E-MRS 1999 Spring Meeting Includes Eclectic Blend of Materials Topics

The European Materials Research Society (E-MRS) 1999 Spring Meeting was held June 1–4, 1999, in Strasbourg, France, at the Palais de la Musique et des Congrès. The meeting included 16 technical symposia, poster sessions, and an exhibit comprising 32 exhibitors. About 1,500 papers were scheduled for presentations (oral and posters) and total attendance was over 1,000. The meeting was chaired by Peter Glasow (Erlangen, Germany) and Gabriel Crean (University College, Ireland).

The materials areas covered included electronic materials; optical materials and properties such as photo-excited processes and applications, molecular optoelectronics, *ab initio* approaches to microelectronics materials, and process modeling; as well as surface engineering and computational materials science. Several symposia were organized and conducted in conjunction with other European societies including the Federation of European Materials Societies (FEMS), Société Française du Vide (SFV), European Physical Society Condensed Matter Division (EPS), Deutsche Materialwissenschaftliche Gesellschaft (German Materials Society), Plasma and Ion Surface Engineering Committee, UK (PISE), and the European Photonics Association.

Plenary Session

A plenary session was held on Wednesday morning, June 2, during which no other sessions were held. The session included a short allocution at the beginning by then E-MRS president Hans-Ulrich Habermeier. Subsequently, five invited plenary talks were presented by speakers from Sweden, Ukraine, Switzerland, and Ireland. The first plenary talk was given by L. Samuelson (Lund University, Sweden) who discussed nano-optics of self-organized quantum dots, concentrating on InP quantum dots in GaInP and GaAs. In order to study nano-optics, new spectroscopic and microscopic tools are being developed, such as the use of microprobe luminescence, so that physical properties of individual quantum dots can now be studied. This has also become possible due to better growth techniques of quantum dots such as the Stranski-Krastanow growth mode. Samuelson made reference to single molecule spectroscopy, a new field that is quickly gaining strength, to understand materials properties at the nano- and molecular-scales.

K. Zweibel's (National Renewable Energy Laboratory, USA) plenary talk was on thin-film photovoltaics. Three main technologies are under consideration: CdTe, CuIn/GaSe and chalcogenide thin films (CIGS). Zweibel said that the costs of producing thin-film photovoltaics are from 5 to 10 times lower than that of wafer silicon photovoltaics. However, manufacturing still includes technical and financial challenges. Zweibel discussed several relevant science-based issues. K. Kern of the Institut de Physique Experimentale, Switzerland, gave his plenary talk on the use of the scanning tunneling microscope as a local probe for studying physical and chemical properties on a nanoscale level as well as manipulating single molecules and atoms. Electronic density of states on surfaces can also be studied using local probes. Kern discussed specific examples including self-organized growth of magnetic nanostructures and nanostructure formation via diffusion-controlled growth by modifying diffusion barriers. He also gave examples of creating artificial structures on a nanoscale level using atom manipulation.

J.M.D. Coey (Trinity College, Ireland) gave a plenary presentation on the science and technology of magnetic oxides. About 12 materials dominate the worldwide $30 billion market for magnetic materials. Of this, oxides comprise about 50%. CrO_2 is the only ferromagnetic oxide used. Coey discussed various aspects of research involving magnetic oxides, with a focus on magnetoresistance. He also indicated that the T_c for magnetites is currently low for applications and a new generation of ferromagnetic oxides with $T_c > 500$ K was needed. M. Valakh (Institute of Semiconductor Physics, Ukraine) closed the plenary session with a talk about materials research in Ukraine, particularly electronic materials. Considering the current economic situation in Ukraine, most recent research has focused on functional materials for use in areas such as information technologies, optoelectronics, and sensors.

The 1998–1999 President of the European Materials Research Society (E-MRS), Hans-Ulrich Habermeier, opened the plenary session of the E-MRS 1999 Spring Meeting on June 2, in the Palais de la Musique et des Congrès in Strasbourg, France.

Technical Sessions

Nine symposia had sessions on all four days while the other seven lasted for two days each. Some of the presentations are described in the following to give a flavor of the range of materials research topics that were discussed at the meeting.

Optical Materials

Single molecule spectroscopy was an important topic at the meeting. In one session in Symposium N on Molecular Photonics at the Interface of Physics, Chemistry, and Biology, U.P. Wild (Swiss Federal Institute of Technology, Switzerland) discussed recent trends in single molecule spectroscopy. The technique, which can also be called single molecule detection, uses fluorescence excitation spectroscopy at low temperatures. Requirements for this technique include low concentrations, small probed space (accomplished using lasers) and high-resolution laser spectroscopy. Wild showed examples of spectral imaging that illustrated that single molecules with frequency shifts caused by excitation are different for different molecules (Stark effect). Absorption spectroscopy by modulating the molecule rather than the light was shown. Wild also showed results for identification of single molecules at room temperature using this technique. In the next presentation, M. Orrit (CNRS et Université Bordeaux, France) reported on recent experiments on single molecule spectroscopy. In particular, he said that a single molecule can be used as a single photon source by rapid adiabatic passage of the molecular resonance through the laser frequency so that the molecule is in its excited state.

T. Basché (Johannes Gutenberg-Universität, Germany) gave a presentation, also in Symposium N, on fluorescence microscopy of single supramolecular assemblies of dendrimers and semiconductor nanocrystals. Using scanning confocal micro-

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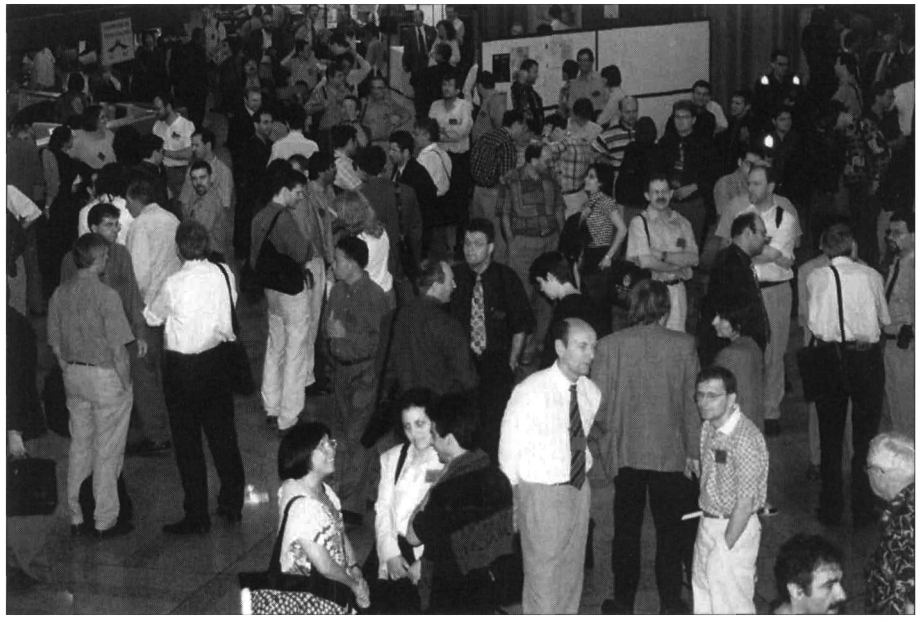
scopy, fluorescence emission of single fluorophores were imaged and results were obtained for dye-decorated dendrimers and semiconductor nanocrystals. In the following talk, Th. Schmidt (University of Linz, Austria) discussed the use of single molecule spectroscopy on biomembranes. Work using wide-field fluorescence microscopy to detect individual fluorescence labeled molecules on artificial as well as native biomembranes was described. The wide-field approach allows for the observation of dynamic processes. Studies on biomembranes including colocalization of proteins, stoichiometry, and diffusion dynamics were presented.

Presentations in this Symposium also reported that liquid-crystal-based optical valves are now operating at less than 100 μW cm^2 threshold power (The Pennsylvania State University, USA). New optical limiters combining an electron transfer moiety with conventional optical limiters (such as phthalocyanines) improve the efficiency and the spectral range of the devices (Thomson CSF, ENS Cachan, France).

In Symposium K on Materials, Technologies, and Applications for Optical Interconnects, in the first session, P. Coudray (Université de Montpellier) discussed integrated optics based on organo-mineral materials. The major objectives for integrated optics are reductions in the number of optical-electrical conversions, and increase in speed of transfer of information. Hybrid organic-inorganic materials are good candidates for integrated optics applications. The organic network can be formed using polymerization while the inorganic or mineral network can be formed using the sol-gel technique. The ratio of each can be changed. Photoimprinted waveguides using masking and ultraviolet (uv) light can be formed on a Si substrate. These waveguides open the door to optical circuits. Coudray showed examples of a power splitter and couplers. He explained that organic-inorganic hybrid materials are suited for optical devices since they are flexible, have a large range of refractive index, and can form several types of guiding structures.

Symposium J covered Materials for Coherent Optics, including a discussion on color holography. H.I. Bjelkhagen (De Montfort University, UK) gave a presentation on recording materials for color holography in which silver halide emulsions and photopolymer materials were found to be the most suitable materials for the recording media. Results using new silver halide materials from Slavich, Russia, and the panchromatic photopolymer material from DuPont were presented. Some problems included scattering in the blue region, multiple exposures, shrinkage of the emulsion, and choice of the laser wavelength. This session was followed by a roundtable discussion on materials for color holography in which one of the basic questions was whether silver halide has a future in holography or if another new material will come into play. The current move toward digital pictures is significantly cutting into traditional markets although movie film and medical x-rays still use silver halide. However, there is not much of a market for photographic holography. Some of the discussions were of a more fundamental nature, that is, where the need is for three-dimensional displays or holography. While the discussions brought out the significant issues, no consensus was reached on new materials or how to increase the market for three-dimensional holographic displays.



Meeting attendees take the opportunity to discuss materials research issues in-between sessions at the E-MRS 1999 Spring Meeting.

Organic-inorganic hybrid materials are suited for optical devices since they are flexible, have a large range of refractive index, and can form several types of guiding structures.

Industrial participants in Symposium J identified needs of the market. To generate coherent radiation, they indicated that new, more coherent, powerful, and cheaper types of lasers are required for the needed ranges of wavelengths, and for propagation, new materials are required for transmission, transformation, and modulation. They also said that new detectors with higher resolution, sensitivity, and dynamics than currently available are needed for the detection and recording of coherent radiation.

Electronic Materials

Symposium M covered Basic Models to Enhance Reliability in Si-Based Devices and Circuits. A. Plößl (Max-Planck-Institut für Mikrostrukturphysik, Germany) gave an overview on materials aspects of silicon-on-insulator (SOI) technology, highlighting the advantages of the reduction of parasitic capacitance, threshold voltage, and leakage current by insulating the electronic devices from the bulk substrate. The major problem appears to be substrate quality. Possible approaches include separation by implanted oxygen (SIMOX), internal thermal oxidation (ITOX), and wafer direct bonding. Plößl discussed various fabrication techniques and their advantages and disadvantages, as well as applications. Also, within Symposium M, W.D. Rau (IHP, Germany) described work on two-dimensional (2D) mapping of the electrostatic potential in transistors using electron holography. The Semiconductor Industry Association (SIA) roadmap indicates that 2D profiling of dopants in semi-

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conductors is crucial. While various techniques have been explored including scanning-tunneling microscopy and etching plus scanning-electron microscopy/atomic force microscopy/transmission-electron microscopy, electron holography in the TEM can map 2D potential distributions in transistors to a resolution of 5 nm. The phase of the electron wave is measured in the TEM and spatial resolutions under 5 nm can be achieved. The electrostatic potential across a *p-n* junction can be extracted as well. Various possibilities include general study of dopant interactions, microscopic calibration of 2D diffusion models in process simulations, dynamic imaging of potential distribution in device structures, and field mapping in III-V quantum structures.

Symposium O, Chalcogenide Semiconductors for Photovoltaics, included a panel discussion on "Next Generation Cells: High Efficiency Concepts, Interface Optimization, and Recyclability." The participants focused on two materials: cadmium telluride and CIGS—$CuInS_2$, $CuInSe_2$, $Cu(In,Ga)Se_2$. Highlights included reports on record performances for a small area CIGS/CdS thin-film solar cell (18.8% efficiency; more than 1% above the previous record), a 16% small area Cd-free CIGS cell with a ZnS-based buffer layer, and a 1000 cm^2 CIGS module (12.8%). In CIGS research, empirical results are being increasingly complemented and supported by fundamental understanding. On the basic science side, dramatic developments were matched by major insights into the chemistry and physics of the materials as used in the cells, and their interfaces, from the microscopic down to the atomic scale, stressing also their polycrystalline nature in the cells. Among the highlights of CIGS-based cells were reports on the atomic-scale structural and chemical characterizations of the heterojunction, and explanation of the cell's major attribute, its stability by self-healing of defects in CIGS, which classifies it as a "smart" material. Much of the work on CdTe emphasized, in addition to the above, the still problematic, back contact, with encouraging reports on Sb_2Te_3, V- and Ni-P containing ones; further evidence for large-scale intermixing at the CdS/CdTe interface, and methods of materials synthesis. This last topic led to energetic discussions on preferred methods for large scale production, spanning the spectrum from chemical and electrochemical deposition to closed-space sublimation (for CdTe) and multisource vapor deposition (for CIGS).

In the first session in Symposium N on Devices and Technology, J. Xu (University of Toronto, Canada) gave an overview of plastic electronics and future trends in microelectronics. He said that, so far, microelectronics has been evolving along a one-dimensional path, namely, miniaturization, and that research and development directions for the near-future have already been mapped out in the SIA roadmap. However, previously underattended areas of research and alternate technologies in the field appear to be rising. Xu said that massively parallel and nonbinary architectures appear to have a serious future. In this regard, plastic electronics appears almost to be the ideal candidate. Xu also made the point that plastic electronics will not and is not intended to replace semiconductor microelectronics but it can do things in ways that cannot be matched by the semiconductor industry. In the subsequent paper, J.A. Rogers (Bell Laboratories/Lucent Technologies, USA) talked about efforts to develop low-cost printing, molding, and high-resolution lithographic methods for fabricating organic optoelectronic devices. Rogers showed examples of printed electronics, organic smart pixels printed on a flexible substrate, and embossed thin films of electroluminescent polymers for high-resolution patterned light-emitting diodes. J. Zyss (École Normale Supérieure de Cachan, France) gave an invited talk on nonlinear photonic engineering encompassing molecular nonlinear optics.

Electroluminescent materials and diodes remain one of the most important topics of Symposium N with a large effort directed toward the demonstration of an electric-field pumped laser source (Hebrew University of Jerusalem and Cavendish Laboratory in Cambridge, UK). The use of multifunctional luminescent materials combining highly anisotropic conjugated polymers with laser-active moieties (organic dyes, rare earth ions) open promising perspectives in that respect (ETH Zürich, FOM Laboratory in the Netherlands). Advances in single crystal preparation and characterization of oligomers have also been reported (CNRS Thiais, Universities of Bologna and Milano).

This Symposium also showed that the

Student Awards Presented at E-MRS 1999 Spring Meeting

Student Awards were presented at the European-Materials Research Society (E-MRS) 1999 Spring Meeting held in Strasbourg, France on June 1–5, 1999. The award recipients are **Manuel Vieira Baptista** (Porto University, Portugal) "Development of Magnetoresistive Shielded Heads Simulation Techniques using Conformal Mapping"; **Andreas Bauknecht** (Hahn-Meitner-Institut, Germany) "Defects in $CuGaSe_2$ Thin Films Grown by MOCVD"; **Yordanos Bisrat** (Oxford University, UK) "An Indentation Technique for Stress Measurment"; **Alexey Bosak** (Moscow State University, Russia) "Thin Films and Bulk CMR Perovskite Solid Solution in Nd-MN-O System"; **Martin Ebert** (University of Raleigh, USA) "*In Situ* Monitoring and Control of MOVPE Growth by Combined RDS and Ellipsometry Measurements"; **Corneliu Ghica** (National Institute for Material Physics, Romania) "Structural Comparison Between La(Y)CaMnO Bulk and PLD Film"; **Robert Hoelzl** (University of Regensburg, Germany) "Gettering Efficiencies of Polysilicon-, Stacking Fault and He Implanted Backsides for Cu and Ni"; **Peter Hones** (École Polytechnique de Lausanne, Switzerland) "Mechanical Properties of Hard Chromium Tungsten Nitride Coatings"; **Kim Hyeon-Soo** (Sungkyunkwan University, Korea) "Effects of Plasma Conditions on the Etch Properties of GaN, AlGaN and InGaN"; **Szabolcs Katai** (Technical University of Budapest, Hungary) "Plasma Analyser for Plasma Assisted Surface Process Diagnostics up to 100 mbar"; **Giedrius Laukaitis Kaunas** (University of Technology, Lithuania) "Stress and Surface Studies of CdS Thin Films"; **Guy Levy-Yourista** (Weizmann Institute of Science, Israel) "Tunable Resonant Grating Waveguide Structures"; **Raul J. Martin-Palma** (Universidad Autonoma, Spain) "Development and Characterization of Porous Silicon-Based Solar Sensors and Cells"; **Emmanuel Mastio** (Nottingham, UK) "High Pressure Pulsed KrF Laser Ablation of a Thin Film Electroluminescent Base Layer ($ZnS:Mn/Y_2O_3$)"; **Panagiotis Patsalas** (Aristotle University of Thessaloniki, Greece) "*In Situ* and Real Time Monitoring by Ellipsometry During Fabrication of Submicron Titanium Nitride/Titanium Silicide Electronic Devices"; **Mark Potter** (University of Durham, England) "A Comprehensive Study of Bevel Etched CdTe/CdS Solar Cells Subjected to Different Cadmium Chloride Anneal Times"; **Cornelia Schoenjahn** (Sheffield Hallam University, UK) "The Interface between TiAlN Hard Coatings and Steel Substrates Generated by High Energetic Cr^+ Bombardment"; and **Monika Stoiber** (University of Leoben, Austria) "Germanium Nanoclusters in Silica Thin Films."

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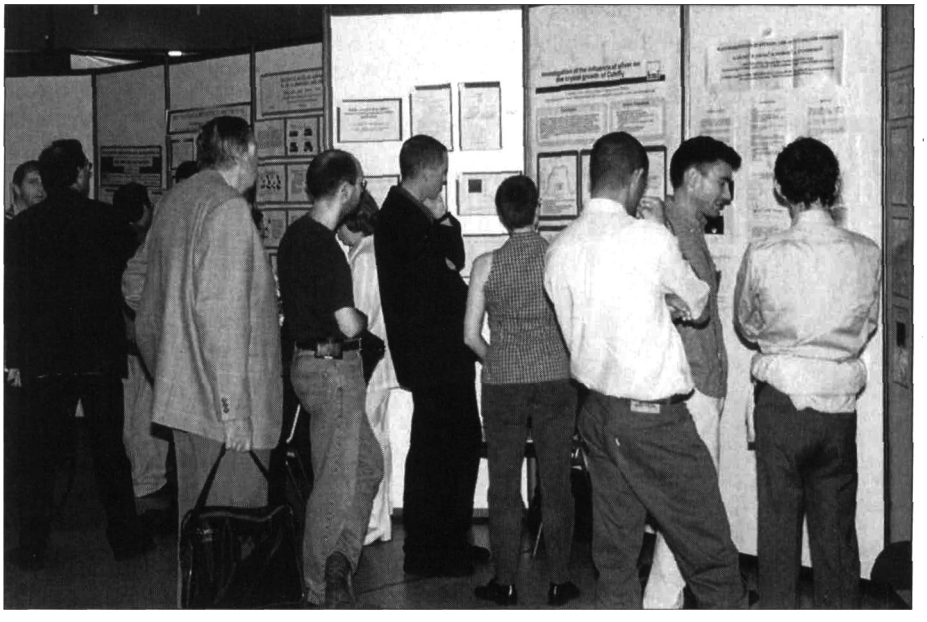
use of transition-metal charge transfer sensitizers or ladder-type conjugated polymers has resulted in interesting performances of photovoltaic molecular materials with a solar/electric power conversion yield as high as 11% (Swiss Federal Institute of Technology, Lausanne, University of Munich).

Symposium I focused on micro- and nanocrystalline semiconductors, beginning with a look at porous silicon. In addition to interesting presentations in the field of basic research, for example, a model covering the formation of different kinds of pores, a variety of applications and devices of porous silicon was presented. Sensors, coatings for solar cells, spectral sensitive photoresistors, and waveguides drew attention. Also in the field of bio-applications, porous silicon seems to play an important role as demonstrated by using this material as a substrate for biosensors.

The second session of this Symposium focused on the growth of these materials, especially the polycrystalline materials for photovoltaic applications and the formation of nanocrystals. Microcrystalline Si on glass substrates holds a great potential for commercial solar cells since this material combines long-term stability with good efficiency at a reasonable manufacturing cost. Even higher efficiencies are reported for tandem cells, which combine one cell of amorphous Si, with its higher bandgap, with another cell of microcrystalline material. Nanocrystals are intensely investigated for the application in nonvolatile electronic memories and show interesting optical properties due to the carrier localization. Another highlight was the combination of theoretical presentations on the nucleation and growth Ge layers on Si in conjunction with several experimental presentations from different groups. In this field the meeting could span the entire range from theory over basic studies to the device performance characteristics of Ge-based detectors. A surprising contribution was the presentation of the photonic properties of spark processed Si, which may show strong charge blockade effects of silicon electrical conductivity under photonic irradiation—this makes this material a semiconductor, which has a lower conductivity, if illuminated. The microscopic understanding of this effect is not yet obvious.

The electrical and optical properties of nanocrystals were explored in Symposium I as an emerging field where semiconducting particles with their modified electrical and optical properties are arranged in a continuously better defined oxide environment. The "nanos" may exchange carriers via tunneling or via thermal excitation over barriers. Their electronic properties, the bandstructure with or without surface states, are increasingly better understood. A distinguished highlight was the presentation of a superlattice structure, which is comprised of Si nanoparticles and insulating layers of SiO_2. These superlattices are well-defined, show stable electrical characteristics and the Coulomb blockade charging effects, which may be well-suited for memory applications. Also the dipolar interaction between nanoparticles and luminescent ions was discussed in several presentations. This process may lead to efficient sensitizing of luminescence in optical devices.



The E-MRS 1999 Spring Meeting included several poster sessions intermixed with oral presentations in various symposia.

Microcrystalline Si on glass substrates holds a great potential for commercial solar cells since this material combines long-term stability with good efficiency at a reasonable manufacturing cost.

The luminescence of precipitates and clusters, especially the FeSi in its various phases, was a strongly debated issue in this Symposium. The situation is apparently still controversial. The careful investigation of electronic transport in TiO_2 nanoparticles was a well-accepted contribution. These oxides with semiconducting properties at elevated temperatures may be understood within the framework of electronic bands and defect or surface states, which pin the Fermi energy. The defect structure itself is sensitive to the atmospheric environment, which gives these systems a high potential for sensor applications.

Other Highlights

Symposium A focused on Photo-Excited Processes and Applications. In one session on crystallization processes, G. Fortunato (IESS-CNR, Italy) discussed excimer-laser crystallization (ELC) techniques for polysilicon thin-film transistors (TFTs). The ELC process has several advantages including glass compatibility, scalability over large areas and high material quality, although it requires tight control of laser energy density. The ELC process was shown to considerably improve the performance of polysilicon TFTs. J.S. Im (Columbia University, USA) presented work on pulsed-laser-induced crystallization of thin Si films, using a technique called sequential lateral solidification (SLS) which yields low defect density crystalline Si films. This has relevance to applications in active-matrix liquid-crystal displays, active-matrix organic light-emitting diodes, TFTs, and integrated displays.

In the same session, F. Huisken (Max-Planck-Institut, Germany) described laser-induced production and deposition of Si clusters by pyrolysis of silane using a CO_2

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laser. The cluster/particle beam is injected into a high vacuum chamber and ionized using an excimer laser for time-of-flight mass spectroscopy. A beam chopper running synchronously with the CO_2 laser is used for size selection. High-resolution electron microscopy was used to reveal details of the crystalline structure of silicon nanoparticles as a function of size. Huisken also described work on photoluminescence of the nanoparticles. Size selection is important for photoluminescence, and smaller nanoparticles result in a wider bandgap. A uv laser was used to excite the films and the photoluminescence was spectrally analyzed. Larger particles were seen to luminesce at a lower energy, or longer wavelength. An astrophysical connection was made in this session: A broad red emission band is observed in astronomical objects, for example in the Orion constellation. This has been attributed to photoluminescence of an interstellar dust grain component excited by the uv radiation from a nearby star. This astrophysical aspect was discussed also in a separate paper by O. Guillois (CEA, France) in Symposium I.

Computational materials science, the topic of Symposium C, is showing a closer integration than before of the diverse methodologies and progress toward hybrid methods. To study electronic structure and dynamics simultaneously, the Car-Parrinello technique has become a real "workhorse" and it is the method of choice for systems of up to a few hundred atoms observed over time periods on the order of 10 ps. For larger systems or longer times, tight-binding molecular dynamics is the preferred approach. Several scientists reported applications of these methods to novel fields such as biomolecules and pharmacological systems, besides the more traditional materials (e.g., metals and semiconductors). Classical electronic band structure methods continue to be very useful tools yielding a great deal of information, from binding energies and activation barriers to excited states.

Classical particle-based simulations, using the Monte Carlo (MC) or molecular dynamics (MD) approaches, increasingly rely on energetic information obtained from first-principles calculations rather than resorting to a phenomenological description. With continuing advances in computer power, MC and MD now permit the study of mesoscopic systems and in some cases approach the scale of macroscopic objects. The largest system reported at the Symposium had over 5,000,000 atoms, with time-scales in MD simulations approaching milliseconds (on the order of tens of millions of time-steps). Spectacular though these numbers may be, only continuum methods permit studies of truly macroscopically large systems, over long time scales (in some cases ranging on the order of centuries). Impressive work along those lines was reported for electromigration, metallic foams, and micromagnetism, to name a few. Here too, major progress has been made in the last few years.

Clearly the main challenge in the years ahead will be the integration of the various methods to span time and length scales. Some work in this direction was presented at the meeting and showed very encouraging signs that major breakthroughs can be expected in this direction in the next few years. There was also strong evidence of the continuing efforts to use the tools of computational materials science to study "real" materials: systems with imperfections or highly complex unit cells, in high-energy collisions, or interacting with solvents.

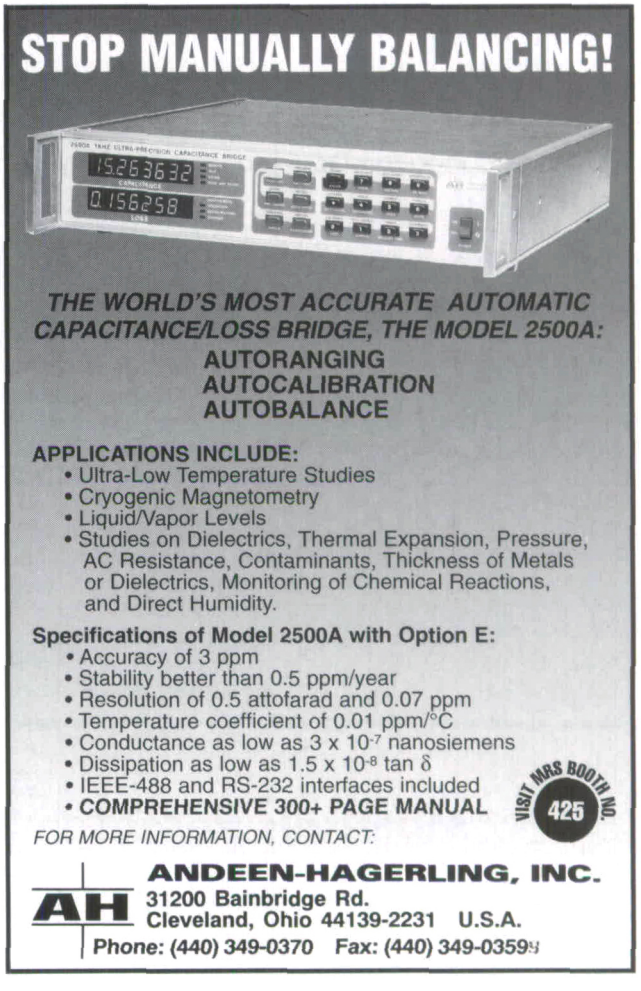
Reported by G. R. Rao with contributions from E-MRS symposium organizers.

MRS-I Announces XIth AGM

The XIth Annual General Meeting (AGM) of the Materials Research Society of India (MRS-I) will be held in Baroda on February 3–5, 2000. It is being organized by the Gujarat Chapter of MRS-I, Sardar Patel University, and Indian Petrochemical Corporation.

The XIth AGM will feature a Theme Seminar on Materials in the Service of Chemical Industries with special emphasis on the materials for the new century.

MRS-I Medal recipients will present lectures in the areas of biomaterials, ceramics and glasses, electronic materials, metals, processing technologies, materials characterization, building materials, composites, polymers, magnetic materials, computer-aided design of materials, thin films, and fracture. See Calendar listing on page 85.



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