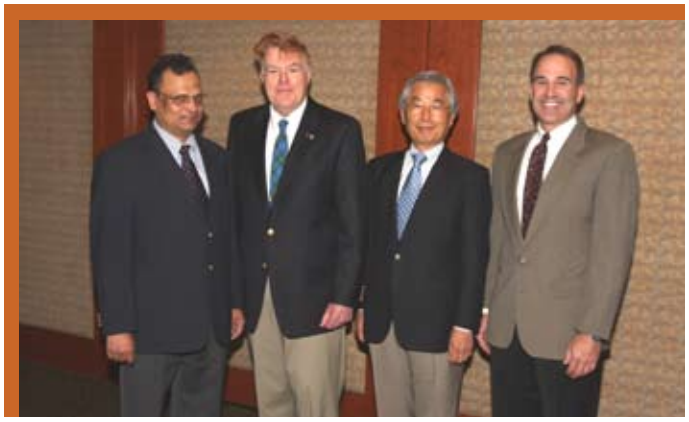
Phoenix Meeting Highlights



Sumio Iijima *(third from left) delivered the ECS Lecture at the Plenary Session of the 213th ECS Meeting in Phoenix, Arizona. Prof. Iijima also was presented with the first Richard E. Smalley Award of the Fullerenes, Nanotubes, and Carbon Nanostructures Division from its current Chair,* **Francis D'Souza** *(far left). On hand to congratulate Prof. Iijima were ECS President* **Barry MacDougall** *(second from left) and ECS Executive Director* **Roque Calvo** *(far right).*

John Newman *(left) was presented with the 2008 Vittorio de Nora Award, one of the Society's highest honors, given for contributions to the field of electrochemical engineering and technology. Presenting Prof. Newman with his medal is ECS President* **Barry MacDougall**.

Eliezer Gileadi *(left) received the 2008 Henry B. Linford Award for Distinguished Teaching from ECS President* **Barry MacDougall**. *The Linford Award is given for excellence in teaching in subject areas of interest to the Society.*

Temperatures topping out at 107°F didn't stop attendees of the 213th ECS Meeting in Phoenix from enjoying the many offerings of downtown Phoenix: from the many tempting local restaurants, to excursions to Sonoma, or even to a Sunday afternoon at the ballpark. The 39 sessions drew in over 1,357 attendees to hear 1,250 presentations. The ECS Annual Business Meeting, held on Tuesday, was a lively luncheon that included a vote on changes to the Constitution and Bylaws (see page 15), awards being given to the best General Student Poster Session papers (see page 57), and presentations to the winners of the IE&EE Division's Outreach Program (see page 11).

Nanometric Objects and Chip-Scale Platforms for Disease Diagnosis

The Phoenix installment of the popular "XYZ ... for the Rest of Us" series was given by **Marc D. Porter** on "Nanometric Objects and Chip-Scale Platforms for Disease Diagnosis." These Sunday evening talks help to educate meeting attendees about

ECS Leadership Circle Awards are presented for loyal support of ECS as demonstrated through the Corporate Membership Program. **Kevin Colbow** *(top photo, at right) of Ballard Power Systems received a Gold Level award for the company's 25 years of corporate membership from ECS President* **Barry MacDougall** *(top photo, at left).* **Jeff Jones** *(bottom photo, at left) of Agilent Technologies received a Bronze Level award the company's 5 years of corporate membership from ECS President* **Barry MacDougall** *(bottom photo, at right). Three other Leadership Circle winners were unable to attend:* **ECO Energy Conversions** *at the Gold Level, for 25 years;* **Varta Automotive Battery**, *also at the Gold Level, for 25 years; and* **Lawrence Berkeley National Lab**, *at the Bronze Level, for five years.*

areas outside of their immediate domain and to promote discussion and cross-disciplinary interactions (the "XYZ" changes with each talk). Prof. Porter began his tutorial by underlining the fact that the demand for early disease detection and the growing threat of bioterrorism have been the twin drivers in the search for ultrasensitive, high-speed, and high-throughput analytical methodologies. The name of the game here is to push the limit of detection and analytical sensitivity to the attomole (10^{-18}) and yoctomole (10^{-24}) limits while doing the analysis at a fast rate of speed. The capabilities of surface enhanced Raman scattering and giant magnetoresistance-based sensing to meet these analytical chemistry needs were then addressed. It was pointed out that the footprint of Raman spectrometers has drastically shrunk in recent years contributing to their adaptability to mobile sensing environments. Raman sensing can be beneficially combined with immunoassays to provide early warning for prostrate and pancreatic cancer.

Strategies for combining these approaches with molecularly-directed chemical modification were discussed and analytical speed advantages were pointed out. For example, conventional methods for diagnosis of bovine wasting disease take up to 12-16 weeks to get back results because of the need for culturing the microorganisms. The new generation bio-analytical approaches circumvent these delays resulting in substantial savings in cost for the animal farming enterprise.

The last part of the talk focused on the development of a flight deployable water quality monitor. This assay was based on colorimetric solid phase extraction technology. The analytical challenges with fluids in microgravity were underlined along with the human challenges (*e.g.*, motion sickness) involved in dealing with flights to simulate microgravity.

Single-Walled Carbon Nanotubes

The ECS Lecture, given by **Sumio Iijima** to a packed Monday morning Plenary Session audience, was entitled, "Single-Walled Carbon Nanotubes: Synthesis, Modification, and Characterizations." Professor Iijima currently holds three professional titles at Meijo University, the National Institute of Advanced Industrial Science and Technology (Tsukuba), and with the organization where he did most of his seminal work on carbon nanotubes (CNTs), namely NEC (Nagoya, Japan). Professor Iijima was introduced by Barry MacDougall, President of the Society. The plenary speaker divided his talk into three topics: (a) synthesis and growth mechanisms of single-walled carbon nanotubes (SWNTs), (b) microscopy of CNTs, and (c) selected applications of SWCNTs and their nanohorn (SWCNH) counterparts.

The talk began with some history mentioning that the oldest paper on CNTs probably dated back to a Russian publication in 1952, although these researchers then were handicapped by the lack of availability of electron microscopy to confirm structure and morphological aspects. Iijima reminded the audience of a career stop in neighboring Arizona State University, first as a postdoctoral fellow (1970-1976) and then as a senior research associate until 1982. Prof. Iijima interspersed his talk with microscopy data collected during this period on SWNTs, fullerenes, and similar materials. The talk then turned to preparative aspects of CNTs. It was pointed out that a major technology roadblock with these materials was the difficulty in process scale-up from milligram to kilogram quantities and cost. He showed pictures of current work in his laboratory addressing these issues including the use of stainless steel substrates (instead of silicon), and nitrogen instead of helium for chemical vapor deposition (CVD) of carbon. A large scale continuous CVD process was also designed with an aim to improve process throughput and lower cost.

The Dielectric Science and Technology (DS&T) Division's Thomas Callinan Award winner **Paul Kohl** *(right) is pictured with the incoming Chair of the DS&T Division* **Durga Misra** *during the Division's Luncheon & Business Meeting during the ECS meeting in Phoenix.*

This fast-moving talk then focused on *in situ* transitions in carbon structure and morphology that accompanies electron bean heating. The process of graphene formation from sp^3 carbon structures and double walled nanotube formation by thermal treatment of peapods were discussed along with fascinating videos of "plumbing" of SWCNTs via *in situ* Joule fusion whereby broken tubes could be "repaired" with an electron beam. Catalyst-free growth of SWNTs rounded out this portion of the lecture focusing on preparative aspects—an important topic especially given that recent claims of electrocatalytic properties of CNTs are often clouded/confounded by problems with the presence of residual metal catalyst nanoparticles in them.

The next part of the lecture focused on structural and microscopic aspects of CNTs, mainly involving the use of high-resolution transmission electron microscopy. The direct imaging of carbon atoms, the hexagonal grapheme network, and atomic defects was discussed. Examples of other elegant studies including those of C_{80}, $Er_3N@C_{80}$ and the *cis-trans* transition of biomolecules within C_{60} "cages." The effect of electron beam irradiation on vacancy dynamics in CNTs and doping of these materials with C_{60} and Cs were discussed. Interestingly, the crystal structure of iodine in a CNT framework was shown to be different from that of the bulk solid.

The last part of the talk dealt with applications of CNTs (particularly SWCNTs) in devices including microelectromechanical systems (MEMS), thin film transistors, flexible electronic devices, supercapacitors, etc. Other applications for SWCNHs included fuel cells, gas storage, drug delivery, and biological recognition. The use of CNTs for cancer treatment via photodynamic therapy was also mentioned. A cautionary item of note in this regard is the potential toxicity of carbon nanomaterials when injected or otherwise assimilated (*i.e.*, inhaled) into the human body. From an application standpoint, difficulties with separating semiconductor and metallic nanotubes were also mentioned by the speaker. All in all, this was a most fascinating talk on a class of materials that are currently enjoying huge popularity in the science, engineering, and biological communities. Whether the exciting possibilities mentioned by the speaker will transcend into practical technologies, only time will tell.

After the lecture, the speaker was presented with the first Richard E. Smalley Award of the Fullerenes, Nanotubes, and Carbon Nanostructures Division by its current Chair, Francis D'Souza.

IDEAS: Intriguing Disclosures of Electrochemical Advances Symposium

Ideas for enhancing the quality and format of the technical program at ECS meetings keep churning up and one of these, under the appropriately titled acronym, IDEAS, made its debut at the Phoenix meeting. The objective of IDEAS is to bring new and fundamentally intriguing ideas in science and engineering to ECS. The first IDEAS was held in Phoenix. **Mark Wightman**, of the University of North Carolina, described the measurement of neurotransmitters in rat brains as rats respond to stimuli; rats generate the same neurotransmitters in anticipation of a reward as generated upon receipt of the reward. **Shelley Minteer**, of St. Louis University, detailed the wiring of mitochondria to electrodes for full conversion of fuel to carbon dioxide and how the introduction of explosives can be sensed at the electrode as mitochondrial kinetics are enhanced by the explosives. **Yueh-Lin (Lynn) Loo**, of Princeton University, discussed solution processable conducting polymers for forming mechanically flexible, low cost electronic components, including transistors; appropriately processed components based on polyaniline (PANI) had extraordinarily high conductivities. **Tom McCarthy**, of the University of Massachusetts, presented extraordinary, quantitative insights and videos on wettability; a better understanding of wettability will enable better control of fluid motion and delivery at surfaces. All four invited presentations were insightful and thought-provoking, clearly fulfilling the objective of IDEAS.

Tutorials on Nanotechnology: Focus on Energy Technology

As another innovation in the meeting program, the Tutorials on Nanotechnology, co-organized by C. Bock and S. Narayanan, were held for the second time in Phoenix. Lectures followed by discussions on various topics of energy technology were presented. **Eric McFarland**, of the University of California, presented an excellent balance between basic science, materials selection, as well as the economics of the topic of "Photoelectrochemical Hydrogen Generation." **Krishnan Rajeshwar**, of the University of Texas in Arlington, followed up with a lecture on "The Science and Technology of Semiconductor-Electrolyte Interfaces: Photovoltaic and Photocatalytic Solar Energy Applications." **Christos Comninellis**, of EPFL (Switzerland), shifted the focus to "Electrode Materials for the Environment," presenting recent on-line mass spectrometry studies utilized to shed light on the involvement of oxide anodes in electrochemical incineration reactions; while **Rachid Yazami**, of Caltech, highlighted the fundamentals of nano-materials for Li-ion batteries and the challenges for their mass production. The final two presentations focused on fuel cells. **Mark Debe**, from 3M, compared his non-conductive, nano-structured catalyst support whiskers to conventional designs, showing their long-lived stability due to the elimination of carbon corrosion. Finally, **Kourosh Malek**, of IFCI (Canada), introduced the challenging, but nevertheless highly relevant topic of modeling catalyst layers on the nanometer scale, tuned to design-improved catalyst layers for enhanced catalyst utilization and better water management. All the tutorial sessions were exceedingly well-attended with the lecture-hall overflowing in some cases with attendees in standing-room only capacity.

From nW to TW

John Newman gave the 2008 Vittorio de Nora Award Lecture entitled, "From nW to TW" after being introduced by President Barry MacDougall. This lecture, as with the one above, covered three topics, namely the Onsager reciprocal relations for multi-component diffusion, the electrochemical reduction of CO_2 and water to CO and H_2 (collaborator: Charles Monroe), and the production of liquid fuels from renewable energy (collaborator: Charles Delacourt). The speaker began his talk by pointing out the 21 orders of magnitude separating the two power units in the lecture title.

Prof. Newman mentioned that the Onsager expressions and their derivation had puzzled him for *ca.* 40 years. He began with some historical notes beginning with Onsager's work itself in 1931 and 1945 and with Wheeler's re-interpretation of the reciprocal relations (expressed rather deceptively simply by $D_{ij} = D_{ji}$) using Green-Kubo theory in 2004. He also noted that there had been criticisms of the original Onsager work (for example, by Coleman and Truesdale in 1960). The speaker then turned to the four interlocking pieces for the theory expounded by Onsager and the governing macroscopic relations. The conclusion of this part of the talk was that the criticisms were unfounded and Prof. Newman has since been entirely convinced about the correctness of the Onsager theory.

The second part of the lecture focused on a more practical and ultimate goal related to making methanol from CO_2 and water. A flow-by electrochemical cell (EC) was discussed and its design was pointed out to be essentially a fuel cell in reverse. It consisted of a proton exchange membrane (PEM) separating a cathode compartment driving the reduction of CO_2 to CO, H_2, and H_2O with the water being oxidized to O_2 in the anode chamber. The PEM facilitates the transport of protons in the reverse direction to the situation in a fuel cell device. Thus this EC system makes syngas (CO + H_2) at a low over-potential by using catalysts such as silver, gold, or zinc and an electrolyte consisting of potassium bicarbonate. The EC performance parameters (current density, voltage, efficiency) were discussed next and the catalyst selectivity was found to decrease in some case due to (CO) poisoning.

The ultimate goal is the synthesis of methanol from CO_2, thereby converting a greenhouse gas to useful fuel. Prof. Newman pointed out that in a solar energy conversion scenario, most of the sunlight would be converted directly to electricity but a fraction would be stored as a fuel such as methanol. He then presented some numbers on separating CO_2 from air (costing some 22 kJ/mol) and then converting it to methanol with a free energy content of 702 kJ/mol. Thus, in the above technology, the electrical power needed for the EC system would come from a photovoltaic system (with a practical efficiency of 17 %) and the EC reactor would operate at an efficiency of 40 %. The overall conversion of CO_2 to syngas would have a net efficiency of 6.8%. Details on the subsequent conversion of syngas to methanol were not presented. The advantages of this overall approach relative to the proposed use of biofuels to solve our energy and environmental problems were finally addressed and they mostly relate to issues related to food impact/price and land use.