1999 MRS Fall Meeting Symposia Topics Interweave Experiments and Theory/Modeling

The annual Materials Research Society Fall Meeting in Boston was held November 28–December 3, 1999. For the first time, the meeting was held at the Hynes Convention Center, in addition to the traditional Boston Marriott at Copley Place. Chaired by Paul D. Bristowe (Cambridge University), David G. Grier (University of Chicago), Fernando A. Ponce (Arizona State University), and Ellen D. Williams (University of Maryland), the meeting, incorporating 43 technical symposia, was attended by close to 4,500 materials researchers and included nearly 3,900 oral and poster papers. In a marked departure from recent years, all poster sessions were held in one place at the Hynes Convention Center, instead of being spread out among two or three different venues. The equipment exhibit was also located solely at the Hynes.

Meeting highlights included the plenary session with a talk by Nobel Laureate Horst Stormer; the awards ceremony, including a talk by Von Hippel Award recipient Richard Stein; the David Turnbull lecture given by Joseph Greene; special seminars on materials research support by DOE, NSF, and NIST; a student mixer; and a panel discussion on Alternative Careers in Science.

The Materials Research Society moved its Fall Meeting into the Hynes Convention Center in Boston in 1999.

Technical Symposia

Soft Materials

In the area of soft materials, Symposium AA explored various materials science aspects of food. An introduction was given by R. Jones (Sheffield, UK) during a Symposium X talk in which he illustrated how, despite the complexity of many foodstuffs, the same basic physical principles govern behavior as for traditional "materials." This same message was reinforced by P. Fryer (Cadbury Ltd., UK) who cast the production of chocolate in the language of metallurgical processing, namely, casting and solidification. A. Smith (John Innes Center, UK) drew attention to the role of biology in controlling the starting material—in this case, starch. As plant biochemists learn more about the enzymes that control starch synthesis, researchers should be able to tailor starches to suit different niche markets, a point also covered by M. Gidley (Unilever Research).

The materials science of phospholipid assemblies was the subject of Symposium EE. Phospholipids are ubiquitous biological molecules which self-assemble into lamellar bilayers and other three-dimen-

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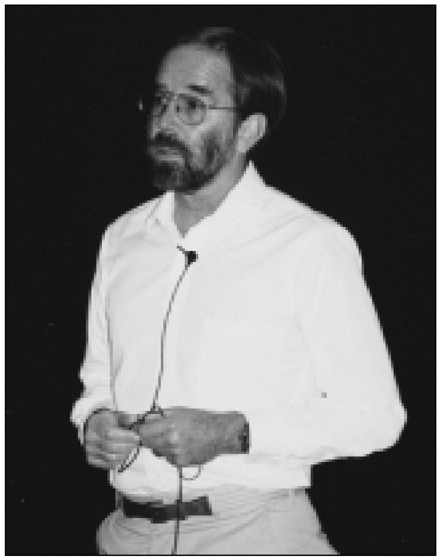
sional constructs which have been extensively utilized for materials synthesis, as models of biological systems, and in biomedical and biotechnological applications. Several papers described research on fundamental properties of lipids, such as self-assembly, structure, dynamics, mechanical properties, polymerization, and biophysical properties of lipid monolayers and bilayers. On the applications side, several contributions described developments in the utilization of lipid assemblies for materials synthesis, supported membrane sensors, controlled release, drug and gene delivery, interfacial control of tissue response, and protein crystallization.

C. Vacanti (U. Massachusetts Medical School) described developments in tissue engineering of bone in Symposium DD, Mineralization in Natural and Synthetic Biomaterials. Vacanti described his well-known work on growing cartilage in the shape of a human ear on a mouse. He also discussed a specific case where a patient whose thumb was cut deeply regained partial use by regeneration of the cartilage. He said that cartilage is different from immature bone cells that only look like cartilage. In another talk, L. Hobbs (MIT) described work on the study of the ultrastructural architecture of bone mineral using high-resolution TEM and field-emission low-voltage SEM. One of the conclusions of this study was that bone is not a mineral-reinforced fibrous matrix but rather two interwoven matrices, one serving as a template for the other. M. Glimcher (Harvard Medical School) described the structure and ultrastructure spatial distribution of apatite crystals in bone. The crystals are nanocrystals in the form of thin platelets that translate to a large surface area. Glimcher also described the mechanism of mineralization of bone.

Smart Materials

Symposium FF addressed the newly emerging field of electroactive polymers (EAPs). The major attractive characteristic of EAPs is the operational similarity to biological muscles wherein under electrical excitation, a large displacement is induced. S. Wax (DARPA) gave a keynote presentation reviewing EAP materials and described one possible application for the development of miniature robots emulating creatures such as dragonflies. R. Baughman (AlliedSignal) talked about utilizing carbon nanotubes as actuators for use as natural muscles and sensors. Baughman described actuators based on single-walled carbon nanotube sheets, which provide stress-generation capabilities equivalent to that of natural muscle and strains higher than those for high modulus ferroelectrics. Single-walled carbon nanotubes have various advantages including high modulus, strength, surface area, and conductivity. Double-layer charge injection is the mechanism used for the actuator. Baughman demonstrated actuators that work in salt water as well as simple solid-state actuators. In the following talk, Y. Bar-Cohen (JPL/Caltech) described activities to develop actuators as wipers for planetary robots using ion-exchange membrane metallic composites (IPMCs). In particular, a dust-wiper is being developed for use on the infrared camera window of a nanorover. This nanorover is scheduled as part of a joint United States-Japan program to send to a nearby asteroid. In addition, Bar-Cohen suggested a challenge to the actuator-research community to develop artificial muscles that are equivalent to natural muscles.



***Joseph Greene** (University of Illinois) presented the Turnbull Lecture. He described H-Mediation and Ultrahigh Doping in $Si_{1-x}Ge_x$ gas-source MBE and discussed atomic-level control using highly constrained growth kinetics. His talk encompassed surface science, computational materials science, and hybrid growth technologies. The ultimate goal of the work is to develop predictive quantitative models.*

Several invited talks were presented in Symposium H, Molecular Electronics. Pushing aside concerns that Moore's scaling law is hitting a wall, the major message was that the area of molecular electronics has stepped in to show the potential for building tiny devices at the nanometer scale if technologists will consider stepping away from the safe silicon haven. Silicon technology can still be scaled for another 10 years, but apparently new technologies will be needed to continue the

ACRONYM KEY

3D: three-dimensional
AFM: atomic force microscopy
ANL: Argonne National Laboratory
BST: barium strontium titanate
CWRU: Case Western Reserve University
DARPA: Defense Advanced Research Projects Agency
DOE: Department of Energy
DRAM: dynamic random-access memories
EEPROM: electrically erasable programmable read-only memory
EXAFS: extended x-ray absorption fine structure
FeRAM: ferroelectric random-access memories
FET: field-effect transistor
HP: Hewlett-Packard
HREM: high-resolution electron microscopy
HTS: high-T_c superconductor
JPL: Jet Propulsion Laboratory
JRCAT: Joint Research Center for Atom Technology
LED: light-emitting diode
LEEM: low-energy electron microscopy
LLNL: Lawrence Livermore National Laboratory
MBE: molecular-beam epitaxy
MEMS: microelectromechanical system
MIT: Massachusetts Institute of Technology
MOCVD: metalorganic chemical vapor deposition
MOS: metal oxide semiconductor
MOVPE: metalorganic vapor-phase epitaxy
NASA: National Aeronautics and Space Administration
NDE: nondestructive evaluation
NIST: National Institute of Standards and Technology
NREL: National Renewable Energy Laboratory
NSF: National Science Foundation
OLED: organic light-emitting diode
ORNL: Oak Ridge National Laboratory
PZT: lead zirconate titanate
RF: radio frequency
SBT: strontium bismuth tantalate
SEM: scanning electron microscopy
SIMS: secondary ion mass spectrometry
SMA: shape memory alloy
SNL: Sandia National Laboratories
SUNY: State University of New York
STM: scanning tunneling microscopy
TEM: transmission electron microscopy
TI: Texas Instruments
UCLA: University of California—Los Angeles
UV: ultraviolet
XRD: x-ray diffraction

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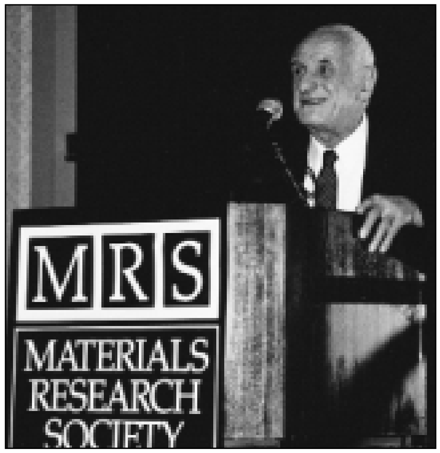
scaling after 10–15 years. R. Lytel (Sun Microsystems) described how electronic devices can be made with molecules, with the aim of 1×10 nm^2 memory cells. Researchers propose using self-assembly to build structures at the molecular level. These molecular-based structures have a large storage capacity, but are still slow, so they are good for archiving purposes, but not for logic. Lytel described the current road map of moving toward optical interconnects in 2005, highly networked machine, and then nanoRAM in 2010, and quantum cryptography in 2015. By 2020, he said that everything will be a computer.

J. Heath's (UCLA) talk on "A Defect-Tolerant Computer Architecture: Opportunities for Nanotechnology" continued the theme of molecular electronics. The aim for the future is 10^{18} operation/s at 1 W power dissipation. Silicon, he said, will run out of steam, or more precisely, it will run out of electrons, so that quantum-state switches involving single electrons will be needed. He described the molecular switch, with one molecule between two wires (in his case, silicon wires) serving as an oxidation-reduction cell. The activation barrier to ionize creates hysteresis, which allows different voltages to accomplish different tasks. One drawback of using molecules is that gain cannot be achieved (something needs to be left for silicon!).

Advanced materials and techniques for nanolithography were the subject of Symposium J. Some of the results included advanced resists based on fullerene-containing polymers (NTT, Japan; University of Birmingham, UK), novel resist concepts based on anisotropic iron oxide-PMMA nanocomposites (Ceramec, France; University of Connecticut), silicon-cage-containing PMMA (University of Connecticut), and nonconventional technologies based on nano-imprint technologies (Princeton). L. Harriott (Lucent Technologies) discussed SCALPEL projection electron-beam lithography. SCALPEL stands for SCattering with Angular Limitation Projection Electron-Beam Lithography and is a reduction-image-production technique using 100-keV electrons. Harriott described current efforts in further developing this technology. In the subsequent talk, D. Carr (Cornell) gave an overview of electron-beam lithography, including a historical perspective and the state of the art.

Symposium I focused on Self-Organized Processes in Semiconductor Alloys, with sessions relating to spontaneous ordering, spontaneous composition modulation, quantum dots, and Ge-Si islanding phenomena. A. Norman (NREL) presented results for the spontaneous formation of lateral quantum wires in short-period superlattice structures of InAs/AlAs. A special session was held on *in situ* real-time studies of growth-induced instabilities, including talks on *in situ* LEEM, x-ray, synchrotron, and optical studies.



*The prestigious Von Hippel award was presented to **Richard Stein** (University of Massachusetts) for his lifetime work in research and education in the field of polymers. In his award talk, Stein presented his work using light scattering to study the structure of polymers. He described various aspects of crystallization in polymers and described how light scattering was used to study polymer-crystal structure. He discussed models describing scattering from spheres that can be related to scattering from polymer-crystal spherulites. Stein also described other techniques for studying crystallization and discussed x-ray diffraction.*

Third in a series, Symposium PP addressed materials for optical limiting. Presentations covered several new materials including new porphyrins, phthalocyanines, dendrimers, fullerenes, and composite materials, especially those based on polymer-dispersed liquid crystals.

Symposium LL on smart materials was the third in a series of such MRS symposia. Among the highlights, B. Koc (Pennsylvania State) and K. Uchino (Pennsylvania State) reported a promising application for a disk-type piezoelectric transformer, which utilized a circular piezoceramic with an asymmetrical electrode configuration. Compared with the conventional rectangular shape, this design realized higher voltage step-up ratio and efficiency. Y. Furuya (Hirosaki University, Japan) introduced the method of electromagnetic nozzleless melt-spinning to manufacture rapid-solidified shape memory alloys (SMAs). This method could improve the characteristics in a high-temperature SMA Ru-Ta, and a ferromagnetic SMA.

Theory and Modeling

Symposium A addressed Multiscale Phenomena in Materials, the theme of which was the phenomena involving properties at different length scales. For example, several presentations discussed elementary properties of dislocations investigated simultaneously using TEM and simulations. Comparisons were also made between different types of numerical approaches, such as molecular-dynamics and dislocation-dynamics simulations, allowing for the possibility of transferring results and extrapolating from one length scale to another.

Papers in Symposium B discussed the use of computational approaches to predicting optical properties of materials. Several theoretical methods that are currently used were described, such as applications of time-dependent density-functional theory and implementations of the Bethe-Salpeter method to calculate spectra of optical constants. Concurrently, trends in experimental studies of optical properties of condensed-matter systems, including solids, clusters, and new materials, were also reported.

Symposium C addressed Microstructural Modeling for Industrial Metals Processing. The central theme was the maturity of finite-element methods for modeling engineering processes and the integration of fundamental physical metallurgy for industrial process predictions. Various processes were covered, including solidification processes, nucleation, deformation and texture, and phase transformations.

Nucleation and growth processes in materials were specifically covered in Symposium E. The Symposium brought together researchers working on various aspects of nonequilibrium processes in materials to discuss current research issues and provide guidelines for future work. As an example, several presentations emphasized particle nucleation and growth, including solid-state reactions, nanosystems, liquid-solid transformations, and solidification and amorphization.

Thin-Film Technology

Symposium K on Thermal-Spray Materials Synthesis featured an Honorary Symposium for Herbert Herman, director of the Center for Thermal-Spray Research, an NSF Materials Research Science Engineering Center at SUNY—Stony Brook, for 15 years as Editor-in-Chief of *Materials Science and Engineering*, and Leading Professor of the Department of Materials Science and Engineering in the area of spray-coating formation and evaluation. In his opening remarks, P. Fauchais (Univer-

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sité de Limoges, France) particularly noted Herman's pioneering role in bringing science into thermal-spray coatings through his work on process control, feedstock-material chemistries, particle characteristics, coating characterization according to the process, and standardization.

Highlights of this Symposium included C.C. Berndt's (SUNY—Stony Brook) report that coatings made by spraying nanopowders of partially stabilized zirconia (PSZ) and alumina (Al_2O_3) exhibit improved mechanical and thermal properties, and that the PSZ coatings contain only the nontransformable tetragonal phase of zirconia (ZrO_2). Cold spraying, so the nanostructured phase is not melted, apparently is the "secret." R.A. Neiser (SNL) discussed the cold-spray process for depositing metal and composite powders at close to room temperature. It was found that at low velocities (~250 m/s), the particles tended to bounce off the substrate surface, but as the velocity was increased to ~900 m/s, they stuck, and very high deposition efficiencies could be obtained. There exists a minimum velocity, the critical velocity (V_{crit}) for deposition, that can be used, along with the spread of the particle velocities around the mean, to calculate the deposition curve. At SNL, the factors influencing V_{crit} for metal-metal deposition are being investigated. One finding is that the oxygen content of cold-sprayed Cu is essentially the same as the initial powder (0.3 wt.%), and the thermal conductivity of the coating (317 W/m K) is very high compared with conventionally sprayed Cu. Another is that the hardness of the powder has the largest influence on V_{crit} (need to increase velocity with increasing hardness), but the hardness of the substrate has no effect.

F. Jansen (Sulzer Innotec Ltd.) described the thermal-shock resistance, thermal-insulation efficiency, and corrosion resistance of thermally sprayed dicalcium silicate (Ca_2SiO_4) coatings as comparable to yttria-stabilized zirconia coatings, and promising as thermal-barrier coatings up to 900°C. The potential of high-velocity oxygen-flame-sprayed barium titanate ($BaTiO_3$), alumina (Al_2O_3), and magnesium aluminate ($MgAl_2O_4$) as dielectric layers with functional properties for electronic components was reported by A. Dent (SUNY—Stony Brook). A number of materials-characterization techniques (SEM, TEM, XRD) were used to investigate phase transformations occurring within these materials as a consequence of thermal spraying. The advantages of thermal spray are that it is a quick and easy way to coat large areas, and it is a high-throughput technology.

On Sunday evening, students took the opportunity to meet one another and other MRS members at the Student Mixer.

S. Sampath (SUNY—Stony Brook) closed the Symposium by noting that Herman's legacy was to develop an integrated approach to thermal spray, to establish some fundamental relationships at each stage with the objective of developing correlations between the intrinsic physics and the processing conditions. The goal is optimizing the process to produce the desired microstructures for the coating design and performance.

Symposium N focused on recent advances in atomic-scale measurements and modeling of epitaxial growth and lithography, and emphasized the mutual synergy between experiments and theory. The experimental talks covered scanning probe microscopy and advances in plan-view and cross-sectional STM techniques. Theory talks were primarily divided between kinetic Monte Carlo simulations of growth and *ab initio* calculations of basic surface properties. A joint session was also held with Symposium I on real-time *in situ* studies of 3D islanding.

Materials Characterization

The subject of most papers presented in Symposium P was the characterization by optical techniques of semiconductors, bulk and heterostructured materials, and devices. Besides the widely used luminescence techniques with a continuous trend toward higher spatial resolution, the increasing capabilities of near-field techniques and Raman spectroscopy were demonstrated in the Symposium. As an example, Domnich et al. (Illinois) combined Raman spectroscopy and indentation to study pressure-induced phase transformations and amorphization in semiconductors (SiC, GaAs, InSb, diamond), providing a powerful and fast tool for *in situ* monitoring of transformations.

Advances in materials problem-solving using the electron microscope were the focus of Symposium Q. A broad spectrum of techniques and applications to materials problems were covered, ranging from low-energy electron microscopy (spin-polarized and energy-filtered) to quantitative high-resolution electron microscopy based on computerized focal-series restoration. Other significant advances included the characterization of magnetic materials and techniques for quantitative microanalysis, which are now reaching a sensitivity that allows segregation at interfaces to be detected down to a fraction of a monolayer. Reports also indicated that field-emission instruments now provide energy-loss spectra with sub-nanometer spatial resolution, allowing near-edge fine structure analysis to probe bonding at defects and interfaces.

Applications of synchrotron radiation techniques were covered within Symposium R. Experimental techniques covered included extended x-ray absorption fine structure, synchrotron x-ray microdiffraction, x-ray scattering techniques, and microtomography. Materials systems studied included mixed metal fluorides, mixed metal oxide catalysts, and metal ion com-

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plexes. In one example, high-resolution angle-resolved photoemission spectroscopy was used to study the temperature dependency of thermoelectric materials. D.J. Jensen (Risø National Laboratory, Denmark) and her colleagues used 3D x-ray microscopy to investigate plastic deformation, re-crystallization, and internal stresses.

Symposium S covered various nondestructive methods (NDE) for materials characterization. The various presentations covered a number of NDE techniques, including x-ray techniques for process control and deformation behavior in high- and low-density materials, and linear and nonlinear acoustics for characterizing fracture, fatigue, and corrosion behavior of aging aircraft materials. Studies were also reported on structure-sensitive properties in magnetic materials and building materials gauged using NDE techniques.

Continuing Topics

Low-energy beam modified surface growth and processing was covered in Symposium L. The beneficial effects of low-energy ion bombardment in the growth of compound semiconductors GaN and GaAs were demonstrated using synchrotron x-ray scattering, electron microscopy, and AFM. The interplay of surface thermodynamics and kinetics in the nanoscale regime was demonstrated with the deposition and subsequent burial of Co nanoparticles on Cu substrates. The presentations indicated the complementary roles played by experiments and theory/simulations. The Symposium was dedicated to the memory of Barbara Cooper, who made seminal contributions to the field of low-energy ion-surface interactions.

Substrate Engineering—Paving the Way to Epitaxy was the topic of Symposium O. A substrate is the base material on which all other fabrication (epitaxial layers or devices, for example) is done, or, a substrate is everything below the devices. The principal issue discussed was the understanding of defect generation in the substrate and avoiding defect propagation into the device region. A number of papers focused on defects in silicon, gallium arsenide, sapphire, and titanates. Papers were also presented on the avoidance or control of defects due to interfacial lattice mismatch between an epitaxially grown thin film and a different base substrate material.

Structure and electronic properties of ultrathin dielectric films on silicon and related structures was the topic of Symposium T. Among the highlights, S. Tamasaki (JRCAT, Japan) reported observation of *in situ* electron spin resonance during initial stages of oxidation of {111} silicon surfaces, D.J. DiMaria (IBM) gave a unified model for degradation in MOS transistors with ultrathin SiO_2 gates, R. Tsu (UNC—Charlotte) presented a paper on a highly efficient electroluminescent device that consists of repeated cells of nine layers of crystalline silicon and one submonolayer of a silicon oxide, and J.-L. Cantin (CNRS—France) reported that treatment of the (100) Si-SiO_2 interface with NO reduced the density of spin-active interface defects below the detection limit after vacuum anneals that have been shown to dissociate any Si–H bonds at the interface (the first report of removal of P_b defects without the use of oxygen).

Due to the growing number of presentations and attendees at MRS Meetings, the 1999 MRS Fall Meeting was held for the first time in the Hynes Convention Center in Boston.

Symposium U highlighted recent developments in amorphous and nanostructured carbon. Some of the themes covered included nanotube growth mechanisms, energy storage in nanotubes and nanoporous carbon, vacuum microelectronics using nanotubes and amorphous carbon, and new measurement techniques for amorphous carbon. Insights into nanotube synthesis were reported by D. Geohegan (ORNL) and M. Yadusaka (NEC, Japan). Both groups used *in situ* optical probes to spatially and temporally image the carbon condensation and nanotube formation process in the vapor phase. W. Zhu (Lucent Technologies) demonstrated that carbon nanotubes can support extraordinarily high current densities, which could result in new applications such as compact, high-power microwave amplifiers.

Thin Films: Stresses and Mechanical Properties was the subject of Symposium V, eighth in a series. Highlights included a demonstration by M.R. Stoudt (NIST) of the superiority of multilayer coatings to the common hard coatings used to improve fatigue resistance of bulk metals, a technique by A. Pundt (Universität Göettingen, Germany) for applying compressive stresses at ambient temperature by loading with hydrogen, and a new design for an on-chip tensile or bend test by T.A. Saif (Illinois—Urbana).

Symposium W covered GaN and related alloys, continuing the symposium series. Progress in lasers included reports of commercialization by Nichia Chemical of a laser operating at a 405-nm wavelength with a 4000-h device lifetime. Improvements in the epitaxy of GaN were discussed, using both selective-area growth techniques (lateral epitaxial overgrowth) and introduction of low-temperature intralayers in the films. Advances in both MBE and MOVPE were reported, including several studies of quantum-dot

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formation in strained alloys. Hydride vapor-phase epitaxy continues to show improvements, particularly for providing very thick films.

Symposium Y on Ferroelectric Thin Films covered a broad spectrum of fundamental and applied topics, including further development of memory devices and significant progress in the areas of materials integration and property characterization, especially ferroelectric domain structure and piezoelectric response. The material systems that continue to receive the most attention are perovskite compounds, lead zirconate titanate (PZT) and barium strontium titanate, and the layered perovskite compound strontium bismuth tantalate (SBT). Advances in the area of FeRAM were demonstrated in a presentation by T. Moise (TI), where the development of embedded ferroelectric random-access memories that may be fabricated through a minimal number of additional mask sets was discussed. A number of presentations focused on the electrical effects and kinetics of hydrogen doping on BST and PZT thin films, since fabrication of DRAM and FeRAM devices requires annealing in hydrogen-containing process ambients. Progress in the understanding of piezoelectric effects in PZT thin films was also reported by several researchers. S. Trolier-McKinstry (Pennsylvania State)

Panelists and Attendees Discuss Alternative Careers: Publishing, Public Policy, and Business Consulting

For materials scientists looking for a 37.5-h work week, sign up for a career in publishing. Such would be the answer based on Daniel T. Kulp's experience as he described his work as senior editor of Rapid Communications in *Physical Review B* during the Alternative Careers in Science panel discussion. As expected, Kulp utilizes his PhD degree in materials science and engineering as he prescreens manuscript submissions, selects referees, and decides on publishability of articles. The highlight of his work, though, seems to be that he works hard during his 37.5 h/week to process as many manuscripts as possible, and then he is done for the week. Unlike Kulp's experience, Betsy Fleischer, editor of *MRS Bulletin*, is responsible for publishing a particular set of articles within a given issue and must work in the office until the articles are prepared in order to meet the production schedule. Michal Freedhoff, a member of the professional Democratic staff in the House Science Committee in Washington, DC, Kelly Kirkpatrick, senior policy analyst in the White House Office of Science and Technology Policy (OSTP), and Linda Meloro, management consultant for PricewaterhouseCoopers, all described exciting careers in which their hours are not their own.

Freedhoff handles legislation relating to and oversight of the Department of Energy in regard to security at national laboratories, technology transfer, solar and renewable energy, and energy research and development. At OSTP, Kirkpatrick's functions include providing authoritative advice in the analysis, development, advocacy, and implementation of Presidential S&T policy; assisting in identifying policy issues and problems requiring the Technology Division's attention; suggesting the outline, scope, schedule, and appropriate staffing for studies; and assisting in coordinating the work of the Technology Division with that of OSTP's other divisions and Presidential agencies. As a consultant, Meloro specializes in supply-chain management for high-tech companies.

The number of hours put into a job is not the only criteron scientists look toward when deciding whether an alternative career in science is for them. The audience asked the panelists questions ranging from salary and required degrees, to the use of headhunters in obtaining a job, to issues involved when transitioning from a traditional path in science to an alternative one.

The panelists said that headhunters are good for the industrial route, but not for the nontraditional route. Editors may get their job leads from announcements in trade magazines, and public-policy opportunities can be gained from congressional fellowships such as those supported by the Materials Research Society/Optical Society of America and by the American Association for the Advancement of Science (AAAS). Various editorial jobs require either a masters or PhD degree in science. The panelists in public policy recommend a PhD degree for the sake of leverage and credibility in their type of work.

In her work as a consultant, Meloro finds her MBA degree a critical supplement to her science degree. She recommends that scientists advance from a BS to a Masters' degree immediately, though, because many people find it difficult to return to school for an advanced degree. The other panelists saw no need for an alternative degree; they learn non-scientific functions "on the job." Fleischer and the panelists in public policy described a wholistic approach to work in their environments. In public policy, scientists work with lawyers as a team to write legislation. In publishing, science editors work with colleagues with various degrees who are all needed to produce the journal.

In their transition from a traditional career to an alternative one, most of the panelists found no difference in the time required or in their family relationships, and they basically received support from other family members during their transition. In her type of work, Fleischer said an editor must choose the job for the love of the work. Freedhoff and Kirkpatrick also said one must "love being on the Hill" to make a career in public policy. The average salary for a legal assistant is \$32k in the House and \$38k in the Senate. Some staffers work 1–2 years, then become highly employable as independent consultants. In her field as a consultant, Meloro said one must put in a lot of traveling and hours of work and can receive good pay. Kulp said that the tradeoff for a 37.5-h work week is a low salary (in terms of scientists' salary range) in a not-for-profit organization.

Asked whether they would want to return to research, none of the panelists desired to go back full-time. Kulp said that some editors do research simultaneously, and Fleischer said that she would enjoy a one-month sabbatical. Statistics from AAAS media fellows show that about 50% stay in media fields, while the rest return to research. Meloro said that rather than return to research, consultants tend to initiate startup companies.

Brian Holloway, a professor at the College of William and Mary, moderated the session. Holloway served as the 1997–1998 MRS/OSA Congressional Science and Engineering Fellow. He worked with Senator John Rockefeller IV, (D-WV).

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Symposium X Provides Topical Reviews for the Nonspecialist

M.A. Reed (Yale) opened Symposium X, Frontiers of Materials Research for the Nonspecialist, on Monday with a discussion on prospects for molecular-scale electronics using molecular self-assembly. He suggested that contacts are the main problem with new device technology, (which is always solved by alchemy!), and switching for molecular electronic devices cannot be FET-like. He also said that for molecular electronics to launch, due to the self-assembling characteristic and the complexity, circuit implementation must change dramatically.

J.W. Perry (Arizona) described applications of two-photon-absorbing materials in 3D technologies. The molecular excitation of a molecule by the simultaneous absorption of two photons is a very useful phenomenon. Two-photon absorption induces various effects, including energy transfer, charge transfer, light emission, and photochemistry. These impact a wide range of applications, including 3D microfabrication, 3D optical memories, and biomedical applications.

R. Jones' (Sheffield) talk on the "Materials Science of Food" introduced the topic for Symposium AA. He demonstrated the applicability of materials-science concepts by giving three examples. Regarding phase separation, the Cahn-Hilliard theory of spinodal decomposition can be applied to mixtures of food such as in desserts. The transport of water in low-water starch systems such as wafers and biscuits are dictated by the glass transition of these systems. Jones also discussed protein adsorption at interfaces, thereby affecting stabilization of colloids.

M. Mrksich (Chicago) described engineering the surfaces of materials for controlling cell adhesion, which depends on protein adsorption. T. Sakuma (Tokyo) assessed the status of superplasticity. He emphasized the need to develop microscopic or atomistic analysis on grain-boundary sliding or grain-boundary failure as well as past mesoscopic analysis of flow stress against strain-rate relationship for future research. Currently engineering application of superplastic forming or joining processes is limited mainly in Al alloys. P.K. Hansma (UCSB) closed Symposium X with a review of single-molecule biomechanics and its implications for materials science.

reported on the use of UV-exposure-induced imprint technique to reduce aging effects in the piezoelectric response of the films, and P. Muralt (Swiss Federal Institute of Technology) highlighted recent results on the effects of film crystallographic orientation on piezoelectric response.

Symposium Z focused on thin films for photonic applications. A. Himeno (NTT) and J. Kenney (Lightwave Microsystems) described wavelength division multiplexing (WDM) devices that provide wavelength separation previously achieved only by high-resolution spectrometers. A 1×128 array-waveguide grating multi/demultiplexer was reported. Polymeric materials are being developed both as waveguides and active devices and were reported by H. Katz (Bell Labs, Lucent Technologies). A novel flat-panel display that uses a polymer waveguide array was reported by H. Lackritz (Gemfire Corporation).

The presentations in Symposium GG covered various aspects of transport properties and microstructure of cement-based materials. The talks on microstructure discussed the fractal nucleation aspects of cement hydration and hydrated-phase formation, and used neutron scattering to probe the structure of the calcium-silicate-hydrate phase, which is the nanoscale glue that holds the majority of cement-based materials together. Several talks focused on the corrosion initiation of steel-reinforced concrete as a function of the chloride penetration rate and other microstructural factors. The role of water movement in the freeze-thaw attack, in fire performance of high-density concrete, and in the repair of historic structures was also discussed.

Symposium HH covered various aspects of superplasticity and understanding, developing, and utilizing the high ductilities of these materials. Several talks discussed ultrafine grain sizes, in the sub-micrometer or nanometer range, which have been shown to be capable of achieving superplastic forming operations at a much faster rate than previously attained. Z. Horita (Kyushu University, Japan) and P.B. Prangnell (Manchester Materials Science Centre, UK) provided detailed descriptions of the procedures for obtaining substantial grain refinement using the process of equal-channel angular pressing in which a material is subjected to a very intense plastic strain without any changes in the cross-sectional dimensions of the sample.

Superconducting materials were the focus of Symposium II, covering crystal chemistry, properties, and key processing issues of bulk materials and films of both conventional and HTSs. Considerable progress was reported in the development of second-generation HTS wires based on YBaCuO-coated conductors. A joint session with Symposia L and O reviewed the development of flexible, biaxially textured substrates, which are required for this application. Several speakers addressed the strong dependence of HTS transport properties on atomic-scale defects, including defects associated with grain boundaries. The emerging consensus is that the low-angle boundaries produced in coated conductor technology will enable transport properties at near-intrinsic performance levels. In late-breaking news, American Superconductor Corporation reported the achievement of high J_c values for YBCO-coated conductors on rolling-assisted biaxially textured substrates, whereby the epitaxial YBCO coating was produced through an economic solution-based process.

Magnetoresistive oxides and related materials were covered in Symposium JJ. Highlights included several reports on phase separation in manganites. Strong experimental evidence for phase separation in $La_{0.7}Ca_{0.3}MnO_3$ came from J. Aarts (University Leiden, The Netherlands), who presented STM results showing spatially inhomogeneous conductivity. As a counter-argument, R. Matzdorf (Tennessee and ORNL) presented detailed evidence of surface reconstruction in another family of compounds, the layered transition-metal oxides, which showed that the surface is certainly not representative of the bulk properties of these materials. Technologically, researchers are still struggling to make magnetoresistive tunnel junctions operable at room temperature. Apparently, one of the most successful uses of the perovskite manganites will be as bolometers. This was demonstrated in several papers that showed significant advantages and improvements over existing vanadium oxide technology in terms of achievable performance of uncooled, infrared imaging arrays.

The papers in Symposium KK addressed a range of issues concerning tunable RF and microwave devices, including electric-field and magnetic-field tuning, devices and materials, fundamentals, and characterization. G. Dionne (MIT Lincoln Laboratory) gave an overview of ferrites that are used in magnetic-field tuned devices. He discussed the basic material structure and how alterations can be made to obtain particular characteristics such as those needed for operation at low temperatures in high-Q devices, where Q stands for "quality factor"; the higher the quality factor, the lower the loss. L.E. Cross (Penn State) gave a comprehensive overview of the materials issues in electric-field tunable dielectrics. It covered different materials systems from titanates to pyrochlores, from single crystals to artificial multilayers, and from the soft-mode behaviors to dielectric relaxation. J. Levy (Pittsburgh) used local optical probes to measure the polarizations in BST thin films and found local polar regions with high dielectric loss. The likely cause of these regions are oxygen vacancies due to processing, impurities, or cation nonstoichiometry.

Various materials-science aspects of MEMS were covered in Symposium MM. Silicon fracture and stress issues, as well as their relationship to materials processing, received a great deal of attention. In the area of new materials, J. Schweitz (Uppsala University, Sweden) revealed a laser focusing tool to fabricate arbitrary MEMS geometries in diamond. T. Friedman (SNL) demonstrated a stress- and stiction-free amorphous diamond with very high elastic modulus and low surface roughness for MEMS applications. J. Sniegowski (SNL) described a 3D photonic lattice fabricated by MEMS processing techniques, which may lead to Si-based photonic crystal devices that are compatible with well-developed Si microelectronics. S. Mani (SNL) showed that a selective tungsten coating improves wear resistance of MEMS parts by more than three orders of magnitude. In MEMS metrology, D. Freeman (MIT) spoke about an optical characterization tool with nm resolution in 3D.

Symposium NN focused on the role chemistry is currently playing in the development of new materials used in the electronics industry. A range of chemical processing techniques was discussed, including the deposition of thin metal oxide and nitride films by MOCVD and sol-gel, metalorganic decomposition, chemical bath deposition, and hydrothermal processing. Materials covered in the Symposium included high-dielectric-constant and ferroelectric oxides, low-dielectric-constant materials, and metal nitride diffusion barriers.

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

*In his award talk, MRS Medalist **M. George Craford** provided an overview of the field of visible LEDs during Symposium X. Significant improvements in brightness (Lumens per watt) have been obtained over the past decade for AlInGaP and AlInGaN LEDs such that outdoor applications have now become possible. Current applications include traffic signals, automobile external lighting, signs, runway lighting at airfields and various signs.*

Experiment and Modeling Form Links Across Length Scales

(See MRS Proceedings Volume 578)

An emerging theme in materials research is the phenomena involving properties at different length scales as reflected in Symposium A, Multiscale Phenomena in Materials—Experiments and Modeling. Such phenomena are complex and cannot easily be dealt with theoretically. Therefore, a cooperative experimental and modeling approach has been developed. Though this combined approach is not new, there is renewed interest as simulations are frequently being substituted for actual experiments.

Several sessions of this Symposium focused on plasticity or related problems like fracture and crack propagation. Considering the high quality and novelty of the papers presented, these studies are clearly getting into a new and successful phase of investigation. At the microscopic scale, the elementary properties of dislocations (like core reactions) are now investigated simultaneously by TEM observations and by simulations. In addition, different types of numerical approaches, like molecular-dynamics and dislocation-dynamics simulations, can now be compared. This provides the possibility of transferring results from the discrete atomic level to higher levels. At the mesoscopic and macroscopic scales, the emphasis was on the possibility of including length scales in the continuum mechanical framework, either through a coupling between dislocation dynamics and finite-element codes or by using strain-gradient methods.

Several presentations showed that experiments performed in a systematic manner can be useful in providing quantitative input for simulations and allow accounting for microstructures in a realistic manner (e.g., the coupling of orientation image mapping with grain-growth phenomena and their simulation by finite-element methods). The Symposium demonstrated the need for a combined experimental and modeling approach, highlighted some of the tremendous progress that has been made, and provided glimpses of what lies ahead in this exciting field.

Symposium Support: LLNL.

Optical Properties Illuminated through Computational Approaches

(See MRS Proceedings Volume 579)

Computational Approaches to Predicting the Optical Properties of Materials, Symposium B, are at a stage of rapid development. Because a quantitative description of the optical properties of materials depends on both ground-state and excited-state properties, progress has been slower here than in other areas. However, recent advances in computational resources and algorithmic developments have dramatically altered this situation. The Symposium focused on new techniques to predict and understand the optical and dielectric properties of materials. It also incorporated recent experimental developments.

One of the dominant themes covered current trends in experimental studies of optical properties of condensed-matter systems, including solids, clusters, and new materials. Another theme involved innovations in theoretical modeling and predictions of optical properties. New numerical developments include the ability to treat large systems (e.g., ~1000-atom clusters) using recently developed algorithms and advanced computer platforms. New theoretical methods included applications of time-dependent density-functional theory and implementations of the Bethe-Salpeter method to calculate spectra of optical constants (n and k) that include excitonic effects. These recent innovations have greatly enhanced the variety of systems that can be studied and the potential quality of theoretical optical spectra. A third theme involved considering the properties of materials under extreme conditions, such as very high temperatures (achieved by laser irradiation), large magnetic fields, and high pressures (achieved in diamond-anvil-cell experiments).

Symposium Support: SGI.

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Poster Prizes Awarded at the 1999 MRS Fall Meeting

The 1999 MRS Fall Meeting chairs Paul D. Bristowe (Cambridge University), David G. Grier (University of Chicago), Fernando A. Ponce (Arizona State University), and Ellen D. Williams (University of Maryland) 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. Posters awarded prizes and their authors were **A Model for Calculating Substrate Curvature During Coalescence of Pt Islands on an Amorphous Substrate**, M.A. Phillips, V. Ramaswamy, B.M. Clemens, and W.D. Nix (Stanford University) (A.3.6); **Tight-Binding Molecular-Dynamics Modeling of Impurity Atom-Grain Boundary Interaction in Diamond**, M. Sternberg, T. Frauenheim, P. Zapol, L.A. Curtiss, D.M. Gruen (University of Paderborn, Germany, and Argonne National Laboratory) (A9.1); **Nano-Photoluminescence Studies of Self-Assembled Quantum Dots**, H. Htoon, H. Yu, D. Kulik, J. Keto, C.K. Shih, O. Baklenov, and A.L. Holmes, Jr. (University of Texas—Austin) (I7.27); ***Ab Initio* Study of the Local Bonding at Metal-Ceramic Heterophase Boundaries**, C. Elsaesser (Max-Planck-Institut für Metallforshung) (M3.1); **Raman Microprobe Analysis of Selected Semiconductors Subject to Contact Loading**, V. Domnich and Yu. Gogotsi (University of Illinois—Chicago) (P8.8); **Microstructural Evolution in Copper Films Undergoing Laser Pulsing at High Pressures**, R. Jakkaraju, C.D. Dobson, and A.L. Greer (University of Cambridge) (V4.11); ***In Situ* Characterization of Stress Development and Relaxation of Gelatin Film During Controlled Drying**, M. Lu, S.-Y. Tam, R. Schunk, and C.J. Brinker (University of New Mexico and Sandia National Laboratories) (V10.9); **Deposition of Zinc-Blende AlN Films on Si(100) and MgO(100) Substrates**, M.P. Thompson, G.W. Auner, A.R. Drews, T.S. Zheleva, and K.A. Jones (Wayne State University, Ford Motor Co., and U.S. Army Research Laboratory) (W3.38); **Low-Frequency Noise in AlGaN/GaN Heterostructures on SiC and Sapphire Substrates**, N. Pala, R. Gaska, M. Shur, J.W. Yang, and M. Asif Khan (Rensselaer Polytechnic Institute and the University of South Carolina) (W11.9); **Optical Properties of AlGaN Quantum-Well Structures**, H. Hirayama, Y. Enomoto, A. Kinoshita, A. Hirata, and Y. Aoyagi (RIKEN and Waseda University) (W11.35); **Orientation and Composition Dependence of Piezoelectric Dielectric Properties of Sputtered $Pb(Zr_x,Ti_{1-x})O_3$ Thin Films**, S. Heboux, P. Muralt, and N. Setter (Federal Institute of Technology, Lausanne) (Y14.2); **Self-Assembled Beta-Sheet Architectures for Bone Tissue Engineering**, G. Spreitzer, J. Doctor, and D. Wright (Duquesne University) (DD5.16); **Peizoelectric and Mechanical Properties of Human and Bovine Cornea**, A.C. Jayasuriya, J.I. Scheinbeim, V. Lubkin, and G. Bennett (Rutgers University and New York Eye and Ear Infirmary) (FF3.1); **Local and Long-Term Structural Changes in the $ND_{1+x}BA_{2-x}CU_3OZ$ HTSC System**, E.A. Goodilin, I.S. Bezverkhiy, Yu.D. Tretyakov, V.V. Petrykin, M. Kakihana, and J. Hester (Moscow State University, Tokyo Institute of Technology, and Australian National Beamline Facility) (II3.17); **Disk-Type Piezoelectric Transformer Design Employing High-Power Piezoelectric Ceramic Material**, B. Koc, Y. Gao, and K. Uchino (Pennsylvania State University) (LL5.8); **Behavior of Actinide Ions during Sludge Washing of Alkaline Radioactive Wastes**, A.H. Bond, K.L. Nash, M.P. Jensen, J.C. Sullivan, and L. Rao, (Argonne National Laboratory and Lawrence Berkeley National Laboratory) (QQ15.2).

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Advances in Modeling Raise the Profile of Industrial Metals Processing

Symposium C, Microstructural Modeling for Industrial Metals Processing, was a new venture for MRS, reflecting the rapid recent expansion in process modeling. A central theme was that finite-element methods are well advanced for modeling processes at the engineering level, and the field is wide open to integrate fundamental physical metallurgy with industrial process prediction.

In solidification processes, covering casting and welding, the papers demonstrated that modeling of grain structure and size provides insight at all levels from simple modifications, to classical theories, to coupled simulations using FE methods with embedded cellular automata (CA). Nucleation remains the most difficult issue. The essential role of modeling in developing novel processing techniques (thixotropic forming and sintering) was also illustrated.

Most papers fell in the area of deformation and texture, where substantial growth and synergy were reported between computational approaches and new experimental tools such as electron back-scatter diffraction. Yield and anisotropy continue to dominate, but increasingly, modelers and experimentalists are linking deformation to annealing by making more detailed interpretation of deformation microstructure at the level of subgrains, and distributions of misorientation. CA methods were also described, in a novel attempt to transfer the success with this technique from casting to recrystallization.

The final series of papers illustrated good progress in modeling phase transformations in steels and aluminum alloys during real industrial thermal histories, particularly by exploiting the internal-state-variable method.

Dynamics of Nonequilibrium Processing Feeds into Alloy Design

(See MRS Proceedings Volume 580)

One of the goals of materials science is to design alloys with pre-specified desirable technological properties. To achieve this goal, a thorough understanding of the fundamental mechanisms underlying materials behavior is necessary. In addition to the equilibrium-phase information contained in phase diagrams, nonequilibrium dynamic processes and metastable phases are known to be crucial in determining materials properties. Symposium E brought together researchers working on various aspects of nonequilibrium processes in materials to discuss current research issues and to provide guidelines for future work. Diffusion-controlled nucleation and growth processes and martensitic and other transformations, such as amorphization, often involving metastable phases that are known to affect long-term phase and microstructural stability, were presented and discussed. As exemplified by several presentations, particular attention was paid to understanding particle nucleation and growth both experimentally and theoretically, solid-state reactions, nanosystems, liquid-solid transformations, and solidification and amorphization. On the theoretical side, fundamental principles governing nucleation and growth, and related phenomena such as coarsening and Ostwald ripening were discussed, and progress was reported on the use of the phase-field method and on Monte Carlo simulations.

Symposium Support: LLNL.

Processing of Nanomaterials Addressed

(See MRS Proceedings Volume 581)

The third in this series of Symposia F on Nanophase and Nanocomposite Materials was a mix of new research and reviews of research from the last decade. The week began with a review presentation by R. Roy (Pennsylvania State) which focused on the commercialization of nanocomposite materials over the past several years. Roy attributed the modest success to issues surrounding the processing of nanomaterials and the marginal improvements offered over conventional systems. One of the more inspiring presentations, by I.-W. Chen (Pennsylvania State), touched on the processing issues that can be overcome using traditional methods developed in the glass industry. He showed that fully dense nanograined systems can be processed using a simple sintering profile. In the applications section, highlights included a novel method for forming robust, highly reflective mirrors and the development of decidedly effective environmental sensors using nanomaterials. The Symposium also featured two poster sessions that drew a noteworthy attendance, and the week closed with a day of presentations on modeling and simulation.

Symposium Support: ONR.

Molecules, Nanotubes, and Nanoparticles Give New Spark to Electronics Scaling

(See MRS Proceedings Volume 582)

Some highlights of Symposium H on Molecular Electronics were projections of the role of molecular electronics in future computing systems and new results, both experimental and theoretical, along several frontiers. The most active areas are (1) synthesis of organic molecules that are then attached to electrodes by self-assembly, (2) carbon nanotubes that are used to fabricate device structures, and (3) semiconductor nanoparticles. The current-voltage characteristics obtained from several structures show enormous promise for useful functional devices. Theoretical calculations showed that they can probe in detail the role of individual atoms at the electrode-molecule contacts and can simulate both two-terminal and three-terminal devices. Many of the papers reported diverse techniques of fabrication and measurement that build a substantive infrastructure and bode well for this emerging field.

Symposium Support: ONR.

Epitaxial Growth Instabilities Lead to Compositional Modulation, Quantum Dots, and Islanding

(See MRS Proceedings Volume 583)

The focus of Symposium I on Self-Organized Processes in Semiconductor Alloys was epitaxial-growth-induced instabilities. Sessions dealt with spontaneous ordering in semiconductor alloys, spontaneous composition modulations, quantum dots, and Ge-Si islanding phenomena. A. Norman (NREL) presented exciting results for the spontaneous formation of lateral quantum wires in short-period superlattice structures of InAs/AlAs. The highlights of the Symposium included (1) a special session on *in situ* real-time studies of growth-induced instabilities, where there were talks presented on *in situ* LEEM studies, *in situ* x-ray studies, *in situ* synchrotron radiation studies, and *in situ* optical studies; and (2) the David Turnbull Award Lecture, presented by Joseph Greene. Two graduate students from this Symposium received the MRS Graduate Student Award: J. Zhang (Gold Award) and X. Liao (Silver Award).

Symposium Support: ARO and NREL.

New Polymer Resists Spur Lithography Below 100 nm

(See MRS Proceedings Volume 584)

Organized for the first time in the framework of MRS and preceded by a tutorial, Symposium J on next-generation lithographic processes for integrated circuits with sub-100-nm resolution focused on the techniques and materials advances necessary for satisfying the Semiconductor Industry Association road map. Significant contributions from LLNL, Lucent Technologies, MIT, and Fraunhofer Institut (Berlin, Germany) have shown that x-ray, electron-beam, and ion-beam lithog raphies are all intrinsically capable of achieving sub-100-nm resolution. Yet the fundamental radiation-polymer interactions appear to set the resolution limit for most of the lithographies, thus calling for novel resists. Advanced resists based on fullerene-containing polymers (NTT, Japan; Birmingham, UK) as well as novel resist concepts based on anisotropic iron oxide-PMMA nanocomposites (Ceramec, France; and Connecticut) or silicon-cage-containing PMMA (Connecticut) have been presented. Nonconventional lithographies (Harvard and Princeton) based on nanoimprint technologies have attracted a lot of attention. The specificity of this Symposium has been to gather experts in microelectronics, polymer synthesis, and materials-research science who usually do not interact and thus to explore new research avenues.

Symposium Support: CERAMEC, City Technologies, ComSys GmbH, Conexant Systems, ONR, SEH America, ST Microelectronics France, and NSF.

Thermal-Spray Symposium Honors H. Herman

Symposium K, Thermal Spray—Materials Synthesis by Thermal Spraying, had four oral sessions including one in honor of H. Herman (SUNY—Stony Brook) on the occasion of his 65th birthday, and one poster session. Of particular interest were the advances made in the quantitative description of the coating formation processes through advanced models and the development of several different plasma-coating techniques for the formation of nanoscale structures.

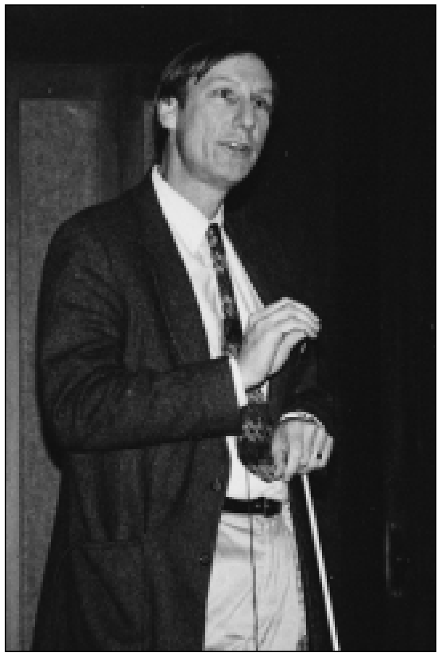
Symposium Support: GE R&D Ctr, Englehard Surface Technologies, Sulzer Metco, Praxair Surface Technologies, Tecnar Automation, Elsevier, ONR, and Tekna Plasma System.

Energetic Beams Modify Surfaces of Superconductors, Semiconductors, and Nanophase Materials

(See MRS Proceedings Volume 585)

The use of energetic beams for the modification of surface morphology and thin-film microstructure was the subject of Symposium L. The Symposium was dedicated to the memory of Barbara Cooper, who made seminal contributions to the field of low-energy ion-surface interactions.

The complementary roles played by experiments and theory/computer simulations in the quest for a better understanding of energetic beam processes was visible in every session. A tutorial by J. Greene (U. Illinois, Urbana) provided both a historical perspective and the future outlook on the wide range of applications of low-energy ion-beam processing of materials. A three-way joint session of Symposia L/O/II addressed the deposition of high-T_c superconductors and related oxides on standard substrates and on metallic tapes. The talks led to a discussion on the ultimate limits to biaxial texture and throughput that could be attained with ion-beam-assisted deposition. Computer simulations examined the role of channeling of the incident-ion energy and the presence of dimers and trimers in the sputtered flux on the development of microstructure in polycrystalline films. The beneficial effects of low-energy-ion bombardment in the growth of the compound semiconductors GaN and GaAs were demonstrated using synchrotron x-ray scattering, electron microscopy, and AFM.



*In his MRS Medalist presentation during Symposium X, **Stephen R. Forrest** (Princeton University) described the advantages and the disadvantages of organics, classifying these aspects as the Good (widely varied structure and properties, can be deposited on almost anything, relatively inexpensive, high luminescent efficiencies), the Bad (soft, poor contact, low mobilities), and the Ugly (hard to dope as* n- *or* p- *type, sensitive to water and oxygen, unstable and difficult to process). Forrest focused on two organic crystalline materials his group has extensively studied: PTCDA and NTCDA. He described layer-by-layer growth of the materials and discussed excitons. Subsequently he described various uses and applications of these materials as OLEDs which are being extensively studied and developed. Forrest also discussed the use of organics as photovoltaics and demonstrated possibilities for applications. He concluded his talk by suggesting that the next 50 years could be the age of organic and molecular optoelectronics.*

Experiments and modeling of self-organized nanometer-scale ripple and quantum-dot formation by ion erosion led to an improved understanding of the relevant microscopic processes. The interplay of surface thermodynamics and kinetics in the nanoscale regime was demonstrated with the deposition and subsequent burial of Co nanoparticles on Cu substrates. Application of accelerated molecular dynamics and hybrid Monte Carlo/molecular-dynamics methods to hyperthermal deposition of copper films provided a glimpse of the potential of these methods for predictive simulations in the future.

Symposium Support: SKION Corp. and Blake Ind.

Simulations Complement Scanning Probe Microscopy to Elucidate Epitaxy and Lithography Processes

(See MRS Proceedings Volume 584)

Symposium N focused on recent advances made in both atomic-scale measurements and models of epitaxial growth as well as lithography. The strength of the Symposium was the nearly equal balance between theoretical and experimental talks, which was intended to make each community aware of what the other could offer. Scanning probe microscopy was the dominant theme of the experimental talks, although other techniques were well represented, particularly in the joint session with Symposium I on real-time *in situ* studies of 3D islanding. Advances in plan-view and cross-sectional STM techniques, in particular, now make it clear that characterization of device materials has reached the point where feedback from such measurements can be used to improve device growth. The theory talks were divided primarily between kinetic Monte Carlo (KMC) simulations of growth and *ab initio* calculations of basic surface properties, although a promising new continuum method utilizing level set techniques was also highlighted. A few talks discussed how to combine *ab initio* data for transition energies with KMC simulations, and this appears to be a promising approach for the development of robust models for growth. Validation of such models by scanning probe microscopy is now at hand and promises to be an exciting area for the future, offering rich collaboration between theorists and experimentalists.

Symposium Support: Omicron Assoc., RHK Technology, Nippon Telegram and Telephone, JEOL USA, Bede Scientific, and NIST.

Substrates Form Important Base for Epitaxy

(See MRS Proceedings Volume 587)

An interesting dichotic perspective became clear during the nearly 60 papers that were presented in Symposium O on

Substrate Engineering—Paving the Way to Epitaxy, namely, a substrate is the base material on which all other fabrication (buffer layers, epitaxial layers, masking, and devices) is done. Or, a substrate is everything below the devices. In both cases, the principal issue was how to understand defect generation in the substrate (however defined) and how to avoid their propagation into the device region. Several papers were presented in the first vein, which studied defects in silicon, gallium arsenide, sapphire, and titanates. In addition, work was presented on directly growing ternary compounds and silicon-germanium compounds using traditional Czochralski crystal-growth techniques. In the second vein, many papers presented concerned the avoidance or control of defects due to interfacial lattice mismatch between an epitaxially grown thin film and a different base substrate material. These were further subdivided into techniques used during epitaxy itself, such as lateral overgrowth or thickness control, and those that were done before epitaxy, such as sample preparation and wafer bonding. This Symposium clearly brought together researchers from many different fields, each with their own perspective but all united in that they make the things that other people make things on.

Symposium Support: Advanced Technology Materials, American Assn. for Crystal Growth, Cree Research, Princeton Scientific, TLI Enterprises, and American Dicing.

Semiconductors Studied with Near-Field, Raman, and Other Optical Techniques

(See MRS Proceedings Volume 588)

The subject of most of the papers presented at Symposium P was the characterization by optical techniques of semiconductors, bulk materials and heterostructures, and devices. Besides the widely used luminescence techniques with a continuous trend toward higher spatial resolution, the increasing capabilities of near-field techniques and Raman spectroscopy were shown in the Symposium.

J.W.P. Hsu et al. (Virginia) used a near-field optical microscope to perform photocurrent imaging and reveal dislocation electrical activity in strain-relaxed GeSi films. The resolution of the near-field photocurrent imaging is about 100 nm, which represents a five- to tenfold improvement over far-field optical techniques. Near-field optical microscopy was used independently by B. Goldberg (Boston) and by X. Borrise et al. (Universitat Autònoma de Barcelona, Spain) to measure the internal spatial modes of optical waveguides.

Domnich et al. (University of Illinois—Chicago) combined Raman microspectroscopy and indentation to study pressure-induced phase transformations and amorphization in semiconductors (SiC, GaAs, InSb, diamond). The combination provides a powerful and fast tool for *in situ* monitoring of transformations. R.P.H. Chang et al. (Northwestern) presented a study of optically pumped lasing in ZnO polycrystalline films and powders. The lasing action is suggested to result from localization of photons within the medium. Essentially, because of the small size of the microcrystals, the scattering mean free path is of the order of the wavelength, and the recurrent light scattering forms closed loop paths for light, which behave as ring cavities for lasers. In the case of ZnO films, the out-of-plane orientation of grains affects the lasing threshold.

Electron Microscopy Strives for Finer Resolution and Quantitative Analysis

(See MRS Proceedings Volume 589)

Symposium Q on Advances in Materials Problem-Solving with the Electron Microscope highlighted the many advances in electron microscopy that have been made over the last several years. Invited speakers covered a broad spectrum of techniques and their applications to materials problems, ranging from low-energy electron microscopy "now available in spin-polarized and energy-filtered flavors" to quantitative high-resolution electron microscopy based on computerized focal-series restoration. Other significant advances were apparent in the characterization of magnetic materials and in techniques for quantitative microanalysis, which are now reaching a sensitivity that allows segregation at interfaces to be detected down to a fraction of a monolayer (at least for some species). Field-emission instruments now provide energy-loss spectra with sub-nanometer spatial resolution, allowing near-edge fine structure analysis to probe bonding at defects and interfaces.

The quantification of electron microscopy data is becoming more prevalent. The increasing use of multivariate statistical methods helps to quantify compositional phase identification in complex systems. In high-resolution imaging, quantitative methods for structure refinement are beginning to be used for practical alloy phase analysis. As shown by several presentations, the linking of experimental observation with physical models and computer simulation of defect structures is becoming an integral part of problem-solving with electron microscopy.

Symposium Support: ORNL, ANL, LBNL, and U. of Illinois.

Wide Range of Synchrotron Radiation Techniques Available

(See MRS Proceedings Volume 590)

Symposium R on Applications of Synchrotron Radiation Techniques to Materials Science showed data on a wide array of topics concerning the use of synchrotron radiation in materials science.

Materials Research Opportunities Funded by U.S. Government Agencies

Special sessions were held to describe materials-research opportunities supported by the Department of Energy (DOE), the National Science Foundation (NSF), and the National Institute of Standards and Technology (NIST). A major emphasis in research funding is for various government agencies to collaborate on research "initiatives" such as the National Nanotechnology Initiative (see Washington News, page 8). From DOE, Iran Thomas, director of the Division of Materials Science (DMS) described the metal and ceramics science team and the team for condensed-matter physics and materials chemistry. Websites for these research teams can be also found on the NSF website under the Division of Materials Research (DMR) (www.nsf.gov). Thomas emphasized that DOE is constantly looking for innovative research ideas and for members of the Materials Research Society to look to research with an interdisciplinary approach rather than vying for one discipline at the expense of another. He referred the audience to the DOE website for a large volume of relevant information (www.doe.gov).

Separately, the National Science Foundation also conducted a session on NSF support for materials research in which Tom Weber, director of the DMR, introduced the research opportunities under the NSF-European Commission project (see *MRS Bulletin*, January 2000, page 12). The first call for proposals ends March 31. Several senior staff members from NSF described opportunities for funding in various disciplines of materials research. The staff also answered questions about proposal submissions and evaluations. A follow-up drop-in session took place on Wednesday.

A session on funding through the Advanced Technology Program of NIST was conducted along the lines of similar presentations by DOE and NSF.

1999 MRS Fall Meeting Graduate Student Awards

The **1999 MRS Graduate Student Gold Award** recipients are (front row): **Craig B. Arnold** (Harvard University), **Jeremy Boomer** (Purdue University), **Kerri J. Blobaum** (The Johns Hopkins University), **Tosja K. Zywietz** (Fritz-Haber-Institut, Berlin), **Jonathon F. Hester** (Massachusetts Institute of Technology); and (back row): **Xiaozhou Liao** (University of Sydney, Australia), **Peter Peumans** (Princeton University), **Claus Zimmerman** (University of Augsburg, Germany), **Steffen Zahn** (New York University), **Nicholas J. Ramer** (University of Pennsylvania), and **Hsin Chiao Luan** (Massachusetts Institute of Technology).

The **1999 MRS Graduate Student Silver Award** recipients are (front row): **Vladyslav Domnich** (University of Illinois), **Adriana E. Lita** (University of Michigan—Ann Arbor), **Luis A. Zepeda-Ruiz** (University of Califor-nia—Santa Barbara), **Mihrimah Ozkan** (University of California—San Diego), **Sergei V. Kalinin** (University of Pennsylvania); (middle row): **Omar Leung** (Stanford University), **Brian W. Smith** (University of Pennsylvania), **Chris Bower** (University of North Carolina—Chapel Hill), **Scott Paulson** (University of North Carolina—Chapel Hill), **William L. Murphy** (University of Michigan), **Jie Zhang** (Michigan Technological University), **Sanjit Singh Dang** (University of Illinois), **Igor Vasiliev** (University of Minnesota), **Brent Ridley** (Massachusetts Institute of Technology); and (top row): **Byron Gates** (University of Washington—Seattle), **Thomas Gehrke** (North Carolina State University), **Niklas Hellgren** (Linköping University, Sweden), **Marc Waelti** (Swiss Federal Institute of Technology), **Edward Kirk Miller** (University of California—Santa Barbara), **Raul J. Martin-Palma** (Universidad Autónoma de Madrid, Spain), and **Douglas A. Vander Griend** (Northwestern University). Not shown: **Andrei Kazaryan** (The Ohio State University), **Anne-Valerie Ruzette** (Massachusetts Institute of Technology), and **Wei Tian** (University of Michigan—Ann Arbor).

Experimental techniques that were covered included EXAFS, synchrotron x-ray micro-diffraction, x-ray scattering techniques, and microtomography, while the types of materials systems studied ranged from mixed metal fluorides to mixed metal oxide catalysts to metal ion complexes. In one example, high-resolution angle-resolved photoemission spectroscopy was used to study the temperature dependency of thermoelectric materials, while another study addressed the study of corrosion using absorption techniques. Topography studies were also detailed relating to the investigation of surface damage of sapphires.

Several studies reported during the Symposium were directed at diffraction experiments. J. Schneider (DESY, Hamburg), for example, described the application of synchrotron radiation diffraction experiments to materials science. In a different experimental approach, D.J. Jensen and her colleagues of Denmark used 3D x-ray microscopy to investigate plastic deformation, re-crystallization, and internal stresses.

Symposium Support: Blake Ind. and Northern Illinois Univ. Graduate School and College of Liberal Arts.

From Aircraft to Silicon Wafers, Nondestructive Testing Measures Up

(See MRS Proceedings Volume 591)

Symposium S represents the latest development in nondestructive methods for the characterization of many classes of materials. Several x-ray techniques were developed or tailored for process control and deformation behavior in high- and low-density materials. Fracture, fatigue, and corrosion behavior of aging aircraft materials were characterized via linear and nonlinear acoustics. Structure-sensitive properties in magnetic materials and building materials were gauged with NDE parameters. Electric and dielectric properties in ceramics and composite materials were investigated. Thickness and interface properties in silicon wafers and thin films were studied. And advanced optical and infrared technologies were studied for the characterization of capacitance, circuit boards, laser diodes, and material growth.

Ultrathin Dielectric Films Important for Silicon Electronics

(See MRS Proceedings Volume 592)

In Symposium T on Structure and Electronic Properties of Ultrathin Dielectric Films on Silicon and Related Structures, S. Yamasaki (JRCAT, Japan) reported observation of *in situ* electron spin resonance during initial stages of oxidation of {111} silicon surfaces. Here he observed a signal from an adatom dangling orbital

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that eventually disappears and is replaced by the standard Pb signal.

D.J. DiMaria (IBM) gave a unified model for degradation in MOS transistors with ultrathin SiO_2 gates. All degradation mechanisms are directly related to release of hydrogen and its subsequent reaction at the Si-SiO_2 interface or in the SiO_2 film. What was both new and important was his discovery that the hydrogen need not come from the SiO_2 film. It can be generated in the silicon substrate at a reverse-biased source-substrate or drain-substrate junction. In fact, this discovery explains why degradation can occur below the 5.0-eV threshold he had previously observed. This result also implies that even the best dielectric film, completely free of hydrogen, will not eliminate hydrogen-induced damage.

R. Tsu (UNC-Charlotte) presented a paper on a highly efficient electroluminescent device that consists of repeated cells of nine layers of crystalline silicon and one sub-monolayer of a silicon oxide. The mechanism for silicon epitaxy above the oxide is currently unclear. However, cross-sectional TEM clearly demonstrated registry between layers of Si below and above the silicon oxide.

J.-L. Cantin (CNRS—France) reported that treatment of the (100) Si-SiO_2 interface with NO reduced the density of spin-active interface defects below the detection limit after vacuum anneals that have been shown to dissociate any Si–H bonds at the interface. This is the first report of removal of Pb defects without the use of hydrogen.

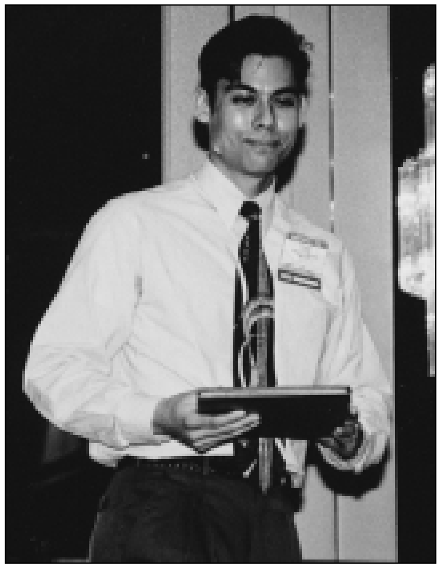
Symposium Support: ST Microelectronics France.

An Elementary Material Exhibits Complex Structure and Properties

(See MRS Proceedings Volume 593)

An amazing diversity of structure and properties is exhibited by one of the simplest elements in the periodic table—carbon. Symposium U, Amorphous and Nanostructured Carbon, highlighted the synthesis, properties, and applications of carbon in the amorphous state and in nanostructured forms, such as nanotubes. Nanotube growth mechanisms, energy storage in nanotubes and nanoporous carbon, vacuum microelectronics using nanotubes and amorphous carbon, and new measurement techniques for amorphous carbon were some of the many highlighted themes.

New insight into nanotube synthesis was reported by D. Geohegan et al. (ORNL) and M. Yudasaka et al. (NEC, Japan). Both used *in situ* optical probes to spatially and temporally image the carbon condensation and nanotube formation process in the vapor phase. Geohegan et al. observed that carbon condensation from the vapor phase occurs prior to metal catalyst condensation, suggesting a noncatalytic synthesis mechanism for the earliest stages of carbon nanotube formation. These researchers also discovered that nanotube growth can be obtained via the solid-phase annealing of undifferentiated carbon deposits collected directly from the laser-ablation process, suggesting that a simple solid-phase bulk-synthesis approach may be viable for nanotube production. Meanwhile, the work of Yudasaka et al. highlighted the role of metal catalysts for nanotube formation. These researchers developed a model in which the growth window for nanotube formation shifts with the condensation temperature of the metal catalyst material, and this can be tuned by catalyst-metal selection and alloying.



***Bradley Ekstrom** of the University of North Texas will serve as the first president of a new MRS University Chapter. The new Chapter was recognized at a presentation on Monday evening.*

Once synthesized, these nanotubes possess a bright future. For example, W. Zhu (Lucent) demonstrated that carbon nanotubes can support extraordinarily high current densities, allowing exciting new applications such as compact, high-power microwave amplifiers.

Symposium Support: Veeco Instruments and MMR Technologies.

Techniques Develop for Testing Mechanical Properties of Thin Films

(See MRS Proceedings Volume 594)

Mechanical behavior of thin films continues to be of great interest to the materials community, as was evident from the excellent attendance at Symposium V on Thin Films: Stresses and Mechanical Properties. A few highlights include presentations from M.R. Stoudt (NIST), who showed that multilayer coatings may be superior to the common hard coatings used to improve fatigue resistance of bulk metals; *in situ* TEM evidence that dislocation motion in metal thin films may be controlled by periodic break-away events from pinning points (M.J. Kobrinsky, MIT); a technique by A. Pundt (Universität Göettingen, Germany) for applying compressive stresses at ambient temperature by loading with hydrogen; the benefits of using a triangular cantilever beam in place of the standard rectangular microbeam bending geometry (J. Florando, Stanford University); a new design for an on-chip tensile or bend test by T.A. Saif (Illinois—Urbana-Champaign); and a discussion by T.N. Marieb (Intel) about the strict requirements for adoption of a characterization technique by the integrated-circuit industry.

Poster presentations were very strong this year, with two Symposium V posters winning awards. The poster by R. Jakkaraju et al. (Cambridge, UK) showed a fascinating checkerboard grain structure that formed as a result of applying high pressure and heat to a film on a substrate that was perforated with a regular array of holes. M. Lu et al. (New Mexico and SNL) showed the application of the cantilever beam-bending method to the characterization of visco-elastic and plastic deformation of polymer films.

Symposium Support: Hysitron, Applied Materials, IBM T.J. Watson Research Ctr, Advanced Micro Devices, Advanced Materials Instruments and Analysis, Micron Technology, Lucent Technologies/Bell Laboratories—Orlando, MTS Systems, Seagate Technology, Dow Chemical, and Novellus Systems.

Basic Science Chases Maturing GaN Technology

(See MRS Proceedings Volume 595)

This continuation of the MRS symposium series on GaN and associated materials (Symposium W) focused on advances in basic science as well as the rapidly maturing technologies involving blue/green light-emitters, detectors, and high-power electronics. Progress in lasers included reports of commercialization by Nichia Chemical of a laser operating at a 405-nm wavelength with a 4000-h device lifetime. At the 450-nm emission wavelength, significant reductions in lifetime are found and are believed to arise from nonideal properties of the InGaN alloy used in the active layer of the device. Transistors for microwave applications were reported to have achieved significant

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success in terms of device speed and high-power capability. Improvements in the epitaxy of GaN were discussed, using both selective-area growth techniques (lateral epitaxial overgrowth) and introduction of low-temperature intra-layers in the films. Advances in both MBE and MOVPE were reported, including several studies of quantum-dot formation in strained alloys. Hydride vapor-phase epitaxy continues to show improvements, particularly for providing very thick films. As the material quality improves, continuing advances in characterization (structural, optical, and electrical) have provided an increased understanding of the role of defects in the materials and the effects of processing steps on material properties. A panel report on Wide-Bandgap Semiconductor Research in Europe provided a useful backdrop for the presentations.

Symposium Support: CMU/ONR, SVT Assoc., and Oriel Instruments.

Materials MicroWorld Displays Prototypes

Materials MicroWorld is a major project undertaken by MRS to develop a set of traveling interactive science exhibits and educational materials to help introduce materials science to the general population. As part of this effort, a special Materials MicroWorld area was set up at the 1999 MRS Fall Meeting, with prototypes of some of the proposed interactive exhibits. Attendees explored the prototypes and contributed ideas for the project. MRS has recently submitted a grant proposal to the National Science Foundation for the project. See the MRS website for more on Materials MicroWorld (www. mrs.org / microworld).

Ferroelectrics Focuses on Memories and other Electronics Applications
(See MRS Proceedings Volume 596)

Symposium Y on Ferroelectric Thin Films covered a broad spectrum of fundamental and applied topics including the further development of memory devices and significant progress in the areas of materials integration and property characterization, especially ferroelectric domain structure and piezoelectric response. In addition, recent results on thin-film orientation and crystallographic effects on materials properties were also highlighted in a number of presentations.

The materials systems that continue to receive the most attention are perovskite compounds, PZT and BST, and the layered perovskite compound SBT. Advances in the area of FeRAM were demonstrated in a presentation by T. Moise (TI), where the development of embedded FeRAM that may be fabricated through a minimal number of additional mask sets was discussed. Embedded FeRAM allows for the read/write speed of DRAMs with the nonvolatility of standard EEPROM devices.

The fabrication of DRAM and FeRAM devices requires annealing in hydrogen-containing process ambients, and such anneals can cause severe degradation of the leakage current and, in ferroelectrics, the polarization of the dielectric layers. This Symposium featured a number of strong presentations on the electrical effects and kinetics of hydrogen-doping of BST and PZT thin films. S. Gilbert (TI) presented simulation results on the ionization energies of the shallow donor states produced by H interstitials in perovskite titanate crystals. He and S. Aggarwal (Maryland) also reported on the electrical degradation during forming gas anneals of BST and PZT capacitors that were encapsulated in interlayer dielectrics, indicating that oxygen loss is not required for hydrogen damage. Gilbert, J.-H. Ahn (Stanford), and J. Baniecki (IBM and Columbia University) showed SIMS data on diffusion of deuterium from MOCVD-grown BST. Gilbert and Ahn reported a large concentration of essentially immobile hydrogen in the as-deposited films. Ahn present-

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ed SIMS data on hydrogen removal from BST during subsequent recovery anneals. Baniecki showed that H introduction increases both the steady-state leakage current densities (apparent interface Schottky barrier lowering) and the transient relaxation currents across BST films.

Advances in the fundamental understanding of material properties were also evident. R. Waser (IFF Research Center Juelich, Germany) reported on the measurement of the frequency dependence (over seven orders of magnitude) of the coercive voltage of PZT and SBT and proposed theoretical models that showed that the observed ferroelectric response of the thin films was not effectively described by the Merz model, but could be modeled by coupling standard ferroelectric switching behavior with a Curie-Von Schweidler response for the relaxation current in the thin-film materials.

The results of studies of thin-film domain structures and switching response at the local scale using scanning probe microscopy techniques were reported by A.I. Kingon (NC State), K. Ghosh (ANL), and S.V. Kalinin (Pennsylvania State).

Significant progress in understanding piezoelectric effects in PZT thin films was also demonstrated during the Symposium. S. Trolier-McKinstry (Pennsylvania State) reported on the use of UV-exposure-induced imprint to reduce aging effects in the piezoelectric response of the films and P. Muralt (EPFL) highlighted recent results on the effects of film crystallographic orientation on piezoelectric response. In a poster presentation that received an MRS Best Poster Award, S. Hiboux (Swiss Federal Institute of Technology) detailed the effects of composition and orientation on the relative magnitudes of the intrinsic and extrinsic contributions to piezoelectric response.

Symposium Support: AXITRON AG, ATMI Ventures, NEC, ST Microelectronics SRL Italy, and Sharp.

Silica, Polymers Lay Foundation for Photonic Applications

(See MRS Proceedings Volume 597)

Symposium Z, Thin Films for Optical Waveguide Devices, focused on thin films for photonic applications. With the ever-growing importance of optical communications, there is a need to develop integrated photonic devices and circuits. Central to their development are thin-film materials. Several different thin-film materials systems are being developed including silica, polymers, and crystalline inorganics for applications such as wavelength division multiplexing (WDM). The thin-film technology that is most advanced for planar lightwave circuits is silica-based. A. Himeno (NTT) and J. Kenney of (Lightwave Microsystems) described WDM devices that provide wavelength separation previously achieved only by high-resolution spectrometers. A 1×128 array-waveguide grating multi/demultiplexer was reported. Polymeric materials are being developed both as waveguides and active devices (H. Katz of Bell Labs, Lucent Technologies). A novel flat-panel display was reported by H. Lackritz (Gemfire Corporation) that uses a polymer waveguide array. Ferroelectric thin films are being developed as integrated modulators and optical switches as described by F. Walker (ORNL). Waveguides with losses of less than 1 dB/cm have been achieved. Their integration with silicon, however, presents a considerable challenge (C. Buchal, Research Center Juelich, Germany). Finally A. Polman (FOM) described the development of thin-film integrated optical amplifiers. The leading technology is Er-doped silica. Several groups reported on photonic bandgap materials and structures, which should certainly impact lightwave circuits in the future.

Symposium Support: Fuji Xerox and Shinkosha Co.

Looking at Food as a Material

The first MRS symposium dedicated to exploring food as a material rather than simply as something we eat (Symposium AA: Materials Science of Food—Processing-Structure-Property Relationships) brought together researchers from both industry and academia, covering a wide area of different types of edible materials. The topic was introduced by R. Jones (Sheffield University, UK), who gave a Symposium X talk to “whet the appetite.” He illustrated how, despite the complexity of many foodstuffs, the same basic physical principles govern behavior as for any more traditional “material.” This same basic message was reinforced by P. Fryer (University of Birmingham, UK), who cast the whole production of chocolate in the language of metallurgical processing, namely, casting and solidification.

Two key aspects that relate to food but are less familiar in other parts of MRS were highlighted later in the Symposium. A. Smith (John Innes Center, UK) drew attention to the role of biology in controlling the starting material (in this case, starch). As plant biochemists learn more about the enzymes that control starch synthesis, it should be possible to tailor starches to suit different niche markets, a point also covered by M. Gidley (Unilever Research, England). P. Lillford, also from Unilever Research, covered the topic of texture as perceived by the consumer, that is, all of us. His message was that we are all experts in knowing how we like our food to feel in the mouth, even if the physical measurements which underpin words such as crispy or flaky are unclear. The challenge for scientists to bridge between the consumer and the materials properties is therefore particularly acute, but the science in this area is still rudimentary.

Symposium Support: Archer Daniels Midland Co., DuPont Agricultural Products, Cerestar USA, Kellogg Co., and Unilever Research.

Polymers and Molecules Light the Way toward Photophysics Insights and New LEDs

(See MRS Proceedings Volume 598)

Symposium BB on Electrical, Optical, and Magnetic Properties of Organic Solid-State Materials highlighted recent advances in a number of emerging and rapidly developing areas of research on organic materials. A one-day session was devoted to organic semiconducting materials and their applications as LEDs, and another half-day session focused on their utilizations in solar cells and thin-film transistors. A.B. Holmes from University of Cambridge reported new synthetic methods for the preparation of poly(arylene vinylene)s, which is one class of polymer materials of prime interest for LEDs. J. Kido (Yamagata University, Japan) reported efficient OLEDs fabricated with chemically doped, thick injection layers. In device applications, progress has been made in fabricating full-color displays using ink-jet printing. A prototype of such a display was demonstrated by Cambridge Display Technology. External quantum efficiency up to 10% was reported for OLEDs doped with phosphorescent organic molecules. Novel, air-stable, *n*-channel organic semiconductors were reported by H.E. Katz (Bell Labs, Lucent Technologies). An inorganic-organic hybrid *p*-channel material was shown to have high field-effect mobility up to 0.5 cm^2/Vs by C. Kagan (IBM T.J. Watson Research Center). Pentacene remains the highest-mobility organic semiconductor, and integrated circuits based on this material were demonstrated by T. Jackson's group at Pennsylvania State University. In a joint session with Symposium PP, research on two-photon-absorbing materials and their applications were highlighted. W. Webb (Cornell) gave an introduction to the photophysics of two- and multiphoton processes and overviewed their application in fluorescence imaging and biophysical measurements in biological materials. S. Marder (Arizona) described symmetric donor/acceptor conjugated molecules with two-photon cross sections over 10 times that of the common-

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ly used dye Rhodamine B, as well as their application in two-photon 3D microfabrication and biological imaging.

Symposium Support: E-Ink, Lucent Technologies/Bell Laboratories, Intl Specialty Products, Lockheed-Martin, Lightwave Microsystems, and NSF.

Apatite Inspires Biomineralization Research

(See MRS Proceedings Volume 599)

Symposium DD on Mineralization in Natural and Synthetic Biomaterials addressed the principles underlying the formation of minerals in biological organisms and the application of these principles to the synthesis of the materials to be used in medical implants and electronic devices.

The mineral present in bone is not hydroxyapatite but nanocrystalline Ca-apatite, containing vacancies caused by Ca deficiency and both stable and labile HPO_4^{2-}, CO_3^{2-} and PO_4^{3-} components, as concluded by M. Glimcher (Harvard Medical School). The labile non-apatitic environments are associated with water and are likely to form a hydrated layer on the surface of the minuscule apatite crystals, as reported by C. Rey (INPT-ENSCT, France). Rey and his team demonstrated that poorly crystalline apatite particles have the ability to agglomerate irreversibly into a solid body at low temperature, presumably due to the ionic exchange reaction of labile ions such as Mg^{2+}, HPO_4^{2-} and CO_3^{2-} present on their surfaces.

Nobel Laureate **Horst Stormer** (Columbia University and Lucent Bell Labs) presented the plenary talk on his work with the discovery of a new form of quantum fluid with fractionally charged excitations for which he received the 1998 Physics Nobel Prize. For more on Stormer's work, visit www.nobel.se/announcement-98/physics98.html and www.phys.columbia.edu/faculty/stormer.htm.

The mineral formation in bones, teeth, and shells is well controlled in biological organisms. The remarkable architecture of biogenic hard materials reflects biomolecular recognition and control of biological inorganic materials. The principles of biomolecule-mineral interactions continue to serve as a source of inspiration for the synthesis of materials. Many biomimetic strategies have been recently developed for the direct synthesis of organized inorganic-based structures with complex pattern and form, as stated by S. Mann (University of Bristol, UK). The key aspect of the biomimetic approach is integration of organic self-assembly and inorganic reaction chemistry to produce hybrid materials via direct or synergistic methods of spatial and chemical templating, as concluded by Mann. This is echoed by the findings of the research team led by I. Aksay (Princeton). The Princeton research team reported the formation of a carbonated calcium phosphate thin film induced on the structurally organized organic surfaces.

Synthetic materials need to have apatite on their surfaces in order to chemically bond to bone. One way to obtain apatite on the implant surfaces is to form an apatite layer on the implants through interaction of implant materials with body fluids. This is represented by bioactive glass-ceramic A-W, as pointed out by T. Nakamura (Tokyo Medical and Dental University, Japan). Another is to coat implants with hydroxyapatite (HA) ceramics. The most widely used HA coatings are produced by a plasma-spraying technique. In spite of its clinical success, the plasma-sprayed HA coating has some drawbacks, as stated by K. de Groot (Leiden University, The Netherlands). Thus, a biomimetic approach for producing apatite coating at room temperature has drawn great interest as a promising alternative to the plasma-spraying process. This approach is based on the finding that some acidic hydroxyl groups such as TiOH, SiOH, and COOH are capable of inducing apatite formation in a calcium phosphate-containing solution metastable to apatite. Two independent research teams, one led by de Groot and the other by T. Kokubo (Kyoto University, Japan), reported that a bone-like apatite film can be generated on the surface of titanium if titanium metal is first treated in a sodium hydroxide solution and then immersed in a simulated body fluid. According to de Groot, such formed apatite coating is currently in clinical trial.

G. Nancollas (SUNY—Buffalo) employed a contact angle along with the surface tension component theory to investigate the roles of interfacial free energy in mineralization and demineralization. The study by his group has shown that the rate of calcium phosphate dissolution decreases markedly with time despite the sustained driving force, eventually approaching zero even though crystals remain in the unsaturated solutions.

Symposium Support: Baxter Healthcare, DePuy Orthopedics, Johnson & Johnson, IsoTis BV, Kyocera, Stryker Howmedica Osteonics, and The Whitaker Foundation.

Phospholipids Assemble and Deliver

Phospholipids are ubiquitous biological molecules that self-assemble into lamellar bilayers and other three-dimensional constructs that have been extensively utilized for materials synthesis, as models of biological systems, and in biomedical and biotechnological applications. Symposium EE (Materials Science of Phospholipid Assemblies) drew participants from diverse backgrounds including materials science, biomedical engineering, biophysics, chemistry, chemical engineering, and medicine. Oral and poster contributions described research on fundamental properties of lipids such as self-assembly, structure, dynamics, mechanical properties, polymerization, and biophysical properties of lipid monolayers and bilayers. On the applications side, several contributions described the latest developments in the utilization of lipid assemblies for materials synthesis, supported membrane sensors, controlled release, drug and gene delivery, interfacial control of tissue response, and protein crystallization.

Symposium Support: Avanti Polar Lipids, The Whitaker Foundation, EndoRex, Northern Lipids, Genzyme Pharmaceuticals, and Sigma-Aldrich.

Electroactive Polymers Show Their Muscle

(See MRS Proceedings Volume 600)

For many years, electroactive ceramics, magnetostrictive materials, and shape memory alloys have been the primary source of actuation materials for manipulation and mobility systems. Electroactive polymers (EAP) received relatively little attention due to their limited capability. In recent years, effective EAP materials have emerged. Their main attractive characteristic is their operational similarity to biological muscles, where under electrical excitation a large displacement is induced. This forum became an important addition to the other forums that were established this year, including the EAP Conference of the SPIE Symposium on

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Smart Structures, which emphasizes actuators and applications. Also, the EAP community was provided with the WW-EAP Newsletter, website and news group, all accessible via http://ndeaa.jpl.nasa.gov/.

An EAP tutorial as part of Symposium FF provided background and an understanding of the fundamentals, potential applications, and challenges. One of the poster papers, reporting the work on the piezoelectric effect in human and bovine cornea, received a best poster award.

The Symposium covered various electroactive polymer materials, properties, and potential applications. S. Wax (DARPA) gave the keynote presentation reviewing the EAP materials that are currently being developed with funding from his agency. He expressed his hope to see the development of miniature robots emulating such creatures as the dragonfly.

Generally, two groups of materials were covered: (1) dry—including electrostrictive, electrostatic, piezoelectric, and ferroelectric; and (2) wet—including IPMC, nanotubes, conductive polymers, and gels. While overall, the dry types require high voltage for their operation, they provide larger mechanical energy density and they can hold a displacement under a dc voltage (critical to robotic applications). More interesting, in the dry EAP area, the recently development of high-strain materials (4–50% strain), such as those reported by Q. Zhang (Pennsylvania State), J. Scheinbeim (Rutgers), J. Su (NASA—Langley), and R. Kornbluh (SRI International), also possess higher elastic energy density than those in inorganic electroactive materials. Some of the dry EAP are capable of operating to high frequencies (>10 kHz). On the other hand, the wet EAPs are superior in requiring low actuation voltage (about a few volts) with high-strain generation capabilities, but are sensitive to drying and some have difficulties holding a displacement under dc activation. The carbon nanotube actuator reported by R. Baughman (AlliedSignal) has the potential to provide substantially higher work density per cycle and higher stress generation capability than any previously known technology.

The potential to operate biologically inspired mechanisms using EAP as artificial muscles and organs is offering exciting applications that are currently considered science fiction. To highlight this potential, the arm-wrestling challenge was presented to the participants of the Symposium. Y. Bar-Cohen (NASA—JPL) challenged the EAP community to develop a robotic hand actuated by EAP that would win an arm-wrestling match against a human opponent. Progress toward this goal will lead to great societal benefits, particularly in the medical area, including effective prosthetics.

"Poster Heaven" is the description that 1999 MRS President Ron Gibala gave to the poster sessions presented in one large hall in the Hynes Convention Center.

Symposium Support: Toray Techno Co., Kureha Chemical Industry Co., Daikin U.S., and ONR.

Cement Weathers the Rain

In cement-based materials (mainly concrete), the measurements of transport properties have some importance in and of themselves, since concrete is often used as a barrier. However, their main use is to help determine durability, since concrete degrades by the ingress of deleterious species (mainly water and chloride and sulfate ions). Concrete durability is an enormous problem, as a several-million-dollar concrete structure, for example a building or bridge, is constructed carefully over a period of months or years and then is left out in the weather for a long period of time. No other valuable material is treated this way. How long the structure lasts then depends on its microstructure, which in turn helps determine its transport properties, which determine the rate at which "bad stuff" gets into the material.

Symposium GG on Transport Properties and Microstructure of Cement-Based Materials covered both the basic and applied aspects of the transport properties and microstructure of cement-based materials. The microstructure talks discussed the fractal nucleation aspects of cement hydration and hydrated-phase formation, and used neutron-scattering data to probe the structure of the calcium-silicate-hydrate phase, which is the nanoscale "glue" that holds the great majority of cement-based materials together. Computer modeling was used to track cement-paste microstructure formation, and to predict transport properties. X-ray microtomography and environmental SEM were used to study cracks, and impedance spectroscopy was used to study the role of conducting fibers in cement-based materials. Concrete petrography was employed to study concrete used in pavement applications, and the Rietveld method was used to analyze quantitative x-ray diffraction measurements of materials often added to concrete.

Transport properties discussed included fluid permeability and ionic diffusivity. These were studied using electrical techniques, divided-cell direct diffusion techniques, and a novel beam-bending technique that used measures of mechanical properties to accurately infer fluid permeability. The relation between these transport properties was also discussed, and how they both depend on concrete pore structure. The talks included careful studies of chloride diffusion in steel-reinforced concrete in various applications, including how chloride diffusivity was measured and its effect on durability. Measuring this rate accurately is not an easy task, and several measurement techniques were presented during the Symposium. This task is complicated by the multiscale pore structure of concrete, from nanometers to millimeters, and by the complex assortment of ions that inhabit the pore space of concrete. It was shown how the effect of the many ions in the pore fluid was significant, and how this effect could be accurately modeled when analyzing real-life chloride diffusivities.

The application of transport properties was then also considered. Several talks focused on the corrosion initiation of steel-reinforced concrete as a function of the chloride penetration rate and other microstructural factors, while others discussed the role of water movement in freeze-thaw attack (nucleation of ice crystals in concrete pores), in the fire performance of high-density concrete, and in the repair of historic structures in Greece.

A joint session was also held with Symposium QQ, Scientific Basis for Nuclear Waste Management XXIII (See MRS Proceedings Volume 608), on the topic of cement-based materials and waste containment. This session was focused on material topics, and essentially showed how the microstructure and transport properties of cement-based materials could be used to study the behavior of these materials in a waste-containment role. Both experimental and modeling components of this study were demonstrated.

Symposium Support: Portland Cement Assn., Master Builders, and Lafarge.

Superplastic Materials Benefit from Ultrafine Grains

(See MRS Proceedings Volume 601)

Symposium HH on Superplasticity—Current Status and Future Potential brought together a wide range of specialists with interests in understanding, developing, and utilizing the high ductilities achieved in superplastic materials. The potential for superplastic forming operations was emphasized by A.J. Barnes (Superform USA) with a detailed review of the steps needed in order to expand the superplastic forming industry from its present specialist niche into a mainstream processing technology.

An important development in the superplasticity field has been the recognition that the production of materials with ultrafine grain sizes, typically in the submicrometer or nanometer range, may provide the capability for achieving superplastic forming operations at much faster strain rates. Z. Horita (Kyushu University, Japan) and P.B. Prangnell (Manchester Materials Science Center, UK) provided detailed descriptions of the procedures for obtaining substantial grain refinement using the process of equal-channel angular pressing in which a material is subjected to a very intense plastic strain without any changes in the cross-sectional dimensions of the sample.

The development of more refined microstructures necessitates the application of advanced characterization procedures such as computer-aided electron backscatter pattern analysis and HREM. The applications of these techniques to superplastic materials were described by T.R. McNelley (Naval Postgraduate School) and Y. Ikuhara (University of Tokyo, Japan).

The Symposium demonstrated the considerable potential for expanding the use of superplastic forming procedures in industry. New developments in the processing of ultrafine-grained materials and in characterizing the microstructures will assist in attaining this potential.

Symposium Support: ARO and LLNL.

Atomic-Scale Defects to Large-Scale Processing Examined for Superconductor Materials

Symposium II on Superconducting Materials focused on the crystal chemistry, properties, and key processing issues of bulk materials and films of both conventional and high-T_c superconductors (HTS). Over 10 years after the discovery of HTS, important insights continue to be developed in the complex crystal chemistry of these materials and provide guidance for materials optimization. Insights derived from detailed structure determinations predict that by controlling lattice distortions at the crossover between the underdoped and over-doped state it may be possible to enhance T_c. Recent studies also reveal that by modulating the electronic structure of spacer layers between the characteristic copper-oxygen planes, the response to applied magnetic fields may

The 1999 MRS Fall Meeting Exhibit marked the first-time use of the Hynes Convention Center. From its user-friendly layout to its exceptional flexibility and perfect location, this state-of-the-art facility was able to house all exhibitors under one roof and provide "one-stop" shopping to over 4,700 attendees. Also offered for the first time on the MRS Exhibit Floor were the "Wheels of Fortune," where attendees had the opportunity to spin the wheels for a chance to win valuable prizes donated by the exhibitors.

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be improved and superconducting transport properties enhanced. Through crystal chemistry control the electronic properties of grain boundaries also may be adjusted.

Sessions on processing and phase equilibria provided valuable new insights for materials optimization. Detailed phase formation mechanisms and kinetics of the (Bi,Pb)SrCaCuO superconductors were discussed. The observation of variability in the microstructure in a <10 μm thick layer near the Ag/Bi-2223 interface (major conductive region) of powder-in-tube processed tapes suggests that further improvement of J_c is possible. Diffusion of cations in the Ag sheath material has been observed, and it was reported that this may have an important effect on the stoichiometry of the HTS material.

Considerable progress was reported in the development of second-generation HTS wires based on YBaCuO-coated conductors. A joint session with Symposia L and O reviewed the development of flexible, biaxially textured substrates, which are required for this application. It is now possible to produce large areas and long lengths of substrates with pseudo-single-crystalline structure (boundaries between adjacent grains have a tilt of 2° or less) through a variety of techniques. Several speakers addressed the strong dependence of HTS transport properties on atomic-scale defects, including defects associated with grain boundaries. The emerging consensus is that the low-angle boundaries produced in coated conductor technology will enable transport properties at near-intrinsic performance levels.

In late-breaking news, American Superconductor Corporation reported the achievement of high J_c values for YBCO-coated conductors on rolling-assisted biaxially textured substrates whereby the epitaxial YBCO coating was produced through an economic solution-based process.

Symposium Support: Siemens AG, ORNL, LANL, JCPDS-Intl Ctr for Diffraction Data, 3M, ISTEC, and IBM T.J. Watson Research Ctr.

Phase-Separation Important for Magnetoresistive Oxides

(See MRS Proceedings Volume 602)

Of the many outstanding contributions to Symposium JJ on Magnetoresistive Oxides and Related Materials, some of the most significant ones dealt with the concept of phase-separation in the manganites. On the theoretical side, M. Moreau (IBM Electronics) described the connection between first-order phase transitions in the presence of disorder and the random-field Ising model and suggested this as the origin of multiphase effects in La-manganite perovskites. Strong experimental evidence for phase separation in $La_{0.7}Ca_{0.3}MnO_3$ came from J. Aarts (University of Leiden, The Netherlands), who presented STM results showing spatially inhomogeneous conductivity. This is, however, a surface study. As a counter-argument, R. Matzdorf (University of Tennessee and ORNL) presented detailed evidence of surface reconstruction in another family of compounds, the layered transition-metal oxides, which showed that the surface is certainly not representative of the bulk properties of these materials. Furthermore, P.J. Majewski (Max-Planck-Institut für Metallforschung, Germany) clearly demonstrated by solid-state chemistry experiments that there are distinct miscibility gaps in the pseudo-binary phase diagrams of the strontium and calcium lanthanum manganites above substitutional levels of $x = 0.35$. Such chemical separation may also lead to some of the observed physical effects. M.E. Gershenson's (Rutgers University) observation of giant $1/f$ noise near the M-I transition in $Pr_{1-x}Ca_xMnO_3$, $x = 0.375$, showed clear evidence for a percolation threshold, implying a multiphase description.

The session on novel oxide materials included a description of chemical vapor deposition growth of epitaxial CrO_2 films (shown by highly spin polarized by Soulen) on TiO_2 substrates at atmospheric pressure, as well as incorporation of these films into magnetic tunnel junctions with a Co counter electrode and an oxidized Co barrier.

Technologically, researchers are still struggling to make magnetoresistive tunnel junctions operable at room temperature. Apparently one of the most successful uses of the perovskite manganites will be as bolometers. This was demonstrated clearly by D.J. Kang (Maryland) and A. Grishin (Royal Institute of Technology, Sweden), who presented significant advantages and improvements over existing vanadium oxide technology in terms of achievable performance of uncooled, infrared imaging arrays.

Symposium Support: JRCAT-ATP, IBM T.J. Watson Research Ctr, Neocera, Micro Ceramics, Shinkosha Co., Pascal Co., and Crystec GmbH.

Tunable RF and Microwave Devices Measure Up

(See MRS Proceedings Volume 603)

The papers in Symposium KK addressed a whole range of issues concerning tunable RF and microwave devices, including electric-field and magnetic-field tuning, devices and materials, fundamentals, and characterizations. R.R. Romanofsky (NASA Glenn Research Center) summarized the experimental results of ferroelectric BSTO and STO thin-film-based coupled microstrip phase shifters (CMPS). A road map to a 3-dB-loss, 360° phase shifter that would enable a novel, electronically steerable, phased-array antenna was presented.

G. Dionne (MIT Lincoln Laboratory) gave an overview of ferrites that are used in magnetic-field tuned devices. He discussed the basic material structure and how alterations can be made to obtain particular characteristics such as those needed for operation at low temperatures in high-Q devices.

L.E. Cross (Pennsylvania State) gave a comprehensive overview of the materials issues in electric-field tunable dielectrics. It covered different materials systems from titanates to pyrochlores, from single crystals to artificial multilayers, and from the soft-mode behaviors to dielectric relaxation.

A. Tagantsev (Swiss Federal Institute of Technology) reviewed the microwave-frequency loss mechanisms in ferroelectric crystals. In the paraelectric phase, the intrinsic loss is due to the multiple-phonon processes and is low. However, a dc bias or local defects can induce polarizations, which will "awaken" the quasi-Debye contributions and increase the loss. J. Levy (Pittsburgh) used local optical probes to measure the polarizations in BST thin films and found local polar regions with high dielectric loss. The likely cause of these regions is oxygen vacancies due to processing, impurities, or cation nonstoichiometry.

Symposium Support: NASA Glenn Research Ctr, Neocera, LANL, and ONR.

Field-Responsive Fluids and Mechanochemical Actuators Find "Smart" Applications Along with More Mature Piezoelectrics

(See MRS Proceedings Volume 604)

The third Symposium on Smart Materials (LL) expanded the covered areas to electro-/magnetorheological fluids and mechanochemical actuators, in addition to the conventional piezoelectric, magnetostrictive, and shape memory materials. Piezoelectric actuators seem to have reached a mature status, and various talks were given on their reliability issues. S. Takahashi (NEC, Japan) reviewed high-vibration-level characteristics for PZT piezoelectric ceramics, using both burst and continuous-voltage-drive methods in order to measure the temperature-rise effect separately. He concluded that the mechanical loss increases significantly with the vibration stress. B. Koc (Pennsylvania State) and K. Uchino (Pennsylvania State) reported on a promising application for a disk-type piezoelectric transformer, which utilized a circular piezoceramic with an asymmetri-

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cal electrode configuration (MRS Poster Award recipient). Compared with the conventional rectangular shape, this new design realized higher voltage step-up ratio and efficiency.

C. Boller (DaimlerChrysler Aerospace, Germany) provided a review covering recent applications of shape memory alloys for automotive and aerospace smart structures. A new method, electromagnetic nozzleless melt-spinning, has been introduced by Y. Furuya (Hirosaki University, Japan) to manufacture rapid-solidified shape memory alloys (SMA). This method could improve the characteristics in a high-temperature SMA Ru-Ta and a ferromagnetic SMA.

The talk on magnetorheological fluids by M.R. Jolly (Lord Corporation) provided an understanding of their practical commercial market. Their damper applications expanded to truck seats and bicycles. T. Narita and Y. Osada (Hokkaido University, Japan) introduced intriguing chemomechanical actuators. Using acrylic acid and n-stearyl acrylate based gel, which can spread fluid on water continuously, they demonstrated a tiny water vehicle made of soft gel.

Symposium Support: ONR.

Mechanical Behavior of MEMS Devices Addressed

(See MRS Proceedings Volume 605)

Symposium MM on Materials Science of Microelectromechanical System (MEMS) Devices focused on materials issues in MEMS, which are critical in bringing many new products to market as well as in assuring product performance and reliability. J. Sniegowski (SNL) and S. Montague (SNL), along with C. Zorman (CWRU), presented a tutorial on "Polycrystalline Silicon and Silicon Carbide as Materials for MEMS." In the Symposium, silicon fracture and stress issues as well as their relationship to materials processing received a great deal of attention. In the area of new materials, J. Schweitz (Uppsala University, Sweden) revealed a laser focusing tool to fabricate arbitrary MEMS geometries in diamond. T. Friedman (SNL) demonstrated a stress- and stiction-free amorphous diamond with very high modulus and low surface roughness for MEMS applications. Sniegowski described a 3D photonic lattice fabricated by MEMS processing techniques that may lead to Si-based photonic crystal devices that are compatible with well-developed Si microelectronics.

MEMS tribology continues to be an area of special interest. B. Crozier (Washington State) described a new test structure that will enable the study of friction over a very large pressure and velocity range. S. Mani (SNL) showed that a selective tungsten coating improves wear resistance of MEMS parts by more than three orders of magnitude. In MEMS metrology, D. Freeman (MIT) spoke about an optical characterization tool with nm resolution in 3D. In MEMS packaging, a number of materials issues remain to be solved. T.F. Marinis (Draper Laboratory) demonstrated an interesting approach based on low-temperature co-fired ceramic materials.

Symposium Support: Xerox Palo Alto Research Ctr, Xerox Research Center of Canada, JIP ELEC, TI, and Rockwell Science Ctr.

Chemical Processing of Dielectrics, Insulators, and Electronic Ceramics Examined

(See MRS Proceedings Volume 606)

Symposium NN on Chemical Processing of Dielectrics, Insulators, and Electronic Ceramics focused on the role chemistry is currently playing in the development of new materials used in the electronics industry. A range of chemical processing techniques were discussed, including the deposition of thin metal oxide and nitride films by MOCVD, sol-gel, metalorganic decomposition, chemical bath deposition, and hydrothermal processing.

A wide variety of materials were covered, including high-dielectric-constant and ferroelectric oxides, low-dielectric-constant materials, and metal nitride diffusion barriers. A major aim of the Symposium was to present an overview of advances in chemistry that are likely to have a significant effect on the development of new thin-film technologies.

Symposium Support: Strem Chemicals and MKS Instruments.

Long-Wavelength Emitters and Quantum-Well Infrared Photodetectors Advance

(See MRS Proceedings Volume 607)

The objective of Symposium OO on Infrared Applications of Semiconductors was to cover the recent progress on interband and inter-subband transitions in III-V and II-VI semiconductors and superlattices as well as the progress on nonlinear optical and OPO materials. Both oral and poster presentations chronicled the extensive progress being made in the modeling, design, fabrication, and characterization of a diverse array of infrared semiconductor structures. A particular focus during this meeting was the advances being made in long-wavelength emitters and quantum-well infrared photodetectors (QWIPs). Laser structures have now been fabricated in GaInAsSb-based materials that operate, with reasonable powers, from 2–4 μm. The same material system is currently generating much interest for thermophotovoltaic cells. QWIPs have now been fabricated from various III-V semiconductors operating in the range 5–20 μm, very often with multicolor operation. It is clear that although many advances have been made in these materials, that much work still has to be completed.

Symposium Support: Air Force Office of Scientific Research.

New Materials Emerge for Optical Limiting

(See MRS Proceedings Volume 597)

Symposium PP on Materials for Optical Limiting was the third in a series devoted to the research and development of materials and devices with nonlinear optical properties for applications such as sensor protection, optical lithography, and optical memory. Areas addressed included theoretical and experimental studies of reverse saturable absorbers, two-photon absorbers, liquid crystals, nanotubes, and photorefractive materials. Joint sessions were held with Symposium BB, where common interests in the electrical and optical properties of organic materials were explored.

The Symposium opened with an overview presentation highlighting the status of work on establishing damage thresholds for biological tissue, which set the scene for many of the subsequent papers. As the week progressed, the wealth of new materials being explored was evident, including new porphyrins, phthalocyanines, dendrimers, fullerenes, and composite materials, especially those based on polymer dispersed liquid-crystal (PDLC) systems. Many of these provided the required threshold and temporal characteristics for activation by Q-switched lasers, provided that sufficient optical gain was available in the optical system in which they were used. For longer pulses, work exploring new photorefractive processes in lithium niobate demonstrated effective optical switching by three orders of magnitude in less than 2 ms. Similar temporal response characteristics were also reported in polymer-based systems. Progress in the realization of pop-up rejection filters was also significant, with promising results in PDLC devices based on holographic reflection gratings.

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