San Francisco Report: Materials Science Registers High on the Scale

Although attendees experienced a few aftershocks (one was 5.4 on the Richter scale), it was materials science that registered high on the scale at the 1990 MRS Spring Meeting in San Francisco. A worldwide spectrum of more than 2,600 participants gathered to exchange information on the latest scientific projects and results in 24 interdisciplinary, materials-related symposia.

Besides such familiar topics as "Better Ceramics Through Chemistry," "Advanced Metallizations in Microelectronics," and "Amorphous Silicon Technology," attendees also found "Materials Issues in Art and Archeology," "Materials for Sensors and Separations," "Alloy Phase Stability and Design," "Ferroelectric Thin Films," and "Materials Interactions Relevant to the Pulp, Paper and Wood Industries."

The diverse array of technical topics and poster sessions was organized by Meeting Chairs John C. Bravman of Stanford University, C. Jeffrey Brinker of Sandia National Laboratories, and William H. Butler of Oak Ridge National Laboratory with the volunteer assistance of some 78 symposium organizers.

Complementing the symposia were 18 selected short courses on advanced materials, materials preparation and fabrication, techniques, and materials characterization. Additional opportunities for in-depth discussions and interaction came in the form of poster sessions, a major equipment exhibit, and a job placement bulletin board.

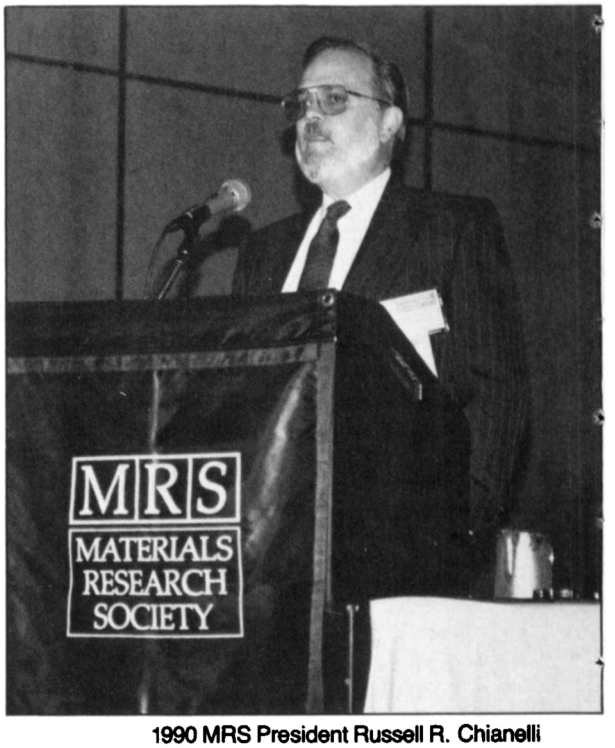
The following summaries of the symposia, written by their organizers, provide a closer look at some of the topical highlights from this meeting. For more details readers are encouraged to order MRS Symposium Proceedings or Extended Abstracts volumes from the MRS Publications Department. (See the list of Proceedings from the 1990 MRS Spring Meeting on p. 57.) In the few instances where proceedings will not be published, readers should contact one of the symposium organizers for further details.

1990 MRS President Russell R. Chianelli addresses the audience during the awards ceremonies and plenary session.

Meeting Chairs John Bravman, Jeffrey Brinker, and William Butler are recognized for organizing the technical program at the 1990 MRS Spring Meeting.

Plenary Speaker Mark D. Zoback, professor of geophysics at Stanford University, questioned theories of earthquake prediction when he spoke on a topic of substantial local interest, "Some New Views of the State of Stress Along the San Andreas Fault."

Poster sessions offer an excellent opportunity for in-depth discussions.



1990 MRS President Russell R. Chianelli

Graduate Student Award Recipients— Eleven graduate students from nine universities in three nations were recognized by MRS with awards for outstanding research papers presented in symposia at the 1990 Spring Meeting. Seated (left to right) are Sufi Zafar, David LaGraffe, Yoad Yagil, Ann Witvrouw, and Werner Wegscheider. Standing (left to right) are Shefford Baker, Ameet Bhansali, Alex Rou, Dennis Eichorst, and Jeffrey Huling. Edward Parsonage is not in the picture.

Meeting Chairs

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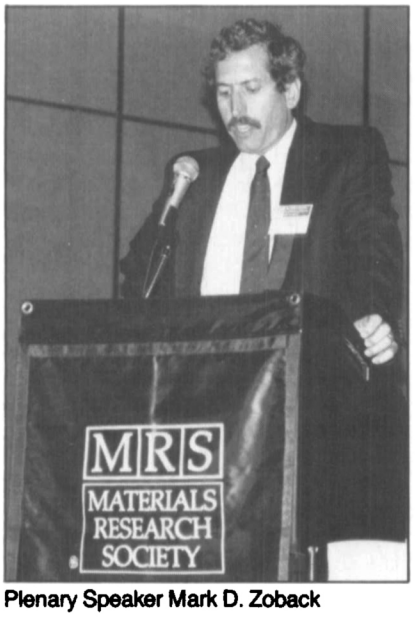

Plenary Speaker Mark D. Zoback


Graduate Student Award Recipients


Poster Session

Better Ceramics Through Chemistry IV (Symposium A)

MRS Symposium Proceedings, Vol. 180

Organizers: *C.J. Brinker (Sandia National Laboratories), D.E. Clark (University of Florida), Donald R. Ulrich (Air Force Office of Scientific Research), and Brian J.J. Zelinski (Arizona Materials Laboratories).*

Support: *Air Force Office of Scientific Research (AFOSR) and Gelest, Inc.*

The continued growth of this symposium, fourth in a series, reflects the ever-increasing number and diversity of scientists and engineers interested in the wet chemical synthesis of ceramics. This year's symposium provided a forum for the presentation of approximately 200 papers, including 40 invited talks, 90 contributed talks, two poster sessions, and one evening topical session.

As in past years, emphasis on the mechanisms and kinetics of reactions in alkoxide/alcohol-based systems continued. However, several key papers addressed the complementary areas of speciation, reactions, and rheology of alkoxide/water and inorganic salt/water precursor systems. This year's meeting also saw the continued emergence of wet chemically derived thin films as an area of vigorously active research. Results on the synthesis, properties and characterization of these films were presented along with discussion of their potential use as chemical sensors, optical waveguides and filters, dielectric, ferroelectric, electrooptic, and superconducting materials. Finally, an evening tutorial session on Biomimetics introduced the topic of "Ceramic Processing in Natural Systems" to a large number of symposium participants.

Advanced Metallizations in Microelectronics (Symposium B)

MRS Symposium Proceedings, Vol. 181

Organizers: *Avishay Katz (AT&T Bell Laboratories), Shyam P. Murarka (Rensselaer Polytechnic Institute), and Ami Appelbaum (Rockwell International Corporation).*

Support: *AT&T Bell Laboratories; A.G. Associates; Kratos Analytical, Inc.; Materials Research Corporation; Nimic, Inc.; Sumitomo Electric, Inc.; Crystacomm, Inc.; and North Eastern Analytical Corporation.*

During this international symposium, more than 130 papers were presented by representatives from more than 12 countries. This symposium focused entirely on the materials and processing issues of metallizations in conjunction with microelectronics applications. The high level of interest in this symposium forced the organizers to reject numerous excellent papers that did not fit this year's theme. Also, high interest was reflected by the attendance, which exceeded 300 at times. The five-day symposium featured 11 oral presentation sessions, an evening poster session, and a successful daily breakfast event honoring

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the invited speakers, session-chairs, and the financial supporters.

Excellent presentations were given by the following invited speakers during the plenary session and through the five-day symposium: W.E. Spicer (Stanford), M.O. Aboelfotoh (IBM), L.C. Feldman (AT&T), A.K. Sinha (AT&T), L.C. Kimerling (AT&T), H.B. Harrison (Griffith University), E. Kolawa (Caltec), R.S. Blewer (Sandia Laboratories), J.M. Gibson (AT&T), J. Nulman (Applied Mat.), J.W. Mayer (Cornell), K.N. Tu (IBM), M. Eizenberg (Technion-IIT), M. Murakami (IBM), C.J. Palmstrom (Bellcore), O. Ueda (Fujitsu), Y. Shapira (Tel-Aviv University), S.N.G. Chu (AT&T), and L. Wen (Academia Sinica).

This symposium allowed the enthusiastic audience and speakers to discuss the recent advances and processes associated with the metallization of Si, InP, GaAs and other compound-semiconductor-based electronic, optonic and optoelectronic devices and ICs, as well as the fundamental materials science, interfacial phenomena, and transport mechanisms.

Polysilicon Thin Films and Interfaces (Symposium C)

MRS Symposium Proceedings, Vol. 182

Organizers: *Bruha Raicu (Integrated Technology Associates), T. Kamins (Hewlett-Packard), and Carl V. Thompson (Massachusetts Institute of Technology).*

Support: *AG Associates; Advanced Micro Devices, Inc.; Applied Materials; Lam Research Corporation; MEMC Electronic Materials, Inc.; Northern Telecom; Peak Systems, Inc.; Process Products Corporation; Prometrix; Siemens AG; and Varian.*

This symposium supported the belief that polycrystalline silicon — a material without which the advancement of integrated circuits is unthinkable — continues to be a challenging, interesting subject for materials scientists and also for technology developers. This is due to a combination of the following important features:

1. Adjustable resistivity through control of doping, grain size, and structure;
2. Excellent high temperature stability;
3. Conformality with complicated vertical geometries specific for advanced VLSI/ULSI architectures; and
4. It is the material of choice for vertically and horizontally scaled, extremely small and fast transistors, sophisticated sensors, thin film transistors, and solar cells.

Nine invited and 69 contributing papers, presented in nine sessions, generated a well-attended, truly international, and multidisciplinary scientific event.

The high energy momentum generated by the invited talks of the plenary session was maintained during the three-day event, providing a forum for challenging discussions. The invited talks were on: "Polysilicon Integration" by J. Ellul and D.I. Calder of NTE Ottawa, "Polycrystalline Silicon as a Mechanical Material" by R.S. Muller of UC Berkeley, and "Poly-Si a Most Important Material" by M.L. Hammond of LAM Research.

Advanced technologies such as rapid thermal processing and beam modification of polysilicon properties continue to challenge material scientists and generate interesting research subjects.

Critical Currents in High-Temperature Superconductors (Symposium D)

Organizers: *John R. Clem (Iowa State University), Jack W. Ekin (National Institute of Standards and Technology), Sungho Jin (AT&T Bell Laboratories), and Donald M. Kroeger (Oak Ridge National Laboratory).*

Support: *Electric Power Research Institute.*

This symposium primarily focused on fundamental aspects of critical currents in the high-temperature superconductors. Interest in this topic has developed with the growing realization that the critical current density J_c (the maximum electrical current density that can be carried before an appreciable electrical resistance develops) is the physical property most critical to applications of the existing copper-oxide superconductors. This symposium, spread over four days and divided into eight oral sessions and two evening poster sessions, included 132 papers (26 invited talks, 41 contributed talks, and 65 poster papers).

Critical currents in bulk ceramic samples of the high-temperature superconductors are profoundly influenced by the granularity of these materials. Accordingly, the critical current density has both an intergranular and an intragranular component. The intergranular critical currents depend strongly on the properties of the grain boundaries and have a "weak link" character, which presently sets severe limits on possible applications of bulk materials. Several papers at this symposium reported on studies of how intergranular critical currents are affected by the grain boundary angle and the chemical composition of the boundary regions. Various processing techniques that promote texturing and grain alignment as ways of getting around the weak-link problem were discussed. For example, melt-processed materials with long grains parallel to the copper-oxygen layers have properties with greatly reduced dependence on the grain boundaries. Although the growth rates of such materials are painfully slow in Y-Ba-Cu-O (about one millimeter per hour), there is still hope that similar methods can eventually be developed and improved to produce long lengths of bulk wire with high critical current densities. In Tl-based wires, for example, zone melting at orders of magnitude higher speed has been used to obtain high J_c in low fields.

The intragranular critical current density of bulk materials corresponds to that of good single crystals. Several papers presented evidence supporting the idea that in $YBa_2Cu_3O_{7-\delta}$, high critical currents are due to vortex pinning primarily by local regions of oxygen deficient material and, to a much lesser extent, by twin boundaries. Numerous papers reported advances in enhancing flux pinning by local damage from neutron, proton, and charged-ion irradiations, as well as by precipitates, voids, and other kinds of small-scale microstructural inhomogeneities. In addition, several papers reported steady progress in the fabrication of superconducting wires and tapes, although the 77 K critical current densities achieved in these structures are still relatively low and strongly magnetic field dependent.

Providing encouragement to these efforts to enhance J_c in bulk materials is the knowledge that high values of J_c at 77 K are now commonly achievable in epitaxial films with copper-oxide planes aligned parallel to the single-crystal substrates. Numerous recent developments in the preparation of high J_c thin films and thin film superlattices were reported. The critical current behavior and the nature of possible flux-pinning defects in high-Jc thin films were also discussed.

High Resolution Electron Microscopy of Defects in Materials (Symposium E)

MRS Symposium Proceedings, Vol. 183

Organizers: *Robert Sinclair (Stanford University), U. Dahmen (University of California, Lawrence Berkeley Laboratory), and David J. Smith (Arizona State University).*

Support: *International Scientific Instruments; JEOL USA, Inc.; Philips Electronic Instruments; and VG Microscopes.*

The highly international flavor of this symposium was evident in participants representing many countries, including Australia, Belgium, China, France, Germany, Holland, Japan, Mexico, Sweden, Switzerland, and the United States. Of the 75 papers submitted to this symposium, 16 were invited. Five sessions of oral presentations were complemented by a high quality and lively poster session.

The opening session started with a dis-

cussion of work on metallic interfaces, particularly multilayers and grain boundaries. It continued with talks on interfaces in other systems, including semiconductors and ceramic composites. The second session was largely devoted to defect studies in silicides and semiconductors, both elemental (e.g., Si) and compound (e.g., GaAs, SiC). The volume of papers in this area clearly indicates that high resolution electron microscopy (HREM) plays a major role in this research field. The third session considered developments in small-probe and other studies, including SEM, STEM, STM, and microanalysis. It concluded with discussions on advances in theoretical image simulations.

The poster session contained a wide variety of papers describing results on geological materials, ceramics, semiconductors, catalysts, metals, oxides, and superconductors. The next oral session highlighted work on compound semiconductor interfaces and the burgeoning field of high T_c superconductors. Finally, work on carbides, oxides, catalysts, quasicrystals and small particles was discussed during the last session.

The overall theme and philosophy of the symposium was emphasis on the new information that had been uniquely provided about material defects using HREM. That this was so convincingly demonstrated over such a broad range of solids was perhaps the most notable impression from this meeting. The most rigorous papers were perhaps those in which carefully obtained micrographs were supplemented with extensive image matching calculations, but the influence of extremely fine-scale phenomena (revealed by HREM) on the properties of material systems was extensively addressed and was equally important to the MRS participants.

Degradation Mechanisms in III-V Compound Semiconductor Devices & Structures (Symposium F)

MRS Symposium Proceedings, Vol. 184

Organizers: *V. Swaminathan (AT&T Bell Laboratories), S.J. Pearton (AT&T Bell Laboratories), and O. Manasreh (Wright Research and Development Center).*

Support: *AT&T Bell Laboratories; Air Force Office of Scientific Research; Charles Evans Associates; Fujitsu Laboratories; General Electric Company; Hughes Aircraft Company; JEOL USA, Inc.; Oxford Instruments North America, Inc.; Spex Industries; United States Army Research Office; and Wright Research and Development Center/Materials Laboratory.*

The objective of this symposium was to bring together people engaged in the research of device degradation and reliability in III-V compound semiconductors to provide a forum for fruitful discussions and education. Since device degradation can mostly be linked to material "quality," it was natural to have MRS as the forum for this symposium. While MRS has previously hosted several symposia on subjects dealing with materials growth and material defects, the emphasis of this symposium was to strike synergy between the two schools of research so as to benefit the identification and control of device failure.

The two-day symposium consisted of six sessions dealing with topics such as reliability and degradation of electronic devices, recombination enhanced motion and related defects, defects in epitaxial layers, degradation of photonic devices, stress effects in device degradation, and reliability and degradation of metal III-V systems. The last session was held jointly with Symposium B - Advanced Metallizations in Microelectronics.

There were 15 invited and 21 contributed papers by authors from Australia, China, Canada, Hungary, India, Japan, Spain, USSR, West Germany, and the United States. The invited papers included: "Making Reliability Estimates When Zero Failures are Seen in Laboratory Aging" by F.R. Nash, "Influence of Point Defects and GaAs Devices" by D.C. Look, "Properties of DX Centers in AlGaAs and Effects on Heterojunction Devices" by P.M. Mooney, "DX Centers and III-V Device Performance" by E. Munoz, "Radiation Enhanced Dislocation Glide and Rapid Degradation" by K. Maeda, "Stability of Multilayered Structures" by Y. Kim, "Device Degradation in III-V Semiconductor Lasers and LEDs" by O. Ueda, "Defect Mechanisms in Degradation of Long Wavelength Laser Diodes" by S.N.G. Chu, "Atomic Diffusion with Strain and Injection" by J.A. Van Vechten, "Application of Strained Layer Superlattices" by D.L. Smith, "Consequences of Strain and Growth Kinetics on Growth Modes and Dislocation Formation in Strained Layer Epitaxy" by J. Singh, "Stability of Metallizations on III-V Semiconductors: A Look at Some of the Fundamental Issues" by C.J. Palmstrom, "Reliable Metallizations for InP Based Opto-Electronic Devices and OEICs" bu O. Wada, "Requirements of Electrical Contacts to Photovoltaic Solar Cells" by T.A. Gessert, "1/f Noise in Metallization" by P. Ficalora. The presentations elicited many responses from the floor, resulting in well-focused and fruitful sessions.

Materials Issues in Art and Archaeology II (Symposium G)

MRS Symposium Proceedings, Vol. 185

Organizers: *James R. Druzik (Getty Conservation Institute), Pamela B. Vandiver (Smithsonian Institution), and George Wheeler (Metropolitan Museum of Art).*

Support: *Getty Conservation Institute; and Conservation Analytical Laboratory, Smithsonian Institution.*

The session on mechanical properties, chaired by J. Druzik, strung together the theme of mechanics and structure. The dramatic results of Mecklenburg's experiments on the thermal-only stress/strain behavior of oil paint films will make a significant impact on the future thinking about works of art in transit. Experiments with different solvents of dramatically differing vapor pressures showed that rapid cooling (fast evaporation) was always associated on the stress/strain curve with a rapid spike followed by exponential decay. If this holds up to further experimental scrutiny, it will be the most spectacular evidence to date that under a regime of constant relative humidity, rapid fluctuations in temperature alone will dynamically alter the stress fields present on canvas painting structures.

During the session on ancient ceramics, chaired by P.B. Vandiver and W.D. Kingery, G. Harbottle showed how combining multivariant analysis and ICP on bricks in the New Netherlands/New York area allowed him to discriminate between brick-manufacturers spatially resolved to within less than a kilometer. ICP was compared to NAA and found to be equally effective at a much lower cost. In an entertaining display of detective work, drilling cores that were used prior to major skyscraper construction in Manhattan and since archived were used to sample clay deposits that would have been at near-surface levels in the 18th century.

During the session on ancient metallurgy, chaired by D. Scott and I. Freestone, Judy Todd pushed back the probable date of the first metallurgical processing of copper and copper alloys in southeast Europe to the fifth millennium B.C.

At the adobe, stone, and stained glass session, chaired by G. Wheeler, E. Wendler quantitatively displayed hygric swelling at the surface of stone as a major destructive influence, while R. Snethlage showed a possible way to reduce this effect by applying bifunctional cationic agents, such as alpha-alkyl-biammonium salts. Sandstone swelling was reduced by 40% after treatment with alkyl-biammonium chloride. G. Wheeler continued his indictment against B72/MTMOS mixtures by showing Si^{29} NMR data where the acrylic inhibits oligomerization and Si-network formation.

During the session on characterization, chaired by N. Indictor and D. Stulik,

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Donahue's presentation on radiocarbon dating was entertaining, Doehne's ESEM was impressive, and Bonadies' work on the current generation of industrial-computed tomography was superb. In the last few years, computed tomography has achieved the same level of resolution as two-dimensional x-radiography. Now it is possible to precisely locate very small casting flaws and bubbles and to create a fully three-dimensional computed rendition of an object with sharp resolution at submillimeter sizes. This permits an unlimited possibility of imaging an art object and slicing up its *surrogate* ad infinitum. High resolution images of medallions within wrapped mummies were shown.

Materials for Sensors and Separations (Symposium H)

Organizers: *Marc Anderson (University of Wisconsin-Madison), John Armor (Air Products and Chemicals, Inc.), D. Jed Harrison (University of Alberta), and Antonio J. Ricco (Sandia National Laboratories).*

This symposium, which was held for the first time, had maximum attendance (approximately 60 people) at all eight sessions. The symposium included speakers from around the world, equally divided between the materials for sensors field and materials for separations field. It was originally intended to create a dialogue between both groups so that those developing sensors might be well served with a first-rate separation device in front of the sensor. This would improve selectivities for species to be detected. For those that took advantage of the symposium's central theme, the conference was a superb success.

The symposium also presented an opportunity for investigators doing work in the separate fields of sensors or separations to report on recent developments in their respective disciplines. In this respect, the importance of novel materials in both fields were presented and discussed.

The crowning highlight of the symposium occurred when the smoke-detecting sensor outside our conference room actually functioned and set off a fire alarm. Unfortunately, the sensor failed to detect the earthquake that occurred.

Thin Film Structures and Phase Stability (Symposium J)

MRS Symposium Proceedings, Vol. 187

Organizers: *Bruce M. Clemens (Stanford University) and William L. Johnson (California Institute of Technology).*

Support: *B.P. America.*

This symposium focused on the ability that thin film deposition and reaction techniques give to engineer materials on the atomic scale. The kinetic and thermodynamic phenomenon in these processes can be used to produce materials with unusual, often metastable, chemical and structural environments. Artificially produced multilayer structures often have unusual conditions of strain, chemical proximity, structure, or disorder. The symposium focused on thin film structures, with emphasis on situations where thin film processing allows formation of metastable phases, highly strained materials, and novel solid state reaction phenomenon.

This two-day symposium included invited and contributed papers, as well as an evening poster session. The first day concentrated on solid state reactions with invited talks by L. Greer from the University of Cambridge, K. Tu from IBM Yorktown Heights, and C. Thompson from the Massachusetts Institute of Technology. Greer observed that the diffusion of Zr is 10^6 times slower than that of Ni in amorphous NiZr, confirming that Ni is the mobile species in solid state amorphization. Tu explained the formation of metastable phases in thin film diffusion couples by the concept of "maximum rate of free energy change." Thompson discussed the formation of amorphous phases in metal silicon systems, and described a two stage nucleation and growth process.

The contributed papers generated discussion on topics such as phase segregation, amorphous silicide formation, room temperature oxidation of silicon, and nucleation during ion beam irradiation. There was a lively poster session on Monday evening with papers on a wide variety of topics covering the general area of thin film science.

The second day featured sessions on epitaxy and multilayer structures with the morning focusing on epitaxial and heteroepitaxial growth of thin films. R. Farrow of IBM Almaden, an invited speaker, led off with a report on the remarkable success he and his co-workers have had in growing single-crystal epitaxial thin films and superlattices of silver, iron, cobalt, and platinum on GaAs. Several talks on epitaxial growth and characterization followed. The afternoon session focused on interfaces and structure of mutlilayered materials. A session on possible stress origins of the supermodulus effect was highlighted by spirited interaction with the audience.

Thin Films: Stresses and Mechanical Properties II (Symposium K)

MRS Symposium Proceedings, Vol. 188

Organizers: *Warren C. Oliver (Oak Ridge National Laboratory), Mary F. Doerner (IBM General Products Division), George M. Pharr (Rice University), and Franz R. Brotzen (Rice University).*

Support: *Nano Instruments, Inc.; IBM Corporation; UltraTherm, Inc.; and Oak Ridge National Laboratory.*

The approximately 70 papers presented in this symposium dealt with topics such as methods for measuring and characterizing the mechanical properties of thin films, methods for assessing residual stresses in thin films, and techniques for producing thin films with novel mechanical properties. Many of the papers discussed the ways small-scale indentation and scratch testing can be used to measure hardness, modulus, adhesion, friction, wear, and creep resistance. Other papers addressed new and novel methods for determining thin film mechanical properties, such as laser-induced film spallation, high pressure torsion testing, microbeam deflection, and atomic force microscopy (for atomic-scale tribological studies).

Reports on techniques for thin film residual stress measurement covered the commonly used substrate curvature and x-ray methods, and more exotic techniques such as holographic interferometry of vibrating thin film membranes and cathodoluminescence in stressed GaAs. Some of the materials discussed more prominently were compositionally modulated structures, ion-implanted materials, hard coatings (particularly TiN), optical coatings, magnetic films, and a variety of metals, ceramics, and organics used in semiconductor device manufacture. The final session in the symposium dealt with the relations between thin film defects and mechanical properties.

Microwave Processing of Materials (Symposium L)

MRS Symposium Proceedings, Vol. 189

Organizers: *William B. Snyder (Oak Ridge National Laboratory); Willard H. Sutton (United Technologies Research Center), D. Lynn Johnson (Northwestern University), Magdy F. Iskander (University of Utah).*

Support: *DOE Energy Conversion and Utilization Technologies (ECUT); Army Research Office, Durham, NC; Electric Power Research Institute/CMF; Gerling Laboratories; Cober Electronics, Inc.; Varian Consolidated Electronics; Wavemat, Inc.; Alcan International Ltd.; Hewlett-Packard.*

Endorsed by: *American Ceramic Society; International Microwave Power Institute.*

This second international symposium on the microwave processing of materials was well attended and stimulated many lively discussions during the 10 sessions of the four-day meeting. Nearly 30% of the 90+ papers were by authors from outside

the United States and represented 14 nations.

The speakers at the opening plenary session set the pace and included: W.A.G. Voss (Canada) on "Model-Informed Microwave Processing of Materials," J.Ch. Bolomey on "Review of the French activity on Microwave Control and Processing of Materials," O.M. Andrade, on "Biological, Medical and Industrial Applications in Brazil," F.D. Gac on "Microwave Processing Research at the Los Alamos National Laboratory," and R.L. Beatty, on "Review of Microwave Processing Projects at Oak Ridge." Lead speakers in the remaining sessions included: V.A. Flyagin (USSR), J. Asmussen, M.F. Iskander, M.A. Janney, M.A. Stuchly (Canada), R.D. Smith, C.Y.-C. Lee and J.E. McGrath, W. Ho, A. Priou (France), S.S. Stuchly (Canada), and J.A. Carpenter.

The symposium spanned a broad range of topics, from fundamental microwave-materials interactions, heating and enhanced chemical reactions, and numerical modeling, design and use of special applicators, dielectric property measurements and techniques to several processing methods (heating, annealing, drying, sintering, curing, joining, and plasma synthesis for ceramics, composites, polymeric, and other materials in both laboratory and industrial applications).

Several topics not covered in the first symposium were introduced, including detoxification of hazardous waste materials, microwave imaging techniques, new processing controls, and new medical applications, such as the use of microwaves to greatly reduce the time for staining and preparing tissues for examination. Such a technique appears likely to lead to the early detection of AIDS and was reported at this symposium by J.S. Hanker, B.L. Giammara and co-workers.

This symposium provided an update on many of the current activities in microwave processing science and technology and highlighted many new and unique applications. Prior to the first session, an informative short-course on microwave interactions with dielectric materials was presented by H.D. Kimery and M.F. Iskander.

Laser Ablation for Materials Synthesis (Symposium N)

MRS Symposium Proceedings, Vol. 191

Organizers: *David C. Paine (Brown University) and John C. Bravman (Stanford University).*

The large number of acronyms used to describe the laser deposition process has reduced the overall visibility of this technique. During the symposium, invited speaker Jeff Cheung (Rockwell) commissioned a referendum on which the audience and speakers voted for the "most appropriate name" for this technique. Although many names were suggested, 41% of the voters favored Pulsed Laser Deposition (PLD). Second place was a close race between Pulsed Laser Ablation (PLA) with 25% and Laser Ablation Deposition (LAD) with 21% of the cast ballots. Whatever one chooses to call it, Pulsed Laser Deposition is emerging as one of the most versatile deposition techniques available for reliably synthesizing thin films of virtually any composition. This two-day symposium attracted considerable attention with 44 contributed papers presented. These papers covered a wide range of topics, including fundamental processes, novel applications, and process optimization.

Invited papers, which discussed the fundamentals of this technique, were presented by J. Cheung (Rockwell), A. Gupta (IBM), L. Lynds (United Technologies), and X.D. Wu (Los Alamos). In PLD, the coupling of large optical fields with solid targets produces dense beams of ground state neutral atoms, molecules, and ions with energy in the range from 2 to 850 eV at modest fluences up to 10 J/cm^2. The non-equilibrium nature of the ejected particles allows a wide range of refractory, compound, and metastable phases to be deposited using this technique. Roughly half the contributed papers in this symposium concerned the deposition of high T_c superconductors — an application for which this technique has been repeatedly proven. The remaining half demonstrated the versatility of PLD in the synthesis of semiconductor epitaxial layers, "band gap engineered" layers, diamond-like carbon, ferroelectrics, SiC, and metallic thin films.

Amorphous Silicon Technology - 1990 (Symposium O)

MRS Symposium Proceedings, Vol. 192

Organizers: *P.C. Taylor (University of Utah), Malcolm J. Thompson (Xerox Palo Alto Research Center), P.G. LeComber (University of Dundee), Y. Hamakawa (Osaka University), and Arun Madan.*

Support: *Asahi Glass Company, Ltd.; Electric Power Research Institute; Elettronava-MV Systems; Fuji Xerox; Glasstech Solar, Inc.; Ovonic Imaging Systems; Sanyo Electric Company, Ltd.; Sharp Corporation; Solar Energy Research Institute; Solarex; and Xerox Corporation.*

This symposium provided a forum for 135 papers in both oral and poster sessions. This year's presentations highlighted recent improvements in solar cell modules, optical devices such as image sensors, the stability of thin-film transistors (TFTs), the growth of narrow-gap alloys based on amorphous silicon, novel growth techniques, modeling of the structure and defects in hydrogenated amorphous silicon (a-Si:H), and the basic understanding of metastabilities in a-Si:H. Also described were several very novel device applications of the a-Si:H technology, such as ultraviolet and x-ray detectors, medical imaging detectors, and high energy particle detectors.

Efficiencies of greater than 10% were reported for single-junction a-Si:H solar cells of reasonable area (10 x 10 cm^2). Advances in stacked cells, as well as novel contacting techniques, were also discussed. There has also been progress in producing high-quality a-SiGe:H alloys of narrower optical band gap for use in tandem solar cells. However, the stability issue remains a fundamental problem even though several engineering advances have minimized the deleterious effects.

Large area devices using TFTs continue to proliferate. The "standard" optical devices, such as image sensors, were a major focus of the symposium, but other novel applications were also discussed. Novel applications of the basic TFT architecture now include particle detectors, tunneling-assisted photomultiplier devices, and dynodes.

One well-attended session focused on recent theoretical advances in understanding the structure and defects in a-Si:H and related alloys. One very important recent advance is the ability to simulate the freezing in of amorphous structures using computer simulations of molecular dynamics. In some of these simulations, the electrons are treated quantum mechanically, while the atomic cores are treated classically. The techniques are now sophisticated enough to begin to look at defects in amorphous structures.

The general problem of stability of a-Si:H and related alloys continues to be both technologically and fundamentally important. The role of hydrogen in driving or influencing the optical and electronic metastabilities in a-Si:H was a major topic. Materials in which the hydrogen diffusion is greatly suppressed were discussed. Although these materials are not useful for devices, they do provide renewed hope of understanding what controls the diffusion processes in these amorphous solids.

Surface and Near Surface Structure of Polymer Interfaces (Symposium P)

Organizers: *Jeffry A. Kelber (University of North Texas), Matthew V. Tirrell (University of Minnesota), Ralph G. Nuzzo (AT&T Bell Laboratories), and Ernesto Occhiello (Istituto Guido Donegani).*

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Support: *Air Force Office of Scientific Research; Army Research Office; Office of Naval Research; and Monsanto Chemical Company.*

Polymers are widely used as surface modifiers in practical applications where the technology hinges on how the polymer interacts with the environment it finds itself in. The "environment" can be another solid surface (metal, ceramic, polymer, etc.) as in the case of microelectronics, adhesion, and lubrication applications. It can also be a liquid as in the case of colloid stabilization or a vapor for film coatings. In all these cases, there is a strong interrelationship between the polymer-environment interactions and configurations of the polymer molecules. This symposium (10 invited and 22 contributed talks) focused on ways to probe, test, and extend the current understanding of the interfacial structure of polymers.

In the session on thin polymer layers and interfaces, M. Stamm (Max-Planck-Institute) and T. Russell (IBM) demonstrated the power of neutron and x-ray reflectivity and scattering techniques to probe buried and near-surface structures of (micro and macro) phase-separated polymers with subnanometer precision. For exposed surfaces, the composition of the interface can be measured using techniques like XPS and SIMS. P. Green (Sandia) and several other speakers described the use of these techniques to study surface segregation effects in block copolymers and polymer blends.

A wide range of topics was covered in the session on monolayers and surface forces. J. Hautman (University of Pennsylvania) described the effect of temperature on dense monolayers of hydrocarbons studied using molecular dynamics simulations. P. McGuiggan (University of California, Santa Barbara), S. Hirz (Stanford), and A. Homola (IBM) presented their novel results on the shear and shear-induced properties of molecularly thin films. A series of talks focused on terminally anchored polymers. On the theoretical side, S. Patel (AT&T Bell Laboratories) presented a mean field theory for neutral polymers, and P. Pincus (University of California, Santa Barbara) showed results for grafted polyelectrolytes. On the experimental side, E. Parsonage and M. Tirrell (University of Minnesota) presented elegant means of tailoring the properties of such layers using mixtures of block copolymers with different molecular weights.

In the session on polymer-solid interactions, J. Pireaux (Facultes Universitaires Notre-Dame de la Paix) demonstrated the power of high-resolution EELS in fingerprinting polymer surfaces with better surface sensitivity than that possible with XPS and SIMS. Several talks focused on spectroscopic means of probing the structure of polyimide surfaces using principally XPS and FTIR. Notably, F. Boerio (University of Cincinnati) discussed the orientation of polyimides at surfaces probed by surface-enhanced Raman scattering, and A. Chakraborty (University of California, Berkeley) showed the conformations of monomers at metal surfaces expected from quantum mechanical calculations. In this session and the one on surfaces, composites, and blends, several talks focused on improving the properties of thin films by exposure to UV or multiple ion beams.

Intermetallic Matrix Composites (Symposium R)

MRS Symposium Proceedings, Vol. 194

Organizers: *Donald L. Anton (United Technologies Research Center), Robert McMeeking (University of California), Daniel Miracle (Wright-Patterson AFB), and Patrick Martin (Los Alamos National Laboratory).*

Support: *Martin Marietta Laboratories; GE Aircraft Engine Business Group; United Technologies Research Center; Office of Naval Research; Los Alamos National Laboratory; NASA Lewis Research Center; and Rockwell Science Center.*

This symposium was the first dedicated solely to the subject of structural intermetallic matrix composite materials in which nominally brittle but quite strong and light intermetallic compounds were reinforced with second phases. It was clear that the motivation behind the majority of papers was the use of intermetallics in future aircraft frames and engines.

In his keynote presentation, J.C. Williams pointed out the economic barriers posed by these systems, which are anticipated to cost in excess of $5,000 per pound, including both high materials as well as fabrication costs. This was cited as a grave limitation both in the study of these materials and also in their final implementation, which will be limited to very specific and critical applications. Micromechanical modeling contributions emphasized determination of the required strength, size, distribution and morphology of reinforcements. Several papers displayed the significance of high aspect ratio reinforcements in enhancing both strength and damage tolerance. Applications of traditional consolidation techniques and introduction of new processes used to fabricate these composite materials were presented.

One of the more interesting aspects of this symposium was the large number of ductile phase toughened systems presented. This is in contrast to the classical strong but weakly bound phase approach used in the majority of ceramic matrix composite efforts. The ductile phases were introduced through solidification, precipitation, or thermo-mechanical integration. Reinforcement distribution and integrity were the topics of papers, which stressed the importance of processing in maintaining reinforcement strength and alignment.

Physical Phenomena in Granular Materials (Symposium S)

MRS Symposium Proceedings, Vol. 195

Organizers: *George D. Cody (Exxon Research and Engineering), Theodore H. Geballe (Stanford University), and Ping Sheng (Exxon Research & Engineering).*

Support: *Army Research Office; National Science Foundation; Office of Naval Research; David Sarnoff Research Center; Deposition Technology; Exxon Research and Engineering Company; GE Corporate Research and Development; IBM Corporation; Kurt J. Lesker Company; Materials Research Corporation; NEC Research Institute; and Schlumberger Doll Research.*

This symposium focused on granular materials which range from metal-insulator composites to dispersions of semiconductor nanometer crystalites and constitute an important class of inhomogeneous materials, with many interesting physical properties and technological applications.

As an international forum for material scientists working on all aspects of granular materials and theory, the symposium featured 100 papers given in four days of oral sessions and one poster session. The topics were remarkably interdisciplinary, covering optical and electrical phenomena, flow and porosity, superconductivity, thermal properties, and applications. Generic theoretical models of varying degree of complexity such as effective medium theories brought unity to the symposium.

The symposium was organized to honor the 65th birthday of Ben Abeles, whose scientific career reflects his significant contributions to the physics of granular materials.

Superplasticity in Metals, Ceramics, and Intermetallics (Symposium T)

MRS Symposium Proceedings, Vol. 196

Organizers: *Merrilea J. Mayo (Sandia National Laboratories), Jeffrey Wadsworth (Lockheed Missiles & Space Company, Inc.), Masaru Kobayashi (Technological University of Nagaoka) and Amiya K. Mukherjee (University of California at Davis).*

Support: *Army Research Office; Office of Naval Research; and National Science Foundation.*

The past year or so has seen fundamental changes in the field of superplasticity. Supposedly brittle materials, such as intermetallics and ceramics, have been shown to exhibit extraordinary ductilities, and high-strain-rate superplasticity might lead to finally incorporating superplastic metals into the mass production of automobile parts, with significant cost savings. This symposium documented many of these advances through the participation of about 50 scientists from nine countries. New world records were also reported at the symposium — among them, 8,000% elongation to failure in a metallic alloy (commercial aluminum bronze), 800% elongation to failure in a ceramic (Y-TZP), and 1,400% extension via internal stress superplasticity in an Al - 20% SiC_w composite.

Because superplasticity has for years been a rather isolated field, it was significant that several sessions drew notable attendance (20-30%) from outside the superplastic community. Of particular interest to attendees seemed to be the talks on novel nanocrystalline microstructures and on intermetallic and ceramic superplasticity. Unfortunately, the number of Soviet and Chinese scientists attending was well below expectation. As a result, several talks on novel superplasticity theories, and on the practical application of superplasticity to intermetallics and superconductors were cancelled at the last minute. The talks were replaced, however, by some distinctly engaging discussion sessions during which the audience was free to query both the authors and each other on their work.

Thanks to the National Science Foundation, the symposium was able to offer four student scholarships, which included registration fees and some money toward travel expenses. The scholarship program attracted not only mature graduate students but also those just beginning their careers. Since the next conference on superplasticity is not until late 1991 in Japan, this symposium represented a first and only chance for some of these students to meet and discuss their work with world experts.

Seasoned superplasticity veterans also found some unique attractions at this year's symposium. Geologic superplasticity was discussed, for the first time, in the context of a general superplasticity conference, with the instructive lecture by the eminent geomechanician, Mervin Paterson. Discussion of superplasticity in bioceramics and non-oxide ceramics also received considerable attention, not only because of topic, but also because the speaker, Fumihiro Wakai, was the first person to demonstrate tensile superplasticity in ceramics.

Materials Interactions Relevant to the Pulp, Paper and Wood Industries (Symposium U)

MRS Symposium Proceedings, Vol. 197

Organizers: *June D. Passaretti (Pfizer Minerals Research Center), Daniel Caulfield (Forest Service, Department of Agriculture), Rustum Roy (Pennsylvania State University), Vance Setterholm (Forest Service, Department of Agriculture), and Stanley F. Sobczynski (Department of Energy).*

Support: *DOE Office of Industrial Programs; National Science Foundation; Pfizer Inc.; and International Paper.*

Co-Sponsor: *TAPPI (Technical Association of Pulp and Paper Industries).*

This first MRS symposium to incorporate pulp, paper, and wood as topics demonstrated that wood and paper, although often overlooked as materials by the materials research community, provide a vibrant field for materials research. Of special interest to materials researchers is the interaction between pulp, paper, and wood with other materials. This general topic was discussed in the five sessions on wood/polymer composites, fiber/fiber interactions, fiber/water interactions, papermaking and coating processes, and surface interactions: fillers and pigments. One recurrent problem discussed throughout the symposium was the need to discover new ways to promote intimate and effective interactions between the highly polar surfaces of wood, paper and cellulose, and materials whose surfaces might tend to be nonpolar.

The 33 presentations were almost equally divided into contributions from government laboratories, industrial laboratories, and universities. The speakers came from the United States, Canada, Sweden, and Finland. Evidence of the timely nature of the symposium was its co-sponsorship by the Technical Association of the Pulp and Paper Industries, and by the financial support of industry (Pfizer Inc. and International Paper), the DOE Office of Industrial Programs, and the NSF.

Epitaxial Heterostructures (Symposium V)

MRS Symposium Proceedings, Vol. 198

Organizers: *Don W. Shaw (Texas Instruments, Inc.), John C. Bean (AT&T Bell Laboratories), Vassilis G. Keramidas (Bellcore), and Paul S. Peercy (Sandia National Laboratories).*

Support: *Air Force Office of Scientific Research; Aixtron, Inc.; Nimic, Inc.; Sumitomo Electric USA Inc.; Spire Corporation; Instruments S.A. Inc.; and V.G. Instruments, Inc.*

Epitaxial heterostructures form the basis for a wide variety of exciting and challenging materials science research endeavors. Concurrently, they are used for multiple devices and integrated circuits, ubiquitously found in many areas of today's science and technology.

The symposium was organized to address the theory, preparation, characterization, and applications of complex layered structures of dissimilar materials prepared by epitaxial growth. The heteroepitaxial theme was carried in a variety of materials combinations, including compound semiconductor heterostructures, metal/semiconductor heterostructures, and silicon germanium structures.

Special sessions dealt with ordering and phase separation issues in compound semiconductors, considering both the theoretical and experimental point of view, and theory and modeling of nucleation phenomena and growth mechanisms in heteroepitaxial films. Of interest were the theoretical predictions of new physical phenomena induced by coherent epitaxy (Zunger, SERI). Pseudomorphic coherence can lead to stabilization of bulk unstable structures, conversion of indirect bandgap constituents to quasi-direct superlattices, and noticeable changes in the temperature-composition phase diagrams of alloys. The theoretical elucidation of the effects of surface steps and other imperfections on the nucleation processes and growth mechanisms in heteroepitaxial films also showed significant progress, just as the trend toward nanostructures makes this understanding essential and imperative (J.A. Venables, Arizona State University). The growth of buried metal/III-V compound semiconductor heterostructures is opening new vistas in heteroepitaxy, from both the physics of interfaces and technological points of view (J.B. Harbison, Bellcore). The trend toward the growth of highly dissimilar materials is continuing with The Heteroepitaxy of InP on Si Substrates (M.M. Al-Jassim, SERI), GaAs Layers on Sapphire (G. Kordas, University of Illinois), and Ge on GaAs (R. Venkatasubramanian, North Carolina State University) and many others.

In Si/Ge superlattices, the report of luminescence from $(Si_m)/Ge_n$ strained monolayer superlattices has gained attention and caused controversy as to its origin and efficiency (M.A. Kallel, UCLA). The heteroepitaxial growth of metastable carbon silicon C_xSi_{1-x}/Si(100) (J.B. Posthill, RTI, North Carolina) lattice matched to silicon and with significantly increased bandgap was of interest because of its possible use as an emitter for silicon heterojunction bipolar transistors.

The implications of these and many other developments in heterostructure nanoelectronics were put into perspective by the plenary speaker, J. Barker (University of Glasgow), who provided a visionary glimpse of the future.

The sessions were well attended, with attendance increasing for topics and invited talks of current interests and decreasing when more evolutionary developments in the field were reported. Interest in the symposium was especially evident in the very good attendance of Friday's late sessions. Some encouraging cross fertilization between people working on the same theme of heteroepitaxy, but in different material systems, did indeed take place — a successful result to one of the symposium's goals.

Workshop on Specimen Preparation for Transmission Electron Microscopy of Materials II (Symposium W)

MRS Symposium Proceedings, Vol. 199

Organizer: *Ron Anderson (IBM).*

Support: *Anatech, Ltd.; E.A. Fischione Instrument Manufacturing; Gatan, Inc.; NSA Hitachi Scientific Instruments, Inc.; JEOL USA, Inc.; Philips Electronics, Inc.; South Bay Technology, Inc.; Carl Zeiss, Inc., and Electron Optics Division.*

Virtually all MRS symposia are filled with transmission electron microscopic analyses. TEM specimen preparation is often the factor that influences the success or failure of a particular scientific investigation. Since the art of TEM specimen preparation is evolving constantly, it was deemed important to periodically present workshops on TEM specimen preparation.

The present workshop, second in a series, was a half-day platform session featuring invited speakers. Speaker invitations were extended to researchers who are making important contributions in areas of specimen preparation that are just emerging or are not receiving the attention they deserve in the physical sciences. In the "just emerging" category, J. Wetzel covered the topic of preparing samples by combining lithographic and reactive ion etching methods, R. Alani discussed chemically assisted ion beam etching, and M. Drechsler focused on making specimens in the form of sharp tips. In the "not receiving attention" category, T. Malis presented an extensive synopsis of the uses of ultramicrotomy in the material sciences, B. Kestel reviewed novel and new methods for preparing samples by jet electropolishing, and T. Kelly covered precision dimpling and ion milling.

A well-attended evening poster session attracted 25 contributions — clearly indicating that many investigators have developed new and evolving methods for preparing various classes of specimens. The largest number of poster contributions was on various aspects of preparing semiconductor specimens for TEM analysis. J. Benedict et al. reported on routine preparation of predefined, micron-sized, cross section samples, while D. Knoesen showed how to delineate n/p junctions on device cross sections. Another group of posters presented methods for preparing particulate and fibrous samples, while several others focused on new or improved tools for specimen preparation.

Ferroelectric Thin Films (Symposium Y)

MRS Symposium Proceedings, Vol. 200

Organizers: *Angus I. Kingon (North Carolina State University) and Edward R. Myers (National Semiconductor).*

Support: *Office of Naval Research; National Semiconductor; Army Research Office; and IBM Corporation.*

This 2 1/2 day symposium was the first time any materials society specifically addressed the topic of ferroelectric thin films. Approximately 50 papers were presented, representing six countries. Following the recent developments in ferroelectric thin films, the program was designed to provide a comprehensive tutorial covering the newest aspects of ferroelectric thin films, covering material systems, new deposition techniques, and physical, electrical, and electro-optic characterization. The symposium attracted and maintained an audience of well over 100 persons for all sessions. The high ratio of attendance to accepted papers further illustrated the timeliness and interest in the rapidly emerging field of ferroelectric thin films.

The first session addressed electro-optic applications, particularly the electro-optic material lithium niobate, as well as chemical vapor deposition of ferroelectric thin films. The first speaker, Dr. S. Hirano, provided insight into the exceptional LiNbO3 material qualities achievable through metal alkoxides spin-on pyrolysis techniques. This was followed by talks detailing sputter deposition and silicon integration with extensive film characterization. The MOCVD section of the session was exemplified by the work carried on by Plessey Research Caswell Limited (C.J. Brierley) highlighting the high deposition rates (10 μm/h), compositional control, and material quality associated with this deposition technique. The choice of precursors, gas compositions, and growth conditions was also discussed. Included in this session were similar chemical deposition techniques such as chemical beam deposition (CBD) and a report on a new hydrothermal-electrochemical approach.

The first day of the symposium concluded with a half-day session on rf sputtering and laser ablation of PZT thin films. The number of papers on sputtering shows the importance sputter deposition has in ferroelectric thin films. The papers indicated the achievement of high quality films (R.A. Roy and S. Krishnakumar) and also the effects of post-deposition thermal processing on the film properties (S.B. Desu, J.R. McNeil, and D-Q. Xiao). Papers on laser ablation indicated that the experience gained in superconductor deposition can be directly applied to the growth of ferroelectric thin films.

The second day covered many topics, including spin-on pyrolysis, microstructural characterization, and physical characterization of ferroelectric films. Spin-on pyrolysis presentations covered synthesis techniques, indicating the importance of the chemical system chosen (B.A. Tuttle, D.A. Payne) on the crystallization during sintering. In addition, several papers addressed the effect of the thermal cycle used to sinter the spin-on films (L.N. Chapin, S.S. Dana, L.F. Francis). Papers covering transmission electron microscopy characterization showed that high microstructural quality can be achieved using either rf sputtering or spin-on techniques. The largest collection and possibly the first images of ferroelectric domains in thin films were presented in this session. The domains were imaged for both spin-on films (S.A. Myers, C-C. Hsueh) and sputtered films (J.P. Goral), as well as some of the first domains in thin films imaged using scanning electron microscopy.

The final session was directed at applications and electrical performance of ferroelectric thin films. Papers presented in this section reported on how electrical cycling affects the extended life of integrated memory devices (D.J. Johnson, A.R. Modak, T.S. Kalkur, L. Kammerdiner, C. Sudhama) and on computer modeling of switching (R.D. Pugh) and commercial criteria for testing.

These contributed papers were presented in conjunction with an outstanding number of invited presentations by leaders in the field of ferroelectrics. The speakers included some of the earliest workers in the field (L.E. Cross, M.H. Francombe) and also current leaders (S. Matsubara, K. Wasa, W. Shepherd, H. Adachi). These speakers were joined by recent researchers (R.A. Roy, M.S. Ameen, N. Abt) to provide a complete picture of the past, present, and future of ferroelectric thin films. MRS