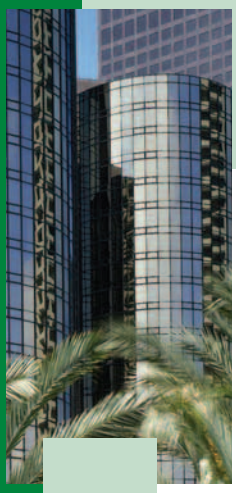


Meeting Highlights

Los Angeles offered meeting attendees a close look at some of the extremes in our world today, from the very unreal world of moviemaking to the harsh realities of sustainable energy. During the week, meeting goers could nightly watch the street outside the hotel turn into a scene from downtown Shanghai, complete with street signs and commercial trucks all lettered in Chinese. One could also watch the surreal production of a high-speed chase scene being acted out in slow-motion. A good part of the meeting focused on energy (see "Mission Impossible" from ECS President Bill Smyrl on page 7). Prof. Nate Lewis delivered the plenary address, giving a very sobering global view of the challenges in achieving affordable, environmentally responsible, and sustainable energy. (See below for a summary of his talk).

Over 1,730 registrants attended 39 sessions to hear over 1,335 papers covering a range of topics from "Battery Safety and Abuse Tolerance" to "Sensor Based on Nanotechnology." Continuing the theme of energy at the meeting, there was also a special session honoring Supramaniam Srinivasan, a visionary who made seminal contributions to the fuel cell field beginning in the early 1960s, and who became one of the most important and respected leaders in that community worldwide. "Srini," as he was known, was also one of the founders of the ECS Energy Technology Division. The Short Course program, held on the Sunday of the meeting, offered eight courses ranging from impedance spectroscopy to the basics of cleaning processes for IC manufacturing.

The Honors and Awards Session on Wednesday inducted the 2005 ECS Class of Fellows and honored two recipients of the Society's top awards: Robert Rapp received the Olin Palladium Award (see below for a summary of his award address); and Joseph Hupp received the Carl Wagner Award. On hand to greet Dr. Rapp was David Cawlfield, a representative from the Olin Company, sponsor of the award. The session was also an opportunity to express some well-deserved thanks to ECS Executive Director Roque Calvo, for 25 years of service to the Society.

October 16-21 2005

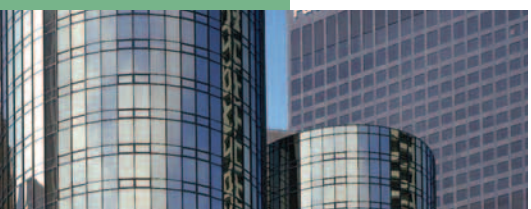
Scientific Challenges in Sustainable Energy Technolgy

Sustainable Energy... *The plenary session, given by* ***Nathan S. Lewis****, of Caltech, gave meeting attendees a broad, global view of the challenges in achieving affordable, environmentally responsible, and sustainable energy. Pictured above are Prof. Lewis (right) and ECS President* ***William Smyrl****.*

Nathan S. Lewis, the 2002 George L. Argyros Professor of Chemistry at the California Institute of Technology, delivered the plenary address on Monday morning. Prof. Lewis has been on the Caltech faculty since 1988 and is also a principal investigator at the Beckman Institute Molecular Materials Resource Center on campus. His research interests include light-induced and "dark" electron transfer reactions at semiconductor/electrolyte interfaces, photoelectrochemistry and solar energy conversion, solar energy processes involving transition-metal complexes and dye-sensitized solar cells, and novel uses of conducting polymers and polymer/conductor composites including the development of sensor arrays.

Prof. Lewis began his highly entertaining and informative lecture by calibrating the audience on power units ranging from a watt (consumed by a laptop computer) to a kW (typical of a bread toaster device) all the way to a terawatt (1 TW=10^{12} W) typical of global power consumption. His talk was organized into the present primary power mix, future constraints imposed by sustainability, theoretical and practical energy potential of various renewables, and the challenges to exploit renewables economically on the needed scale to meet environmental constraints. He referred to his campus website (http://nsl.caltech.edu; see the "Global Energy Perspective" link) where the talk is available and can be downloaded. He showed figures on the available fossil fuel resource base, illustrating that there is plenty of coal for the next hundred odd years—enough to meet projected demands. Thus, renewables will not play a role in primary power generation unless or until technological/cost breakthroughs are achieved or externalities are introduced (*e.g.*, environmentally-driven carbon taxes).

The talk then switched to a discussion on energy and sustainability, and specifically the analysis of Marty Hoffert et al. ("Energy Implications of Future Atmospheric Stabilization of CO_2 Content," *Nature*, **395**, 881, 1998). These authors underscore the pitfalls of a "wait-and-see" policy. They point out that stabilization of greenhouse gases (specifically CO_2) in the atmosphere, to levels that are considered safe in terms of catastrophic climate changes, will not occur unless and until policy incentives are made on renewable energy R&D to overcome socioeconomic inertia. Capitalization of carbon-free power is needed on a 10-30 TW scale by 2050. This, in the authors' crystal ball, could require efforts, perhaps international, pursued with the urgency of the Manhattan Project or the Apollo space program. Lewis then displayed graphic examples of observations of global climate change including the systematic



and gradual retreating of glaciers (Glacier National Park, 1910-1997), melting of the Greenland ice sheet, coral bleaching, and the rising of sea levels.

The talk then turned to examining the energy potential of various forms of renewable energy (hydro, geothermal, ocean/tides, wind, biomass, and solar) and also the nuclear (fission and fusion) option. Carbon sequestration technology was reviewed. The final part of the talk centered on solar energy conversion. It was noted that solar electricity is currently capacity-limited (100 MW mean power output manufactured in 2001) and also subsidized in countries like Japan and Germany. The industry shows high growth; but starts from a small base. The cost is favorable, and technology competitive, in off-grid installations. The rudiments of solar photovoltaic technology were then presented, the author noting the need to produce fuel to offset the down-time (at nightfall) of a solar energy system. A fuel cell was compared and contrasted with a photoelectrolysis system that produces hydrogen from water. The speaker concluded his fast-moving talk by noting that "disruptive" technologies were needed (*e.g.*, solar paint) to make the solar option practically viable in a renewable energy mix. Policy changes will also be needed to gradually wean ourselves away from carbon-centric energy, because failure is not an option in terms of the environmental consequences. ■

Nate Lewis *(second from left), the plenary lecturer at the Los Angeles meeting, answered questions after his presentation on Monday morning.*

*The **2005 Class of ECS Fellows** were inducted at the Honors and Awards Sessions by ECS President Bill Smyrl. Seated, from left to right are: **Takeshi Hattori, Radoslav Adzic, John R. Scully**, (President Bill Smyrl), **Hans-Henning Strehblow, Philippe Marcus**, and **Paul Natishan**. Standing, from left to right, are: **Derek Pletcher, Bruno Scrosati, Mark Williams, Jean-Pierre Leburton, Jim L. Davidson, Charles Martin**, and **Rajiv Singh**.*

Hot Corrosion of Materials

Robert Rapp, the 2005 Olin Palladium Award recipient, gave his address at the Honors and Awards session on Wednesday morning. The awardee was introduced by his colleague, Gerald Frankel, Director of the Ohio State University Fontana Corrosion Center. Professor Rapp was born in Lafayette, Indiana; and after undergraduate education with honors in metallurgical engineering from Purdue University, completed his MS and PhD at Carnegie-Mellon University. Following a postdoctoral stint with Carl Wagner (coincidentally the first Palladium Medal recipient of the Society and in whose honor the Carl Wagner ECS Award is named) at the Max-Planck-Institut for Physical Chemistry in Goettingen, Germany, he served in the U.S. Air Force as a first lt. and research metallurgist stationed at the WPAFB in Dayton, Ohio. Frankel noted that the stay in Germany had a personal poignancy, having contributed to Dr. Rapp meeting his future wife, Heidi, who was also present at the award lecture. Rapp's distinguished academic career began in 1963 at The Ohio State University, from where he retired from teaching in 1995. He continues his research activities at OSU to the present time.

Robert Rapp *(center) received the 2005 Olin Palladium Award for outstanding contributions to the fundamental understanding of all types of electrochemical and corrosion phenomena and processes. ECS President **Bill Smyrl** (left) presented the award on behalf of the Society. **Jerry Frankel**, Director of the OSU Fontana Corrosion Center, introduced the award recipient at the Honors and Awards session on Wednesday of the meeting week.*

The award address began by acknowledging the contributions of his mentors

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Looking for Lithium Ions...

A recent fixture on the ECS meeting landscape has been the "XYZ for the Rest of Us" talk series on Sunday evenings. This edition featured Li-ion battery technology and was given by Clare Grey of the State University of New York (SUNY) Stony Brook. The talk was organized around how rechargeable batteries worked; technical requirements for 21st century devices, the breakthroughs needed to achieve these goals, and new measurement probes (such as nuclear magnetic resonance or NMR) of battery operation, mechanisms, and performance. The Holy Grail in this field centers on batteries that last very long and deliver power in an infinitely short duration of time. While handheld devices such as cell phones need low power, quite the opposite is demanded from batteries for uninterrupted power supplies (UPS) (*Editor's note:* See article by Nishide and Suga in this issue, p. XX) and hybrid electric vehicles.

The "rocking chair" battery based on a Li anode and a MnO_2 cathode—the device that kicked off a flurry of activity on Li-ion batteries—was then discussed. These devices are light and have high voltage stemming from the Li/Li^+ redox couple. Other examples of this battery technology include Li intercalated into TiS_2 (pioneered by Mark Whittingham), the $LiCoO_2$ device operated with a carbon anode (pioneered by John Goodenough), and the Sony cell capable of delivering 90 Wh/kg. Grey pointed out that these and other types of cells have been reviewed by Tarascon and Armand, *Nature*, **414**, 359 (2001). There are several drawbacks with these first-generation Li-ion cells related to component mate-

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Hot Corrosion of Materials
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A representative from the Olin Corporation, ***David Cawlfield*** *(left), was on hand to greet the Olin Palladium Medalist,* ***Bob Rapp****.*

(namely Wagner and Marcel Pourbaix) to the Rapp research program. The phenomenon, now known as "hot corrosion" (a term coined by Rapp), began with observations of turbine engine failures in Ni-base alloys during the Vietnam War. Sulfides and salt products were seen (subsequently traced to a thin sodium sulfate-based fused salt film).The early studies of Goebel, Pettit, and De Cresente and co-workers, while noting the footprints of this type of corrosion, did not address the mechanistic details. These studies noted that dissolved sulfur oxides were somehow involved (unlike O_2 in conventional corrosion) and that hot corrosion led to fluxing/dissolution of the protective scale.

Over the years, Rapp and his coworkers established that phase diagrams (of the sort pioneered by Pourbaix) were the key in understanding the mechanism of the hot corrosion process. The speaker first presented the essential aspects of the Na-S-O ternary phase stability diagram, in which the activity of sodium oxide was the independent variable (much like pH in the more conventional Pourbaix diagram). He showed how mapping the nickel and chromium (another component in turbines) onto the parent Na-S-O diagram at selected high temperatures (*e.g.*, 1173-1200K) immediately showed the reactivity of these metals toward the fused salt. The contributions of his students, D. Gupta and Y. Zhang, were acknowledged by Prof. Rapp in this context. Both acidic and basic dissolution modes were recognized and discussed in these studies. The thermodynamic/thermochemical analysis methodology was extended to many other oxides, both basic (derived from Co and Fe), and acidic (Al), as well as silica. With K. Goto, Rapp proposed a fundamental mechanism (negative solubility gradient criterion) to explain the mechanism of hot corrosion.

The talk then centered on measurement tools at high temperatures (*e.g.*, potentiometry) to establish the veracity of the models by monitoring of the melt basicity and O_2 activity. The contributions of C. O. Park and N. Otsuka were highlighted in this portion of the talk. The formation of nickel sulfides at the oxide/salt interface was discussed, via extraction of sulfur from the salt raising the basicity of the medium by as much as 4 decades. The key variables in this interfacial high temperature phenomenon are Ni purity and the melt basicity. Synergistic dissolution involving Fe and Cr in sodium sulfate (work done by collaborator Y. S. Hwang) revealed why Cr is an optimal alloying element to combat hot corrosion of metals in the salt. These studies showed how consumptive re-precipitation of the oxide will not occur in the presence of Cr in the salt film.

The talk wound up by noting the recent studies on high temperature and low temperature variants in hot corrosion as elaborated by Pettit *et al.*, Shores, and Luthra and others. The National Science Foundation was finally thanked for sponsoring the work that was presented. Roger Staehle was acknowledged by Rapp for teaching him the Pourbaix methodology. Professor Rapp concluded his award address by offering a simple thanks to his wife, Heidi, for her understanding and steadfast support through the years. ■

Joseph Hupp *(right) received the 2005 Carl Wagner Award, given for significant achievements in research in areas of interest to ECS, and significant contributions in the guidance and development of students or colleagues in education, industry, or government. Presenting him with the award was ECS President* ***Bill Smyrl****.*

The ***ECS Young Author Awards*** *are given each year for the two best papers published in the* Journal of The Electrochemical Society. *The 2004 award recipients were (left)* ***Rohan Akolkar*** *(Vol. 151, No. 11, 2004, p. C702) and* ***Yi-koan Hong*** *(JES, Vol. 151, No. 11, 2004, p. G756).*

ECS Executive Director ***Roque Calvo*** *(left) received a special award for his 25 years of service to ECS from ECS President* ***Bill Smyrl****. The award recognized Calvo's "exceptional leadership, which has contributed so greatly to the continued growth and success of the Society."*

Looking for Lithium Ions...
(continued from previous page)

rial toxicity and scarcity (*e.g.*, Co), low capacity, and short-circuits arising from dendritic growth. The new markets (projected at 1 million kWh and $1-3 billion) for these lightweight batteries demand even better performance; and thus the search continues for new anode materials (nanoparticles and composites) and new cathode materials (manganese spinels, phosphates, layered materials) that are cheap and non-toxic.

The second part of the lecture focused on the deployment of state-of-the-art measurement probes such as solid-state NMR to Li-ion battery electrodes for investigating function and failure modes. NMR spectroscopy, used in conjunction with other techniques such as X-ray diffraction and absorption spectroscopies, can shed light on the role that local structure plays in controlling Li-ion transport and battery performance. ■