International Conference on Electronic Materials Held in Australia for the First Time

www.aumrs.com.au/ICEM-08
Meeting Scenes: www.mrs.org/ICEM-08

For the first time, a meeting of the International Union of Materials Research Societies (IUMRS) was hosted by the Australian Materials Research Society (A-MRS). The 2008 IUMRS International Conference on Electronic Materials (IUMRS-ICEM 2008), chaired by James S. Williams of the Australian National University and president of A-MRS, was held in Sydney, Australia on July 28 to August 1, 2008. The Meeting featured six technical themes comprising 20 symposia, some of which were held jointly with the 2008 Conference on Optoelectronic and Microelectronic Materials and Devices (COMMAD 08); plenary lectures; two forums, one on energy and one on industry; poster sessions; and an equipment exhibit. With abstracts from 51 countries submitted, 1000 presentations were scheduled. Following are a few selected highlights from the Meeting. For fuller coverage provided by the Materials Research Society, see Meeting Scenes at Web site www.mrs.org/ICEM-08.

Nobel laureate Sir Harold W. Kroto (left) of The Florida State University, USA and C.N.R. Rao of the Jawaharlal Nehru Centre for Advanced Scientific Research, India presented plenary lectures at IUMRS-ICEM 2008 held in Australia.

Sir Harold W. Kroto (The Florida State University, USA and 1996 Nobel laureate in chemistry) kicked off the conference with a plenary presentation on "Architecture in NanoSpace." Chemistry, physics, and biology come together at the interface of nanoscience and nanotechnology. Complex molecules that "do things" are being made, based on understanding the clustering behavior of molecules. Kroto and others in the United Kingdom grew up tinkering with Meccano toys, experiencing the "nuts and bolts" of engineering at an early age. Such tinkering skills are now being applied to versatile fullerene structures including carbon nanotubes; buckyballs, large and small; and functionalized constructions. Kroto also now spends much of his time inspiring young people around the world with the marvels of fullerenes through lectures, fullerene models, and humor. In his presentation, Kroto chronicled fullerene developments after their debut more than 20 years ago, and the many researchers who contributed. Starting from confirming the hollow cage structure and putting other elements—such as lanthanum—inside, nanoscale devices paralleling devices in standard engineering are now being created. From a thermometer based on a metal-filled nanotube to advanced molecular electronics, fullerenes continue to feed the creativity of scientists. Such developments require a paradigm shift in synthetic chemistry so that very large molecules can be carefully structured. Kroto's ultimate challenge is to make a tennis racket from bundled nanotubes to the tune of 10^{15}, all of the same diameter, forming a resilient surface held together by van der Waal's "glue." Structurally analogous to a bundle of straws, if developed, Kroto said this would be the strongest material in the chemical world. For additional illustrations of some key elements of the field, see the Vega Science Trust Web site (www.vega.org.uk) and the Global Educational Outreach Web site (www.geoset.info).

In another plenary address, C.N.R. Rao (Jawaharlal Nehru Centre for Advanced Scientific Research, India) spoke about new routes for achieving multiferroic materials, which simultaneously exhibit some form of ferromagnetism and ferroelectricity. Among the mechanisms examined for achieving multiferroics were lone-pair effects and local non-centrosymmetry. Lone-pair effects are believed to be the source of ferroelectricity in $BiMnO_3$, with the lone pair on the Bi ion leading to structural distortions. There does remain some doubt as to whether $BiMnO_3$ is ferroelectric at all, as theory and experimental work have shown $BiMnO_3$ to belong to a centrosymmetric space group. However, more recent results show that different phases of $BiMnO_3$ exist for different oxygen stoichiometries, and these phases may be non-centrosymmetric. As a result, further studies still need to be conducted to confirm ferroelectricity in $BiMnO_3$. An alternative route to multiferroic materials is through local non-centrosymmetry. This mechanism is present in $YCrO_3$, wherein non-centrosymmetric space groups provide a better fit to diffraction data in the short-range regime, while centrosymmetric space groups fit better at longer scales. Such local non-centrosymmetry is found to be consistent with a number of rare-earth chromites and their ferroelectricity has been confirmed by second-harmonic generation. Rao also presented new results on ferroelectric-ferromagnetic nanoparticles. It is known that all oxide nanoparticles show some surface ferromagnetism, while $BaTiO_3$ nanoparticles are also known to be ferroelectric. As a result, these oxide nanoparticles may provide another route to multiferroic materials.

Photonic crystals, wherein the refractive index changes periodically in two or three dimensions, is the subject of significant and extensive current research. Plenary speaker Susumu Noda (Kyoto University, Japan) described recent results in the manipulation of photons by engineering the photonic crystal structure.

In another plenary address, Stuart S.P. Parkin (IBM Almaden Research Center, USA) discussed spintronics and its application to memories and logic devices.

Plenary speaker Mildred S. Dresselhaus (Massachusetts Institute of Technology, USA) looked at materials developments to address the growing worldwide energy consumption from 13 TW in 2000 to an expected 40–50 TW by 2100. Dresselhaus said that nanomaterials, with their unique properties at the nanoscale and high surface areas for catalytic behavior, are well-suited for energy applications. Pt_3Ni catalysts provide a 10× improvement over pure Pt catalysts in fuel cell oxygen reduction reactions. These catalytic breakthroughs are especially important, as an exponential relationship exists for catalytic activity, thus promoting a Moore's law behavior. For example, carrier multiplication in semiconductor nanocrystals, in which a single photon has been shown to generate as many as six electron–hole pairs, may provide a route for increased solar cell efficiency. Dresselhaus concluded by saying incremental advances will be insufficient to address emerging energy needs and large discoveries are necessary.

Energy was covered in greater depth in the Energy Forum later in the week chaired by James S. Williams (ANU), Elizabeth L. Fleischer (MRS), Alan J. Hurd

During the Industry Forum held at IUMRS-ICEM 2008, panelists discussed case studies of Australian start-up companies.

(Los Alamos National Laboratory, USA) and Ken Baldwin (ANU). The Forum was an extension of the *MRS Bulletin* issue on "Harnessing Materials for Energy" (www.mrs.org/bulletin_energy) published earlier in 2008.

The first several talks presented the urgency for innovative energy technology development, framed by climate change and growing demand by the developing countries as they strive for parity with the developed world.

Janette Lindesay, a climatologist with the Australian National University, addressed "Climate Change Tipping Points," defined as a specific threshold beyond which there could be drastic consequences to the Earth's environment and human life. She described current modeling efforts to estimate various figures for variables such as temperature change and carbon dioxide levels. To define policy-relevant tipping elements, she described a thought experiment to demonstrate the interconnectedness of various effects. In terms of the El Niño southern oscillation, a modified El Niño could affect the Indian monsoon, which could result in a change in the Tibetan albedo. This could in turn affect the bistability of Saharan vegetation in Africa, which could lead to the collapse of the Amazonian forest, leading to reduced performance of the marine carbon pump that absorbs carbon from the atmosphere. While all of this is hypothetical, it demonstrates the interconnections between complex systems. Currently, many individuals have identified 2°C as a temperature change tipping point corresponding to a 450 ppm level of CO_2 in the atmosphere (which is now at 300 ppm). Clearly there is a sense of tremendous urgency to come up with solutions and to not push systems beyond such tipping points, said Lindesay. Moving with a sense of urgency to increase efficiency and expand renewable alternatives, she said, is the best bet toward avoiding such tipping points.

V.S. Arunachalam (Center for Study of Science, Technology and Policy, India), in his presentation on, "The Global Energy Landscape," agreed that the danger is real. The current energy crisis is truly a global problem and should be looked at for global solutions, he said. While developing nations such as China and India are accelerating their needs for energy, on a per capita basis the "developed" countries such as the G8 nations have a significantly higher energy consumption. While much focus is on renewable sources, Arunachalam described coal as an important "equal opportunity" option for energy, which is not going to disappear any time soon. Improved processes with greater efficiency and carbon capture and sequestration will therefore be important areas of development. He said that solar and nuclear are critical technologies for solving the energy problems for countries such as India. He also discussed biofuels, though caution is needed in terms of diverting resources from the food supply.

With the burden of the message from the previous talks weighing on him, David S. Ginley (National Renewable Energy Laboratory, USA) presented renewable energy opportunities that can contribute to the solution. While renewable energy such as solar fluctuates and varies by location and over time, a global electricity grid could bridge such imbalances and reduce the need for energy storage.

Subsequent sessions of the Energy Forum focused on specific materials challenges, including solar energy (Andrew Blakers, Australian National University; Eicke Weber, Fraunhofer Institute for Solar Energy Systems, Germany; and Dave Eaglesham, First Solar, USA); and hydrogen, storage, and nuclear options (Calum Drummond, Commonwealth Scientific and Industrial Research Organisation, Australia and Maurice Ripley, Australian Nuclear Science and Technology Organisation, Australia).

In the Industry Forum, Gabriel Crean of the Athlone Institute of Technology, Ireland and 2008 president of IUMRS, gave a report on the Irish economy and landscape, the Irish Government Policy Framework for Industry, the Indigenous Industry Sector, the Global Entrepreneurship Monitor, and the future challenges for Irish start-up companies. Ireland's economic growth has outstripped that of the United States and the European Union. The government of Ireland is very interested in the progress of Irish companies in the world market and offers a well-focused series of programs that are monitored closely, Crean said. In 2007, there were 1600 start-up inquiries, with 79 startups, 1500 new jobs projected in three years, and €69 million of investment supported by Enterprise Ireland.

Eaglesham recounted the history of First Solar (USA) and gave an instructive talk on what it takes to get a product to market. The First Solar technology is to deposit cadmium telluride onto glass substrates and the thrust of First Solar is to differentiate itself from its competition with sound business strategies and to add to the technology as production continues. And Parkin talked about the new class of solid-state memory that is being developed at IBM Almaden (USA) that will have the same cost as a magnetic hard-drive in a computer with no moving parts and with the speed of a flash memory but with longevity and the ability to be rewritten many times.

The plenary presentations in the Industry Forum were followed by Australian start-up case studies (Jose Alarco of The Very Small Particle Company, Karl Föger of Ceramic Fuel Cells Limited, Richard Taylor of Mesaplexx, Dax Kukulj of RPO P/L, and Scott Butcher of BluGlass Ltd.).

ICEM runs every two years. The next meeting will be hosted by MRS-Korea on August 22–27, 2010.

International Conference in Asia Held in Japan

Meeting Scenes: www.mrs.org/ica2008

The 2008 IUMRS International Conference in Asia (IUMRS-ICA 2008), organized by the Materials Research Society of Japan and supported by MRS regional societies in Asia: Chinese Materials Research Society (C-MRS), Materials Research Society of India (MRS-I), Materials Research Society of Korea (MRS-K), Materials Research Society of Singapore (MRS-S), and Materials Research Society of Taiwan (MRS-T), was held on December 9–13, 2008 in Nagoya. The conference featured new materials research from not only Asia but also around the world. The conference included six plenary presentations and over 40 technical topics. Following are a few selected plenary presentations from the Meeting. For fuller Meeting coverage provided by the Materials Research Society, see Meeting Scenes at Web site www.mrs.org/ica2008.

Osamu Takai (left) of Nagoya University, chair of the IUMRS-ICA 2008 conference held in Japan, and Naoki Kishimoto of National Institute for Materials Science, president of MRS-Japan.

During the opening ceremony, Osamu Takai (Nagoya University), chair of the conference, said that there are a number of current environmental issues that the world is grappling with, and this conference is a way to get information on the latest relevant research in advanced materials that could make a difference. The president of MRS-Japan, Naoki Kishimoto (National Institute for Materials Science), mentioned the recent economic turmoil around the globe and said Asia is now a critical player on the world stage. The conference is therefore clearly relevant from that perspective, Kishimoto said. The other major issue is renewable energy, for which materials technology in particular has many solutions to offer.

Sumio Iijima (Meijo University, Japan), well known as the discoverer of carbon nanotubes (CNTs) in 1991, made clear in his plenary talk that there is still a lot of work to be done with this material. After giving an overview of various CNT developments, Iijima discussed practical applications of CNTs. These include uses in flexible electronics, as gas adsorbers (based on the specific surface area), and in composite materials. One example is in microelectromechanical systems wherein a relay was demonstrated with all parts made from CNTs. Iijima described "nanohorn" aggregates which could be used for drug delivery applications. In one specific example, he discussed using the nanohorns for photodynamic therapy wherein light is used to activate specifically targeted tumors in the body.

Plenary speaker Suk-Joong L. Kang (Korea Advanced Institute of Science and Technology, South Korea) introduced the terms abnormal grain growth (AGG), normal grain growth (NGG), and stagnant grain growth (SGG) observed in any type of microstructural development. Through the concepts of grain growth rate, grain size, driving force, and interface mobility, he introduced the importance of interface structure where the equilibrium shape of a crystal can be predicted from the polar plot and the crystallographic plane corresponding to the cusps in the polar plot appearing on the equilibrium surface. Growth rate versus driving force gives rise to various growth modes leading to rough surface (continuous growth) or faceted surface (two-dimensional nucleation and growth, defect-assisted growth twinning, and dislocations). Growth of a crystal consists of serial processes of diffusion and interface reactions wherein for rounded crystals the growth rate is governed by diffusion and for faceted crystals, the growth rate is a mixed control of diffusion and interface reaction. Kang demonstrated that in a faceted system, there are three kinds of grains: growing grains, stagnant grains, and dissolving grains. He further discussed microstructure tailoring in two-phase systems and grain boundary structure: rough (disordered) and faceted (ordered). He showed that it is possible to tailor polycrystalline structures by controlling the structural transition of the interface by temperature, dopants, and oxygen partial pressure.

In a plenary presentation on bulk glassy alloys (BGA), Akihisa Inoue (President, Tohoku University, Japan) introduced Zr-based glassy alloys and properties of hypo-eutectic BGA. The Zr-Al Cu-Ni system with 70% Zr has very large plastic strains and high fracture toughness. Mechanical properties of bulk metallic glasses (BMGs) are ductile at low temperatures (77 K). Poissons ratio decreases with decreasing temperature whereas the strain increases (ductility) which improves mechanical strength at low temperatures. Ti-based BMGs (Ti-Zr-

Recipients of the IUMRS-ICA 2008 Young Researcher Award.

Cu-Pd system, 7–10 mm) are useful as biomedical implants for artificial teeth and for the formation of bone-like apatite. Porous titanate is important for formation of high adhesion hydroxyapatite. Applications of Zr-Ti and Fe-based alloys include metallic glass diaphragms for pressure sensors, geared motors (2.4 mm diameter) constructed with metallic glass gears, a three-stage microgear motor which is 20 times stronger than ordinary vibration motors (4 mm), connection adapters, and advanced medical equipment.

Plenary speaker Akira Fujishima (Kanagawa Academy of Science and Technology, Japan) discussed the importance of the photocatalysis phenomenon of TiO_2 in various areas of day-to-day life. He presented work on transparent TiO_2-coated films on which bacteria was cultured and killed by heat treatment. With the addition of silver cations, bacteria could be killed in the dark. This technology has been implemented in hospitals and by the highway association of Japan. Fujishima also presented examples of TiO_2 coated on soda lime glass for self-cleaning surfaces, and TiO_2-coated air filters for air cleaning systems to deodorize, disinfect, and decompose dust. He explained the importance of superhydrophilicity of TiO_2 (antifogging effect) and its applications in the transportation industry, including glassed-in smoking areas in Japanese Shinkansen (Bullet) trains to keep them clean as well as application to the exteriors of the newer trains. Fujishima also presented his latest work on TiO_2 nanosheets, which possess a smooth surface enabling a stain-free exterior.

Plenary speaker Baixin Liu (Tsinghua University, China) summarized up-to-date experimental studies on the formation of amorphous alloys/metallic glasses by ion beam mixing of multiple metal layers in equilibrium miscible and immiscible binary metal systems; and Samuel Stupp (Northwestern University, USA) gave a plenary address on the self-assembly of supramolecular materials for applications in regenerative materials.

XVII International Materials Research Congress in Mexico Held in August 2008

Meeting Scenes: www.mrs.org/mex08

The XVII International Materials Research Congress, chaired by Juan Mendez Nonell, president of the Mexican Materials Research Society, was held in Cancún on August 17–21, 2008. Through recent outreach efforts with the Materials Research Society, the conference saw a significant MRS presence, as introduced by then MRS president Cynthia A. Volkert (University of Göttingen). During the opening ceremony, Volkert introduced the MRS officers who were supporting the meeting, including Alan J. Hurd of Los Alamos National Laboratory and 2008 MRS immediate past-president; Shef Baker of Cornell University and 2008 vice president/president-elect; and Todd Osman, the new executive director of MRS. Volkert also described a memorandum of agreement between the two societies stating that MRS will continue the "Meeting Scene" coverage of the Mexico conferences for three years. Other benefits of the cooperation include electronic membership in MRS for MRS-Mexico members, jointly organized symposia starting in 2009, and an arrangement whereby poster award winners from the International Materials Research Congress will be invited to present their posters at the MRS Spring Meeting in San Francisco. Similarly, poster winners from the MRS Spring Meeting will present their posters at the International Materials Research Congress in Cancún. Following are a few selected plenary presentations from the Meeting. For fuller Meeting coverage provided by the Materials Research Society, see Meeting Scenes at Web site www.mrs.org/Mex08.

Among the various activities at the conference were five plenary presentations. Plenary speaker Ibrahim Dincer (University of Ontario Institute of Technology, Canada) is known for his pioneering efforts in the field of sustainable energy. He is the editor-in-chief for the *International Journal of Energy Research* and the *International Journal of Exergy*. Dincer began his presentation by discussing the current energy issues facing the world today, then proceeded to discuss the topic of renewable energy resources and the potential of hydrogen in helping to resolve these issues. A major challenge facing the large-scale implementation of a hydrogen-based energy program, Dincer said, is the need to develop all aspects of hydrogen production, storage, and transportation. While much effort is currently under way toward achieving this, a major component of any alternative energy implementation plan is the establishment of an efficient distribution infrastructure. Although there is no current distribution system for hydrogen, a distribution infrastructure is already in place for ammonia. Dincer proposed the use of ammonia as a hydrogen source and presented a number of theoretical economic calculations in order to compare the expected performance of ammonia-based energy systems with more traditional fossil-fuel–based and optional environmentally friendly (i.e., wind, solar) solutions.

Plenary speaker Alan J. Russell is a Distinguished University Professor of Surgery and the Founding Director of the McGowan Institute for Regenerative Medicine at the University of Pittsburgh, USA. Russell briefly reviewed the primary challenge faced in the field of conventional bactericidal materials. He said that although a number of chemistries—including various antibiotics, the use of silver ions, halides, and quaternary ammonium compounds—have been the focus of extensive research studies, there is a significant risk of bacterial resistance because these technologies have involved the slow release of active materials. His stated solution was to polymerize and covalently bind these active compounds to permanent substrates to prevent leaching.

Juan Mendez Nonell, president of the Mexican Materials Research Society and chair of the XVII International Materials Research Congress.

Other plenary topics included the mechanics of nanostructural materials (Volkert); concrete deterioration (María del Carmen Andrade Perdrix, Institute of Construction Sciences-CSIC, Madrid, Spain), and particle surface modification (Richard Partch, Clarkson University, USA).

VII Annual Meeting of Brazil-MRS Held in Autumn 2008

www.sbpmat.org.br/7meeting
Meeting Scenes: www.mrs.org/Brazil08

The VII Annual Meeting of the Brazilian Materials Research Society, chaired by Aldo Craievich (University of São Paulo, Brazil) and Reginaldo Muccillo (Energy and Nuclear Research Institute, Brazil) with program chair Osvaldo Novais de Oliveira Jr. (University of São Paulo, Brazil), was held in Guaruja, state of São Paulo from September 28 to October 2, 2008. The meeting attracted 1100 participants from more than 10 countries and included 14 thematic symposia and nine plenary lectures. Following are a few selected plenary presentations from the Meeting. For fuller Meeting coverage provided by the Materials Research Society, see Meeting Scenes at Web site www.mrs.org/Brazil08.

Plenary speaker Alexandra Navrotsky (University of California, Davis, USA) opened the meeting with a lecture on the energetics of nanomaterials. She described calorimetric studies of oxide nanoparticles which have established systematic trends in energetics at the nanoscale. Typically, idealized nanoparticles are considered for investigations. However, real nanoparticles do not have ideal characteristics, with a distribution of sizes, irregular varying shapes, defects, and imperfectly controlled surfaces for example. With this in consideration, Navrotsky described the competition among polymorphism, surface energies, and hydration. This has been shown to lead to a crossover in phase stability at the nanoscale. Metastable polymorphs were found to have lower surface energy. Oxyhydroxides have a lower surface energy than oxides, and hydrated surfaces have lower surface energy than dry surfaces. Ultimately, surface energy depends on morphology. Navrotsky also described the effects of morphology for ZnO where nanoneedles were shown to have the highest surface energy, nanorods intermediate, and nanoparticles the smallest.

Enrico Traversa (Università di Roma "Tor Vergata," Rome, Italy) and Gehan Amaratunga (Cambridge University, UK) both addressed the topic of energy in their plenary lectures. In discussing the current energy situation in the world, Traversa said it is clear from an environmental and sustainability viewpoint that alternate energy sources need to be used. Another interesting dynamic is that the overall population around the world is aging and will require adequate health care in the future. For solutions to these problems, materials will play a key role with required improvements in performance. The approach followed by Traversa's research group is to find nanostructured materials with innovative characteristics. For gas-sensing applications, he described reducing the size of semiconducting metal oxides to increase sensitivity of sensors. In the area of energy, Traversa said the availability of solid-oxide fuel cells is limited by the high operation temperature (1000°C) of commercial cells needed due to the use of yttria-stabilized zirconia (YSZ) as a solid electrolyte. One solution is to develop nanostructured materials for the electrolyte in order to reduce the temperature below 700°C. Nanostructured materials can also be developed for the cathode, anode, and protonic conductors. In the health area, Traversa described some recent work in his group on cardiac tissue engineering which requires millimeter-scale, micrometer-scale, and nanoscale structures all within the same single structure.

Amaratunga described his group's ongoing research using nanocomposites for photovoltaic (PV) energy harvesting. He presented a transparent PV cell fabricated by dispersing single-walled carbon nanotubes (SWNTs) onto a transparent substrate and then growing ZnO nanowires over them using the hydrothermal method. Another PV cell was fabricated by growing ZnO nanowires on a fabric composed of electrospun carbon fiber. A black dye was included to enhance light absorption. Considering the reverse process, Amaratunga fabricated ZnO-SWNT composite light-emitting diodes, which display a strong monochromatic emission at 450 nm. Amaratunga speculated that the source of this emission had to do with defect sites in ZnO nanowires that might act as cavities for light amplification.

Other plenary topics included layer-by-layer fabrication processes for nanoassembly of soft matter devices (Gero Decher, Institute Charles Sadron and Université Louis Pasteur, France); materials science solutions to particulate matter pollution (Agusti Sin, Pirelli Eco Technology, Italy); mechanical properties of metal nanowires and nanoporous foam (Brian Derby, University of Manchester, UK); nanostructures and properties of materials (Gernot Kostorz, Swiss Federal Institute of Technology, Zürich); dielectric charging and electrostatic adhesion (Fernando Galembeck, State University of Campinas, Brazil); and the prioritization of research and development topics in advanced materials (Fernando Rizzo, Center for Strategic Studies and Management Brazil).

From left to right: Brazilian-MRS President Fernando Lázaro Freire, Jr., (Pontifícia Universidade Católica do Rio de Janeiro) with conference chairs Aldo Craievich (University of São Paulo) and Reginaldo Muccillo (Energy and Nuclear Research Institute) and program chair Osvaldo Novais de Oliveira, Jr., (University of São Paulo), at the opening of the VII Annual Meeting of B-MRS.