in this Symposium is motivated by their possible applications as functional components in nanoscale devices, and in the near future further significant progress can be expected in the applications of organic materials as sensors, switches, wires, and molecular electronic components.

Symposium Support: ARO.

Plasma Deposition and Treatment of Polymers Focuses on Biomaterials
(See MRS Proceedings Volume 544)

Symposium Y on Plasma Deposition and Treatment of Polymers was organized around themes which presently also drive a rapid expansion in technological applications of this field: The first, plasma treatments for biomaterials, focused mainly on the complex issues of how biological fluids or living cells interact with plasma-treated polymeric surfaces or plasma-polymer deposits with deliberately engineered surface functionalities or containing metal clusters. The current methodologies for creating such surfaces (e.g., by pulsed plasmas) and for characterizing them by photoelectron spectroscopies, static secondary ion mass spectroscopy, nuclear magnetic resonance, atomic force microscopy, and other modern techniques, were discussed in invited contributions by D.G. Castner (Washington), P. Favia (Bari), H.J. Griesser (CSIRO, Melbourne), and K.K.



The youngest participant of the 1998 Materials Research Society Fall Meeting in Boston, Ward Melville High School student Ian Wong, displays his poster, "Adsorption of Lambda DNA on Modified Gold Surfaces," (U5.9) done in collaboration with researchers at the State University of New York—Stony Brook and Columbia University.

Gleason (MIT), for example, and in numerous other presentations. The latter author's talk on fluorocarbon films, however, dealt with another important area of application, namely "plasma processing for electronics and optics"; in particular, the very timely subject of low-permittivity dielectrics for multilevel integrated characteristics, derived from volatile organosilicon precursors, were exemplified in invited presentations by T. Weidman (Applied Materials) and L. Martinu (École Polytechnique, Montréal), the former for all-dry ULSI lithography and the latter for permeation barriers, multilayer optical filters, and protective coatings. Many authors (e.g., F. Arefi and R. Lamendola, universities of Paris and Bari, respectively) dealt with the important issue of adhesion promotion to polymer surfaces by plasma pretreatments, where not only the material's surface functionality is changed by the plasma chemistry, but short-wavelength uv radiation from the plasma can also favorably modify the polymer's subsurface region to depths exceeding 100 nm.

Thermoelectric Materials Keep Their Cool
(See MRS Proceedings Volume 545)

Symposium Z on thermoelectric materials research focused on research related to new Materials for Small-Scale Refrigeration and Power Generation Applications. The organizers tried to place a special emphasis on graduate student participation and presentations at this Symposium. An awards committee of attendees was set up who did not have any association with students to make the selections. First and second place awards were given for the best graduate student oral presentations with a $150 prize. There was a tie for first place and no second place was given. This award was shared between R.T. Littleton IV (Paper Z11.2) of Clemson University and C. Jones (Paper Z12.4) of Cornell University. The poster session awards were given to A. Pope (Paper Z4.19) of Clemson University (First Place, $150) and the second place award of $100 each was shared by K-S. Choi (Paper Z4.10) from Michigan State University and K. Proctor (Paper Z4.26) of Cornell University. The number of students presenting talks and posters showed a substantial increase from those who participated in the last Symposium, which was held during the 1997 MRS Spring Meeting.

An overview of the Symposium will be published as a Perspectives in Science in an upcoming issue of *Science* ("Holey or Unholey Semiconductors for New Thermoelectric Materials" by Terry M. Tritt). This title was the title of the plenary talk given by G. Slack (RPI) which focuses on the concept of filling open cage structures with loosely bound atams to scatter phonons and reduce thermal conductivity. Many new materials and concepts were discussed. B. Sales and D. Mandrus (ORNL), D. Johnson (Oregon) and G. Slack (RPI) reported on work on a family of materials called skutterudites which was the first material indicitive of Slack's concept of a phonon-glass:electron crystal (PGEC). Another group of these open cage structure materials called clathrates were discussed by a number of groups: G. Nolas (Marlow Ind.) and G. Slack, G. Stuckey (UCSB), O. Sankey (Arizona State) and C. Uher (Michigan).

Nanostructure materials are also a major topic in thermoelectrics and results on quantum wires were presented by M. Dresselhaus's group at MIT. G. Chen (UCLA) and R. Venkatasubramarian (Research Triangle Institute) presented work on superlattice structures. Another novel concept based on these superlattice structures was thermionic emission, presented by G. Mahan (Tennessee) and A. Shakouri (UCSB). A new group of intermetallic materials called Half-Heusler alloys was presented by numerous groups: Uher, R. Cava (Princeton), V. Browning (NRL, and in collaboration with J. Poon at UVA and Tritt at Clemson) and other intermetallics were presented by F. DiSalvo's group at Cornell University.

Additional materials and concepts were also presented: chalcogenide systems by M. Kanatzidis (Michigan State), J. Sharp

(Marlow Ind.), and pentatellurides by Tritt's group at Clemson University (with Littleton and Kolis). The advantage of using ADP was discussed by Sales where he showed that valuable information about the thermal properties of materials could be derived by ADP information. Another new class of materials for thermoelectrics called quasicrystals was presented by Tritt's group at Clemson (with Pope). Another new concept for thermoelectrics is using pressure tuning (presented by J. Badding of Penn State) to mimic the chemical pressure in a sytem and led to information about doping potential strategies.

Symposium Support: MMR Tech., Quantum Design, GM, ONR, and Keithley Instruments.

Chemical Synthesis and Chemically Directed Assembly Opens Road to Devices Below 50 nm

Symposium BB, Nonlithographic Methods for Organizing Nanoscopic Building Blocks into Functional Materials, focused on the assembly of nanoscale components into functional macroscopic materials. The importance of these emerging technologies is illustrated by the need to develop methods for fabricating smaller, higher density data storage devices. Chemical synthesis and chemically directed assembly of device components will clearly play a large role in the cost-effective production of devices with minimum size features below 50 nm.

A majority of papers described the use of particles with diameters ranging from ca. 5 nm to several microns as fundamental building blocks for constructing new macroscopic materials. Due to recent advances in synthetic methodology, virtually any material desired (e.g., Au, Ni, Co, CdS, CdSe, latex) may be synthesized in colloidal form with excellent control over particle size and dispersity. C.B. Murray (IBM), for example, showed control over the size and dispersity of cobalt nanocrystals. Crystals between 1 nm and 15 nm were synthesized which were uniform in size to within 1 lattice constant. The monodispersity facilitates crystal packing into two- and three-dimensional "supercrystals." Murray is investigating the effects of cobalt size, shape, and packing density on magnetic behavior.

Other reported nanocrystal organization methods employed molecular recognition as tools for constructing assemblies with spatially well-defined architectures. In this respect, DNA is proving to be an excellent scaffold from which to organize nanoscale objects. As one example, J.L. Coffer (Texas Christian University) described the growth of CdS ring structures using plasmid DNA as a template.

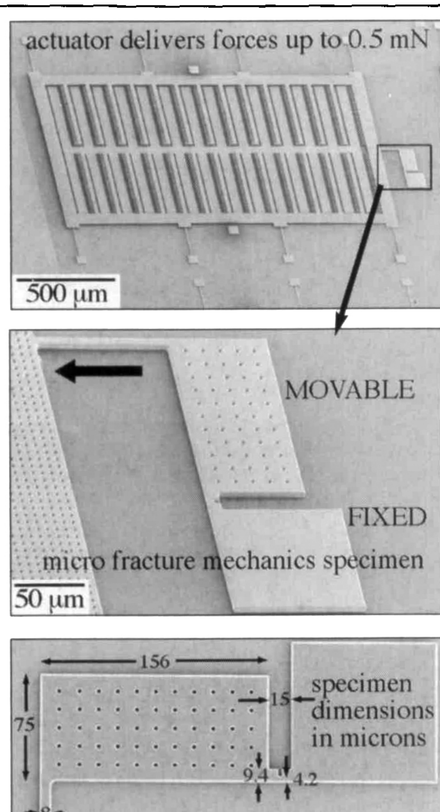
Symposium Support: ARO, Air Force Office of Scientific Research, and NSF.

Microstructures Take on New Meaning: Sensors and Actuators on a Chip

(See MRS Proceedings Volume 546)

Thematic sessions for Symposium AA, Materials Science of Microelectromechanical Systems (MEMS) Devices, were devoted to mechanical and physical properties of materials at the size scale relevant to MEMS devices, adhesion and coatings, new materials for MEMS, and MEMS processing. The micrographs from A.H. Heuer's group at CWRU show an on-chip surface micromachined single-edge notched beam fabricated from polysilicon. Crack propagation from the notch occurs in this microfracture mechanics device entirely by electrostatic actuation. While polysilicon represents the most widely exploited material currently being used for MEMS devices, many new materials and new sensing and actuation schemes are being evaluated for extending MEMS to new application areas. Materials science issues are key to this development.

Symposium Support: TI/DARPA, SNL, TI Microcomponents Tech Ctr, and TI.



Combinatorial Chemistry Finds Uses in Electronic Materials, Sensors, and Heterogenous Catalysts

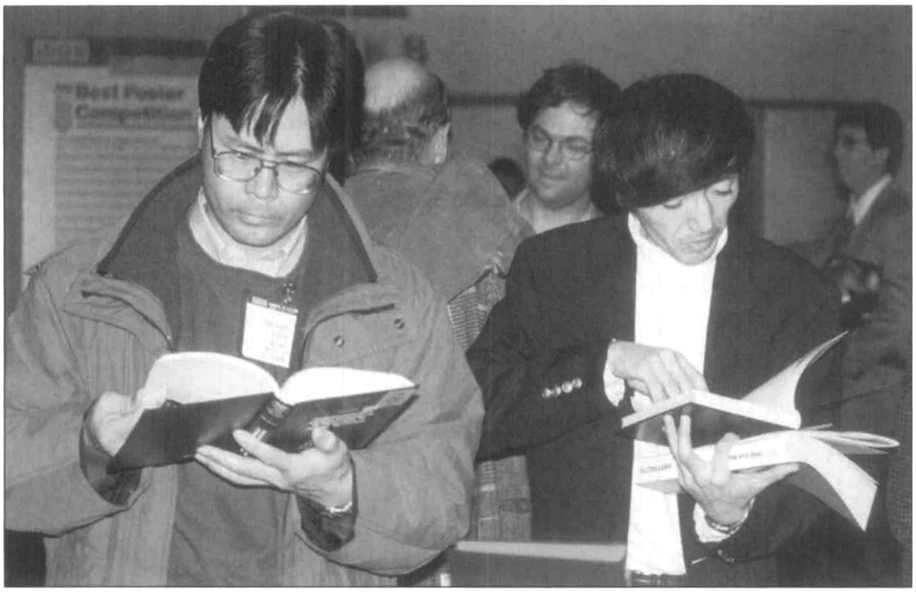
The inaugural MRS Symposium on combinatorial materials discovery and device optimization highlighted major advancements in this rapidly growing field. The combinatorial technique consists of fabricating large arrays of diverse materials and rapidly testing them to find those of interest. The method has found useful applications in very diverse areas of research, including electronics materials, sensors, and heterogeneous catalysts. R.B. van Dover of Lucent Technologies discussed the discovery of a practical dielectric with a higher figure-of-merit than existing materials used in DRAMs. The new materials can be processed at low temperatures compatible with the IC-fabrication process. A.J. Matzger of Caltech described the fabrication and testing of arrays of chemiresistors for sensing TNT vapors in minefields. The chemical composition of each sensor is combinatorially varied, thereby generating a large diversity of useful sensor responses caused by the analyte vapor. P. Cong of Symyx discussed the development and testing of a high-throughput mass spectrometer and optical system for rapidly screening libraries of heterogeneous catalysts. Analytes are transported from above each catalyst spot to the detector via a small-bore tube which is scanned over the surface of the library wafer. The system achieves high sensitivity, high analyte specificity, and short measurement times, all of which are important for rapidly discovering new catalysts.

Symposium Support: DuPont and Symyx.

Solid-State Chemistry Spans from Intermetallics to Insulating Oxides

(See MRS Proceedings Volume 547)

Symposium DD, Solid-State Chemistry of Inorganic Materials, spanned a large area of chemistry on materials ranging from intermetallics to insulating oxides. Synthesis of new materials with unique properties was highlighted with talks by F. DiSalvo (Cornell) on ternary nitrides, S.-J. Hwu (Clemson) on electrochemical synthesis, and T. Mason (Northwestern) on new transparent oxide conductors. A. Navrotsky (UCD) presented calorimetry data on nanophase oxides and oxyhydroxides. The very small energy differences among different structures suggest a complexity of inorganic behavior analogous to the "energy landscape" seen in proteins.



Meeting attendees browse through proceedings volumes available at the 1998 Materials Research Society Fall Meeting in Boston.

Navrotsky suggested that researchers' ability to make new metastable materials is limited by their ability to find mechanistic pathways and structure-directing templates rather than by stringent energetic constraints. M.A. Subramanian (DuPont) presented work on the distorted-perovskite oxides of the formula $Se_{1-x}Te_xCuO_3$ ($0 \leq x \leq 1$) where all the Cu is in the +2 oxidation state. $SeCuO_3$ is ferromagnetic with transition temperature of about 50 K and $TeCuO_3$ is an antiferromagnet with transition temperature about 9 K. They are both electrical insulators. Subramanian studied the solid solution which is a single phase showing a ferromagnetic-antiferromagnetic crossover coincident with a Cu-O-Cu angle of 127°, consistent with the Goodenough-Kanamori rules. T. Vanderah (NIST) discussed materials important to wireless communications technologies. Every modern commercial wireless communication and detection system either under deployment or advanced development incorporates oxide ceramics with unique electrical properties as critical elements. These ceramic oxides are used in a variety of components in cellular communications circuits that store, filter, and/or transfer electromagnetic energy with minimal loss, for example, resonators (bandpass filters) and circulators. Vanderah provided a good overview of our present knowledge and then presented several new phases of ferrites in the $BaO\text{-}Fe_2O_3\text{-}TiO_2$ system and discussed structure-property relationships.

Symposium Support: IBM, CERDEC, DuPont, NSF, and Inel.

Solid-State Ionics Important for Electric-Based Transportation
(See MRS Proceedings Volume 548)

The growing interest in the development and commercialization of electric-based transportation, such as electric and hybrid vehicles, has significantly strengthened the interest in solid state ionics materials, the topic of Symposium EE. The key to market success of electric-based transportation apparently relates to the development of advanced materials capable of storing high-energy and providing high-power in demand. The Symposium has covered key material issues related to energy storage devices, electrocatalysis, electrochromics displays, sensors, and bio-ionics.

The major contributions were related to the challenges and new opportunities in design and optimization of materials for energy storage devices, in particular the advanced lithium batteries. Fundamentals of materials synthesis, including synthesis of novel transition metal oxides, ionic and electronic conductive polymers, insertion and intercalation compounds, and carbonaceous and graphitic materials were covered. Materials aspects of ambient and high-temperature solid-state fuel cells and sensors, new approaches in design of electrochromic devices, and displays were also presented. Theoretical aspects of ion motion in solids, and factors influencing ion transport in solid and liquid electrolytes were presented. Design and optimization of solid-state batteries, sensors, and fuel cells were also discussed. The presentations concluded that due to the environmental issues such as global warming by CO_2, acid rain, noise pollution, and a unique prospect of electric-based transportation for improving the environment, the solid-state ionic community will have a tremendous opportunity to contribute in the development of combustionless technologies.

Symposium Support: LBNL.

Porosity, Monolithic Materials, and Combinatorials Methods Contribute to Catalytic Materials
(See MRS Proceedings Volume 549)

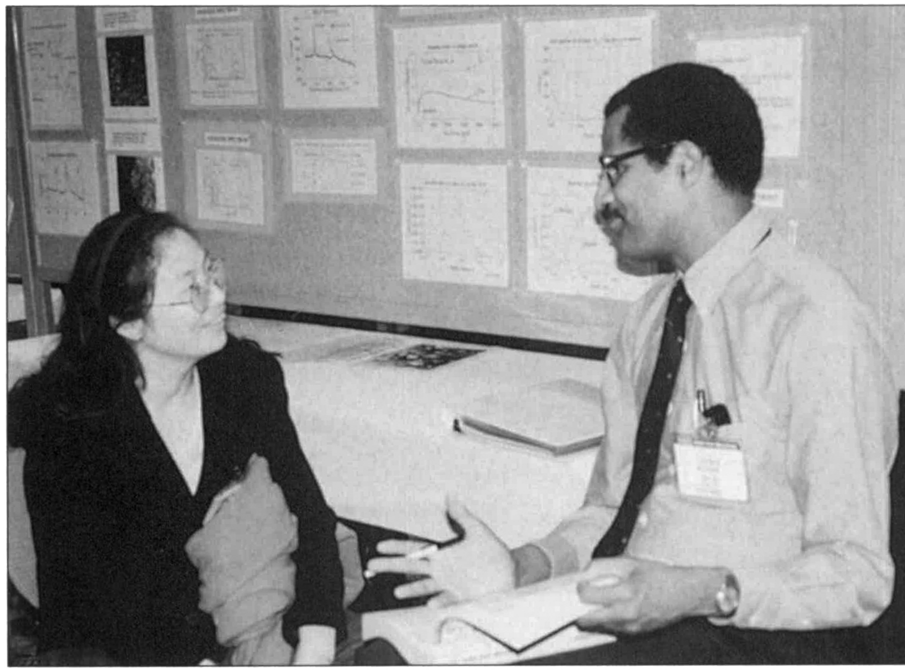
Materials science and engineering continue to have an important impact on the development of new catalysts through advances in the synthesis of new compositions; the control of porosity; and in shaping, manufacturing, and characterization. Recent progress was well-illustrated in Symposium FF, Advanced Catalytic Materials, at which three topics were particularly noteworthy.

One major topic of interest was the control of porosity and surface area using new synthetic methodologies. High surface area hexa-aluminates, of interest in the catalytic combustion of natural gas, could be prepared by the reverse emulsion technique in which sol-gel chemistry is carried out in water droplets suspended in oil (Zarur and Ying, MIT). Macroporosity was addressed by Stein et al. (Minnesota) who showed that ca. 500-nm diameter latex spheres could be used as templates for the sol-gel synthesis of titania, zirconia, or other oxides with ordered macroporosity. Bradley (Max Planck, Mulheim) showed that microporous silicon nitrides could be obtained, via polymer pyrolysis, with a narrow pore size distribution capable of molecular size discrimination in base-catalyzed reactions.

Monolithic materials, used as a single piece rather than as randomly packed beds of small particles, are receiving increasing attention, as indicated by a review lecture (J. Moulijn, T.U. Delft). Two industrial contributions (T. Sweeting, Vesuvius Hi-Tech Ceramics; K. Butcher, Porvair Advanced Materials) dealt with ceramic foams, materials successfully commercialized as filters for molten metals, but now attracting interest as catalyst supports. Coating of monoliths with catalytically active hexa-aluminate layers was discussed by Eguchi (Kyushu).

A full day was devoted to a joint session with Symposium CC on combinatorial methods applied to catalysis. The speed of development here is significant, with minaturization, automation, new analytical techniques, and information technology all contributing to an explosive development in the ability to rapidly screen new catalyst materials. This is an area to watch—or participate in.

Symposium Support: Criterion Catalyst, Exxon Research and Engineering Co., and Norton Chemicals.



Researchers take the opportunity to discuss their work at the 1998 Materials Research Society Fall Meeting in Boston.

Polymeric Materials are Used for Drugs, Delivery, and Devices

(See MRS Proceedings Volume 550)

Symposium GG, Polymeric Materials—Drugs, Delivery, and Devices, covered a broad range of topics in the areas of novel polymeric drugs and their mechanism of action, recent advances in the science of slow release and novel delivery systems, and medical devices. G.M. Whitesides (Harvard) spoke on multivalent processes in biology and how these concepts might be implemented in the design of novel pharmaceuticals, using the interactions of sialic acid modified acrylamides with influenza as a model. W.H. Mandeville (GelTex Pharmaceuticals) described the development of new polymeric bile acid sequestrants and their application as cholesterol lowering agents. The properties of vesosomes, sized aggregates of unilameller vesicles attached to each other through the interaction between streptavidin/avidin and biotin anchored in the membrane, and their potential as encapsulants for a variety of water or lipid soluble drugs, were presented by D. Trommeshauser (UCSB). The stability of these systems can be extended for up to a month depending upon composition. Recent work by J.L. Thomas (Columbia) dealt with the mechanism by which polyamidoamide (Starburst) dendrimers disrupt lipid membranes. Polyamidoamide dendrimers have shown remarkable efficacy as vectors for the transfection of DNA into mammalian cells. In model systems, liposomes composed of phosphatidylcholine show only weak interactions with dendrimers, while liposomes composed of a mixture of lipids with different packing parameters are severely disrupted. These results suggest that dendrimers may help to disrupt cell membranes by perturbing proper lipid mixing.

Symposium Support: GelTex Pharmaceuticals and NJ Center for Biomaterials and Medical Devices.

Materials Move into Space

(See MRS Proceedings Volume 551)

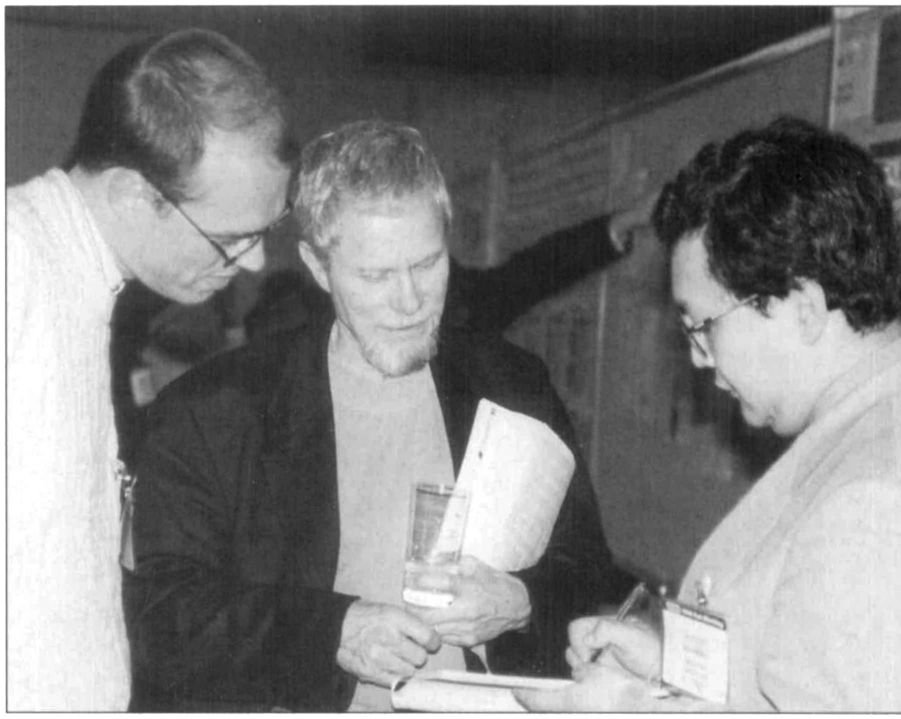
Symposium JJ on Materials in Space—Science, Technology, and Exploration, was held in part to commemorate the 40th anniversary of NASA. The Symposium began with a tutorial on Sunday that gave an introduction to materials and space power (D. Flood, NASA Lewis Research Center), the near earth space environment (B. Banks, NASA Lewis Research Center), and the exploration of Mars (G. Landis, Ohio Aerospace Institute). The meeting itself began with an excellent plenary session that explored numerous aspects of materials in space. These included topics introduced in the tutorial as well as NASA's Microgravity Materials Science Program (M. Wargo, NASA HQ) and international efforts related to microgravity science (R. Herring, Canadian Space Agency and H. Fecht, speaking on behalf of ESA) and materials for protection of astronauts from space radiation (J. Wilson, NASA Langley Research Center).

One session focused on Mars Pathfinder Mission Results presented by D. Ferguson (NASA Lewis Research Center), Landis, and G. Hickey (JPL). Fundamental studies occupied Tuesday morning including a session on quantum effects on materials and devices and fundamental studies of microgravity materials science. The Symposium then shifted back to enabling technology with an excellent broad-based session on space photovoltaic materials that covered III-V devices, thin-film technology, and thermophotovoltaics. The Symposium's poster session included presentations on advanced technologies for space exploration and thin films and coatings for space applications. Poster JJ7.9 presented by S. Kishimoto captured the spirit of the Symposium and one of that evening's poster awards (see sidebar).

One session focused on results of flight experiments and included excellent presentations from across the nation including D. Matson (MIT), A. Sacco (Northeastern), M. Glicksman (RPI), S. Lehoczky (NASA Marshall Space Flight Center), J. Andrews (UAB), and W. Johnson (Caltech). Session chair M. Wargo announced a NASA broad agency announcement due out at the end of 1998 and encouraged participation from all in attendance (wargo@hq.nasa.gov).

The Symposium ended with a two-part informal discussion centered on microgravity materials research and was chaired by J. Prahl (CWRU and Back-up Payload Specialist STS-50, USML-1). The first event was a panel discussion focused on the user microgravity community and the NASA/International Microgravity Materials Science interface. The second event was a keynote session featuring Payload Specialist Sacco (STS-73, USML-2) with commentary by the session chair and D. Matthiesen (CWRU and Back-up Payload Specialist STS-73, USML-2). The focus of the keynote session—which like the panel discussion was more informal and involved lively feedback from the audience—was the relationship between payload and mission specialists and performing and analyzing materials science experiments in space.

Symposium Support: NASA HQ, Elsevier, and NASA-Lewis Research Ctr.



Attendees of the 1998 Materials Research Society Fall Meeting in Boston discuss research during the poster sessions.

Defects Tip the Balance of Toughness and Corrosion Resistance in Intermetallics

(See MRS Proceedings Volume 552)

Symposium KK on High-Temperature Ordered Intermetallic Alloys represented the eighth in this MRS series treating the microstructure, processing, and properties of intermetallic compounds. Both invited and contributed papers highlighted the intensive, worldwide investigation of these materials for structural applications. A number of talks in the titanium-aluminides session focused on dislocation-level mechanisms to explain the observed microstructure-property relationships. Recent work has also focused on creep, fatigue, and processing as titanium-aluminide systems mature toward application. Several talks focused on the critical role that point defects play in the mechanical properties of iron-aluminides and nickel-aluminides. Advances in several promising transition-metal silicides were also presented. In particular, niobium-silicides were shown to have excellent fracture toughness and creep strength, although oxidation resistance remains a concern. Molybdenum-silicides on the other hand have excellent oxidation resistance at high temperature but suffer from poor fracture toughness. Several presentations on Laves phase alloys focused on mechanisms for promoting twinning as a means of improving low temperature toughness. Finally, the importance of computational modeling coupled with detailed experimental analysis of dislocations and interfaces was demonstrated in several presentations on nickel-aluminide-based systems.

Symposium Support: ORNL.

Applications of Quasicrystals Reported

(See MRS Proceedings Volume 553)

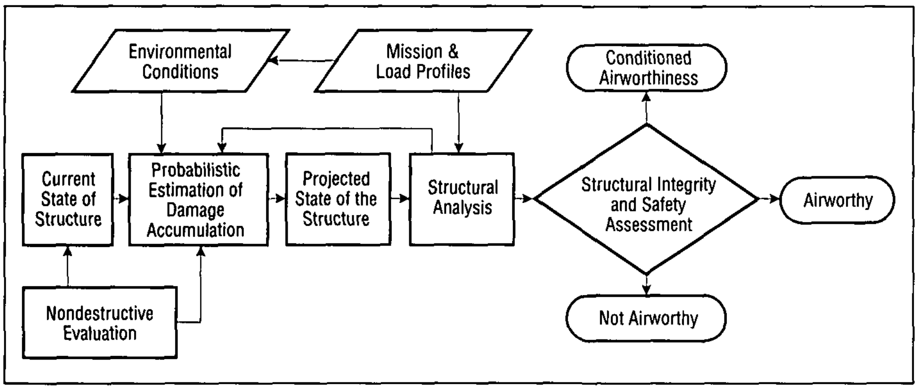
Symposium LL on Quasicrystals described some of the first applications, or near-applications, of quasicrystalline materials. One product on the market is a high-strength steel being used in surgical tools and electrical shavers. The steel contains quasicrystalline precipitates, which are unusually stable against Ostwald ripening. This stability is attributed to the low interfacial energy of the precipitates, and provides flexibility in processing by making the steel resistant to overaging. A ton of quasicrystals will be produced and consumed annually in this steel. A second product is an aluminum alloy which meets or exceeds the specific Air Force Goal level of high strength at elevated temperature; this material contains a quasicrystalline component and is formed by extrusion of gas atomized powders. A third application is not on the market, but is a strong possibility: quasicrystalline thermal barrier coatings. Here, two attractive properties of quasicrystals combine: low thermal conductivity (comparable to yttria-doped zirconia), and plastic behavior at high temperatures. The latter property ensures that the coatings suffer little cracking or spalling due to mismatch in thermal expansion coefficient. (The Al-rich alloys generally become ductile around 70–80% of the melting temperature.) Interdiffusion at elevated temperature between the coating and the substrate can cause transformation of the quasicrystalline phase and loss of thermal insulating behavior; hence, the development of an effective interdiffusion barrier, as reported at the Symposium, is highly significant. The materials are being tested on turbine blades in aircraft engines. The Symposium also included many excellent papers discussing atomic-scale structure, growth of high-quality samples, and physical and mechanical properties. The field is evolving rapidly toward a coherent and highly sophisticated understanding of these materials.

Symposium Support: Ford and Noran Instruments Japan/JEOL.

Airworthiness Assurance is Aim of Aging Aircraft Research

The two-day Symposium on Aging of Engineered Systems with Focus on Aircraft (NN) focused on issues of airworthiness assurance that pertain to aging aircraft. The principal objective of the Symposium was to foster continued developments in the scientific and technological tools for ensuring the safety, reliability, and availability of aircraft in the commercial and military fleet. It is designed to provide a forum for exchange of information between practitioners and researchers in the structures, materials, and nondestructive inspection communities that span across a broad spectrum of disciplines, and to sharpen the focus on common and connecting issues.

Key representatives from industry and government made overview presentations to highlight the technological and operational issues. Overview talks were presented on specific scientific and technological issues, such as corrosion science, corrosion and mechanical interaction in fatigue, probabilistic analysis of damage evolution, and quantitative nondestructive evaluations. Other speakers reported on developments in ongoing research. Through this information exchange and open discussions within and outside of the sessions, the objective was largely achieved. To encourage this informal dialogue, no proceedings will be published so that scientists interested in specific talks may request information directly from the speakers.



Airworthiness Assurance.
Key Players: Operators; Manufacturers; Regulators
Technical Support: Structures; Materials; NDI

Aging of engineered systems, like its human counterpart, is not simply a problem of being old; it begins on day one. Airworthiness assurance, therefore, is a process that ensures the continued safety, reliability, and availability of aircraft in the commercial and military fleet. The concern for aging aircraft is heightened by the fact that commercial transport aircraft built in the 1960s and 1970s are remaining in service beyond their original design objective of 20 years. The average age of U. S. Air Force aircraft is now about 19 years, with an average projected further service of 20 or more years.

Aging involves, for example, airframe and other primary structure, engines, control and other subsystems, and avionics. The Symposium focused principally upon the structural integrity aspects of the first two. The responsibility for airworthiness assurance falls principally upon the operators, manufacturers, and regulators. The process of airworthiness assurance is reflected in the flow chart (see figure). It is accomplished through diligent inspection, maintenance, and sharing of information and experience. Technological support is derived through nondestructive inspection, damage accumulation modeling, and structural analysis.

Symposium Support: Air Force Office of Scientific Research.

Diamond, Ceramic, Polymer Coatings Processed by Vapor Deposition

(See MRS Proceedings Volume 555)

Over 100 oral and poster papers were presented in Symposium OO—Properties and Processing of Vapor-Deposited Coatings—to describe leading-edge research efforts associated with generating relevant processing–microstructure–property–performance relationships of coatings produced by CVD and PVD methods. Various coating materials and applications were discussed during three days of the Symposium, ranging from producing high-quality diamond coatings, to developing large-scale or novel DLC processes, to understanding metal–ceramic interface adhesion behavior in thermal barrier coatings, to identifying corrosion-resistant ceramic coating materials for high-temperature structural applications, to preparing polymeric thin films for integrated circuits. Rapid advances in industrial process scale-up were reported. For example, LANL and GM are involved in a joint effort to develop a large-scale DLC coating chamber (5 feet diameter by 15 feet long) based on a novel process concept called "plasma ion immersion process." At the other front, meaningful computational and experimental progress made in understanding the reaction kinetics, particularly gas phase chemistry, of complex CVD processes were discussed. The importance of understanding the initial nucleation and growth behavior of vapor-deposited materials was demonstrated in many coating systems, notably for diamond growth on Ni and Al_2O_3 substrates. For high-temperature structural applications, the adverse effects of trace impurities such as sulfur and grain boundaries on the metal–ceramic interface adhesion behavior of thermal barrier coatings were discussed along with related processing issues. Overall, the Symposium clearly showed that (1) vapor-deposited coatings are being actively pursued for diverse technological benefits, and (2) the coating community is increasingly relying on generating appropriate processing–microstructure–property relationships to guide integrated coating process and product development.

Symposium Support: Morton Adv. Materials and PNNL.

Structural Design, Fabrication, and Long-Term Stability are Focus of Ceramic Matrix Composite Developments

The inclusion of Symposium PP on Recent Advances in Ceramic Matrix Composites demonstrated the continued interest in and importance of ceramic matrix composites for meeting materials needs in current and future high-temperature applications. The size of the Symposium, and nature of the presentations, however, highlighted the shift from basic or generic research to focused, applications-oriented studies. It is evident that many of the CMC systems are maturing, even becoming commercial products, and thus emphasis is changing from materials and process development to performance, environmental stability, and life.

The utilization of new materials in any application requires detailed information concerning mechanical properties and thermochemical stability in the as-fabricated state and after exposure to service environments. Much effort is being expended to establish standardized test methods for CMCs which will provide engineering data to be employed by the users, that is, designers and component manufacturers. In addition, the long-term stability of ceramic composites especially in moisture-containing environments has become a topic of considerable interest. Apparently, the greatest benefits of the utilization of CMCs will be realized in applications that involve combustion. Detailed microstructural analysis of the materials after they are aged in simulated service environments, and inserted into field tests, is providing a better understanding of the mechanisms associated with degradation and failure. The information gathered from standardized testing, environmental exposures, and characterization is being used as input for life and performance models. Life prediction combined with new and unique nondestructive characterization techniques is providing the confidence necessary for the use of CMCs in several commercial applications.

Emphasis on silicon-containing materials such as silicon carbide and silicon nitride continues. However, the corrosion of these systems in moisture-containing environments has become an obvious concern, and thus the quest for new and improved ceramic composites persists. One technique being pursued to improve the stability of nonoxide ceramics in corrosive atmospheres is the application of "environmental barrier coatings" or EBCs. Like thermal barrier coatings for metallic components, the majority of EBCs are oxide layers and thus significant challenges are associated

IUMRS Forum Participants Focus on International Collaboration

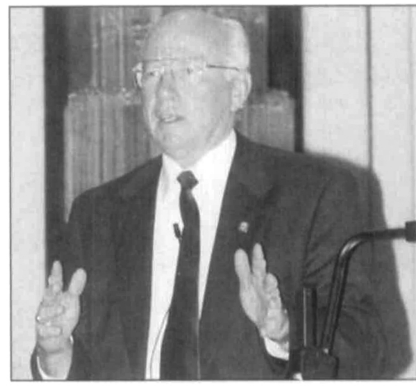
International collaboration and the future of materials research formed the theme of a forum sponsored by the International Union of Materials Research Societies (IUMRS) and hosted by the Materials Research Society on December 2 during its 1998 Fall Meeting in Boston. The panel featured U.S. Rep. Vernon J. Ehlers (R-Mich.); Ezio Andreta, Director of DG XII/F (and now, as of January 1, DG XII/C-1) of the European Commission; Rita Colwell, Director of the U.S. National Science Foundation (NSF); and Robert A. Eisenstein, Assistant Director of the Mathematical and Physical Sciences in NSF. The panel was moderated by R.P.H. Chang (Northwestern University), General Secretary of IUMRS.

1998 MRS President Robert J. Nemanich (North Carolina State University) welcomed the distinguished panelists, noting that MRS placed a special emphasis in 1998 on developing an international perspective in all of its activities. This effort on the Society's part has included enhanced involvement in and support of IUMRS, as an adhering body of IUMRS. Rodney C. Ewing (University of Michigan), 1998 IUMRS President, spoke next, saying that the purpose of the multisociety union is to facilitate research and teaching across countries and across disciplinary boundaries. He expressed appreciation to MRS for its help in organizing the forum, as part of the worldwide efforts of IUMRS.

Rep. Ehlers, who holds a PhD degree in physics, then took the podium to speak about the national science-policy study that was recently completed under his leadership within the U.S. House Committee on Science and released to the public. The study, titled "Unlocking Our Future: Toward a New National Science Policy," represents the first successful attempt at creating an updated national science policy since the Vannevar Bush report released in 1945. Ehlers described the process of drafting the new report and talked about key points of the report itself. He said that ignorance of science has become socially acceptable and must change in order to enhance progress in science and technology. He also promoted improvement of science and math education between the primary and graduate-school levels. On an international scale, Ehlers' report makes several recommendations toward ensuring the success of collaborative research, among them: establishing clear objectives from the outset; ensuring long-term, stable funding from all parties involved; allowing more funding for speculative research projects as part of the broader portfolio; and giving more consideration to interdisciplinary work, particularly as it applies to international collaborations.

From NSF, Rita Colwell talked about the impact of information technology on scientific interdisciplinary collaborations. The "porous boundaries" of materials science, Colwell said, are one reason for the power and foment in materials research today. With the practical application of information technology around the world decoupling work from any particular location, "we can work with people on the other side of the world as if they were just next door," she said. Colwell described as "alchemy" the ability of materials science to blend disciplines and forge international networks, based on information technology. "Materials will continue to play a seminal role as the rest of science mines this field for its wisdom," she said.

Ezio Andreta described the European Union's (EU) "Fifth Framework Programme," which is a policy program supporting a large range of research from basic science to applied, precompetitive research of interest to European industry. The details of the program are proposed and implemented by the European Commission (EC), the executive arm of the EU. With the work of the EC, research becomes an instrument for supporting European competitiveness with the rest of the world, Andreta said. He noted that an agreement for scientific and technological cooperation between the EU and the United States was concluded in 1997 and approved in October 1998.



U.S. Congressional Representative ***Vernon J. Ehlers*** *(R-Mich.) describes his study on science policy during the International Union of Materials Research Societies Forum at the 1998 Materials Research Society Fall Meeting in Boston.*

Robert Eisenstein spoke more specifically about the directorate within NSF that includes materials research, while stressing the importance of international cooperation and NSF's role in facilitating the exchange of scientific ideas. "People-to-people contact" is the most important thing, he said, citing NSF's efforts in recent years to foster this activity generally. He noted the international workshops and conferences held in recent years in Leuven, Belgium; Rio de Janeiro, Brazil; and, more recently, Hawaii, as examples of the multinational scientific dialogue that NSF is active in promoting. In concluding the forum, Eisenstein quoted former NSF Director Neal Lane in urging materials researchers to take on a new role as "civic scientists" and play an active part in promoting their science to the community at large. "This role," he said, "is one in which science shares in defining our future."

For more information about the Ehlers report, see *MRS Bulletin*, November 1998, pages 19 and 20, and MRS website http://www.mrs.org/publications/bulletin/1998/nov/pubaffairs.html. The science report is available on the web at http://www.house.gov/science/science_policy_study.htm.

Full information about NSF can be obtained at website http://www.nsf.gov/.

For more information on the EC's "Fifth Framework Programme" see MRS Bulletin, August 1998, page 4.

R.P.H. Chang, IUMRS General Secretary
Robert J. Nemanich, 1998 MRS President
Rodney C. Ewing, 1998 IUMRS President

(Left to right): ***Robert A. Eisenstein****, Assistant Director of the Mathematical and Physical Sciences in the U.S. National Science Foundation (NSF);* ***Ezio Andreta*** *of the European Commission; and Director of NSF* ***Rita Colwell*** *present talks on international collaboration during the International Union of Materials Research Societies Forum at the 1998 Materials Research Society Fall Meeting in Boston.*

with the deposition and life of the coatings. Due to the aforementioned factors, interest in oxide-oxide composite systems has also surged. Oxide ceramics should possess improved stability in oxidizing environments; however, the design and fabrication of composites containing these materials presents a new set of obstacles and opportunities. Although great progress has been, and continues to be, made in the advancement and improvement of CMCs, much more must be accomplished to better understand the materials and to optimize performance so that these materials will achieve full acceptance and be integrated into demanding high-temperature applications.

Symposium Support: ORNL.

Poster Prizes Awarded at the 1998 MRS Fall Meeting

The 1998 MRS Fall Meeting Chairs Clyde Briant (Brown University), Eric Chason (Brown University), Howard Katz (Lucent Technologies), and Yuh Shiohara (ISTEC) awarded prizes for the best poster presentations. Prize recipients from poster sessions received $500, a certificate, and the honor of having the winning poster displayed for the remainder of the Meeting. Poster award recipients are **A Novel Approach for Lateral Epitaxy Growth of GaN Structures—LEGOS**, T.S. Zheleva, D. Thomson, S. Smith, P. Rajagopal, K. Linthicum, T. Gehrke, and R. Davis (North Carolina State University) (G3.38); **Comparison and Screening of Hole Transport Materials Based on Triarylamines in OLEDs**, C. Schmitz, M. Thelakkat, and H-W. Schmidt (Universitat Bayreuth) (R3.11); **Copper-Conducting Nasicon-Type $CuTi_2(PO_4)_3$ Glass-Ceramics for Application to a Novel O_2 Sensor**, K. Yamamoto, T. Kasuga, and M. Nogami (Nagoya Institute of Technology) (EE3.99); **Integration of Multilayers in Er-Doped Porous Silicon Structures for Optoelectronic Devices**, H. Lopez, S. Chan, L. Tsybeskov, and P. Fauchet (University of Rochester) (F5.22); **Development of Metallic Closed Cellular Materials Containing Polymer**, S. Kishimoto (NRIM) (JJ7.9); **Fast X-Ray Measurements with Imaging Plates in Supercooled Zr-Al-Ni Liquid**; S. Sato (ERATO, JST, Sendai), E. Matsubara (Kyoto University), Y. Waseda, T. Zhang, and A. Inoue (Tohoku University) (MM3.2); **Nanometer-Scale Imaging of Strain in Ge-Island on Si(001) Surface**, T. Ide, A. Sakai, and K. Shimizu (NEC Corp.) (B3.9); **Microstructure and Size Distribution of Compound Semiconductor Nanocrystals Synthesized by Ion Implantation**, A. Meldrum, I. Anderson, C. White, L. Boatner, R. Zuhr (ORNL), D. Henderson, M. Wu, A. Ueda, and R. Mu (Fisk University) (F8.11); and **Subsolidus Phase Relations in the Ternary Systems AO-AL_2O_3-Nb_2O_5 (A-Mg,Ca)**, W. Febo Ayala (University of Puerto Rico), J. Loezos and T. Vanderah (National Institute of Standards and Technology).

The 1998 MRS Fall Meeting Chairs Clyde Briant (Brown University), Eric Chason (Brown University), Howard Katz (Lucent Technologies), and Yuh Shiohara (ISTEC) award prizes for best poster presentation.

Safe and Effective Management of Nuclear Wastes Presented

(See MRS Proceedings Volume 556)

Close to 200 papers were presented at the 22nd meeting of the Scientific Basis for Nuclear Waste Management, Symposium QQ, on various topics such as waste form development, corrosion, waste treatment, engineered barrier systems, radionuclide migration, natural analogues, and performance assessment.

In the keynote address, D.R. Wilkins (TRW Inc.) provided an overview of the viability assessment process for the Yucca Mountain Project. Accomplishments from two decades of surface and underground investigations were discussed in light of the potential performance of the geologic repository. Another highlight of the Symposium centered on an interactive question and answer panel session discussing the performance assessment aspects of nuclear waste disposal and needs for future research. Panel members consisted of A. Van Luik (DOE), M.L. Wilson (SNL), R.B. Codell (USNRC), and J.H. Kessler (EPRI Inc.), with M.J. Apted (QuantiSci Inc.) acting as session moderator.

A.A. Sagues (South Florida) discussed the corrosion behavior of the two-shell, outer A517 carbon steel and inner nickel-base superalloy (Alloy 22) waste package container. Electrochemical conditions known to be responsible for passive behavior and breakdown in the Alloy 22 were examined under a range of potential repository environments. Projected lifetimes and uncertainties for the waste package behavior over a period of 105 years were also discussed.

R.J. Finch (ANL) presented results from five years of corrosion testing of spent nuclear fuel. Fuel fragments reacted predominantly through their outer surfaces with lesser dissolution along grain boundaries and micrometer-sized intergranular fuel particles. The outer surfaces of the fuel fragments were also enveloped by layers of uranium alteration phases. Alteration phase compositions and the extent of fuel-grain boundary dissolution were dependent on the amount of groundwater contact.

Symposium Support: Southwest Research Inst., Geomatrix Consultants, SNL, LLNC, and PNNC.