

# Denver COLORADO

## Meeting Highlights

Denver held at least one surprise for attendees of the 209<sup>th</sup> ECS meeting: The “Mile-High City” showered late arrivals and night-owls with a short-lived snow storm one evening. The Hot Topic breakfast on Monday morning featured James Trainham, Vice President of Science and Technology for PPG Industries and formerly of DuPont and Invista. Dr. Trainham spoke about “Outsourcing R&D to Developing Countries: Threat or Opportunity?” and discussed why outsourcing is not just about cost savings, but about building capability. New organizers, new symposia, and new attendees are always welcome at ECS meetings; but the Denver meeting had its share of farewells. The Silicon Materials Science and Technology symposium held its 10<sup>th</sup> session in Denver; but it was the last to be organized by Howard Huff. Current and past organizers were on hand to celebrate 40 years of remarkable science in the field and to thank Dr. Huff and his wife Helen for their many

years of organizing the symposium, which has meant so much to the solid-state activities of the Society and the electronics community at large.

At the ECS Annual Business Meeting, ECS President William Smyrl reported that 2005 had been another excellent year for ECS. The *Journal* and *Letters* set records for the largest number of papers published in both journals. The President thanked the editors of the two journals, Paul A. Kohl and Dennis Hess, the entire Editorial Board, and Curt Holmes for his tremendous leadership for the past five years as chair of our Publication Committee.

President Smyrl also noted that as the year 2006 comes to a close, so would the Centennial Campaign. Because of the success of the campaign, ECS has been able to add a number of new activities that will help to advance our science; and he mentioned a few of the significant ones. ECS has a new fellowship named in honor of Hebert H. Uhlig; and the Society was

able to establish the first full graduate student scholarship named in honor of Oronzio De Nora. Through the generous support of Intel Corporation, the new Gordon Moore Award for Outstanding Achievement in Solid State Science and Technology has been endowed. Through funds raised from the campaign, ECS has been able to build the new ECS Digital Library (accessed at the new and improved ECS website), which provides advanced search capabilities for the *Journal*, *Letters*, and *Meeting Abstracts*, and presents the newest publication, *ECS Transactions*. ECS has also been able to improve student benefits and services, and provide additional grants to support participation at our meetings. President Smyrl noted that these accomplishments were quite impressive, but as any diligent president will tell you, “There is still more to do.” He expressed the hope that members would continue to support ECS through our annual giving campaign.

The President went on to note with regret that two ECS Past Presidents passed away over the past year. Paul Milner, President in 1985, and Walter Hamer, President in 1964, were both outstanding leaders in the Society. Dr. Smyrl said that, “As Paul is more of a contemporary to me, I can say from my own experience that there has never been finer person in the Society or a leader who had a greater commitment to ECS.”

Lastly, those members present at the Annual Meeting voted to approve recommendations to amend the ECS Constitution. Those amendments will now go on to a vote by the ECS membership. Included are provisions to allow electronic balloting for the election of ECS officers and future amendments.

### Renewable Energy: Progress and Promise

Ralph Overend of the National Renewable Energy Laboratory (NREL), Golden, CO delivered the plenary



The Silicon Materials Science and Technology symposium held its 10<sup>th</sup> session in Denver, and it was the last to be organized by Howard Huff. Present and past organizers were on hand to celebrate 40 years of remarkable science in the field. Back row, from left to right, are **HANS RICHTER**, **DIETER GILLES**, **WALTER HUBER**, **HOWARD HUFF**, **BERND KOLBESEN**, and **ULRICH GÖSELE**. In the front row, from left to right, are **COR CLAEYS**, **WILFRIED VON AMMON**, **LASZLO FABRY**, **HELEN HUFF**, **HIDEKI TSUYA**, and **MASAHIRO WATANABE**.



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address on Monday morning. The speaker was introduced by Barry MacDougall, Vice-President of the Society and a postdoctoral colleague of Dr. Overend's at the National Research Council (NRC) of Canada. In the 1970s, Dr. Overend was at the NRC as manager of the Bioenergy Program and advisor on biomass energy to the Department of Energy, Mines, and Resources of the Canadian government. He joined NREL in 1990 to provide technical leadership in biomass, including field management of the U.S. Department of Energy's Biomass Power Program. Dr. Overend has provided significant input to national policy decisions concerning the resource and carbon cycle implications of large-scale biomass energy deployment.

Dr. Overend began his talk by noting the enormous challenges associated with energy solutions and that a balanced portfolio of energy options was needed. The "sawtooth-shaped" profile of CO<sub>2</sub> in the atmosphere was noted underlining the positive slope of this profile and the associated effects on global warming. Capping the CO<sub>2</sub> at 550 ppm would require that two innovation gaps be bridged, namely that of carbon sequestration and the development of hydrogen synfuel. The corresponding energy demand gap in a "CBF 550 World" would have to be filled by a combination of nuclear energy and renewables.

The talk next turned to petroleum, in terms of both the resource base and the increasing demand. In this context, the Hubbert's bell curve was discussed; and it was noted that while consumption of the first trillion barrels of oil spanned a 125-year timeframe, the next trillion would be consumed in only 30-odd years! The effect of population growth and urbanization in this energy equation was discussed with a footnote of the exponential growth in energy demand not only in the U.S. but in other countries such as China and India. It was pointed out that renewables constituted only ca. 6% of the total energy mix in 2004 with an increase to 7% if it was "business as usual." Clearly this need for capping of carbon-based energy calls for a new paradigm for energy solutions with energy efficiency, renewable energy, nuclear energy, and distributed energy all playing key roles.

Dr. Overend then turned to a summary of NREL's mission and activities in renewable energy. He identified the laboratory as providing the key link between science and technology in renewable energy. A major area of effort was in energy efficiency, specifically in technologies related to smart roofs and windows, new building materials, and lighting technologies from non-incandescent sources. Recall that a major source of inefficiency in traditional light bulbs lies with the fact that a major fraction of the input electrical energy is transduced into heat rather than light. Other areas of activity at NREL and partnerships with academia and industry involve photovoltaics, solar thermal, wind, biomass, and geothermal. The status and potential of each of these energy approaches were discussed. [Editor's Note: This portion of the talk complemented that given by Prof. Nathan Lewis of CalTech at the Los Angeles meeting (fall 2005).]

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The Plenary Lecturer for the Denver meeting was **RALPH OVEREND** (center), who spoke about "Renewable Energy: Progress and Promise," to an audience of over 1,000. (See the story for a summary of his talk.) **BARRY MACDOUGALL** (left), ECS Vice-President, and colleague of Dr. Overend's, introduced the speaker. ECS President **BILL SMYRL** (right) joined them for this photo.



**FLORIAN MANSFELD** (center) was presented with the 2006 Vittorio de Nora Award, one of the Society's highest forms of recognition. Prof. Mansfeld received the award from ECS President **BILL SMYRL** (left), and was introduced by his longtime friend and colleague, **WOLFGANG LORENZ** (right). (See story for a summary of his talk.)



The 2006 Henry B. Linford Award was presented to **DEREK PLETCHER** (left) by ECS President **BILL SMYRL**. The award is given for excellence in teaching in subject areas of interest to ECS.

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In the concluding portion of the lecture, ethanol economy, hydrogen, and future prospects of renewable energy were addressed. The speaker reminded the audience that “Corn was King in America, especially in the Midwest.” Recent developments in genomics and optimizing corn production were briefly discussed. Dr. Overend then talked about the recommendations coming out of the Department of Energy (Basic Energy Sciences) workshop on solar energy utilization held in April 2005. He concluded the talk on an optimistic note by stating that renewables can meet the 15 TW (terra watts) of non-carbon energy needed to cap the CO<sub>2</sub> level at 550 ppm or even 30 TW needed for a 350 ppm level. What this entailed was a concerted R&D effort by engineers and scientists alike and he exhorted the ECS community to meet this challenge by working on renewable energy solutions.

## The Interaction of Bacteria and Metal Surfaces

Florian Mansfield, a professor of materials science at the University of Southern California, delivered the 2006 Vittorio de Nora award address on Wednesday morning. The awardee was introduced by Prof. W. J. Lorenz, of the University of Karlsruhe, who pointed out that Dr. Mansfield had a wide range of hobbies and interests outside of his chosen profession, ranging from professional sports (soccer and football, especially following the USC Trojans), tennis and mountain biking, to opera. Prior to joining USC, Dr. Mansfield had a long and distinguished career at Rockwell International Science Center in Thousand Oaks, CA.

Dr. Mansfield began his award address by recognizing his mentors and colleagues in the field of corrosion science and electrochemical impedance spectroscopy (EIS). He reminisced that he actually wanted to work with Paul Delahay (then at Louisiana State University) after completing his PhD in physical chemistry from the University of Munich. However he wound up at MIT with H. H. Uhlig, where he was also influenced by the work of S. Gilman and M. Salomon. During his postdoctoral tenure in Germany with W. J. Lorenz, he overlapped with many scientists who carved out distinguished careers of their own, among them, E. Parry, K. Oldham, and G. Lauer. Finally he mentioned his long-term collaborators, M. Kendig, B. Little, and C. Breslin, and acknowledged the contributions of his many postdoctoral fellows and students.

The talk was organized into four topics: microbially-induced corrosion (MIC), microbially-induced corrosion inhibition (MICI), bacterial batteries, and microbial fuel cells. Dr. Mansfield began by discussing the formation of biofilms on stainless steel and the subsequent ennoblement where the corrosion potential systematically shifts to more positive potentials on exposure to bacteria-containing media. He showed EIS data using both natural and artificial seawater exposure from Key West, FL of SS 316L and copper coupon samples. The effect of cathodic protection on biofilm formation was discussed. This approach has implications in the biomedical engineering field in terms of protecting metal implants in the human body and inhibiting infections.

Dr. Mansfield then turned to MICI by showing data on aluminum (Al 2024), mild steel and brass. Artificial seawater containing *S. algae* and *S. ana* was used as the corrosion-inducing medium and the influence of the addition of kanamycin (an antibiotic which “kills” the biofilm) was discussed using EIS data processed in the Bode plot format.

The strategy of using genetically-modified bacteria for corrosion inhibition was mentioned as were the mechanistic

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The Leadership Circle Awards recognize long-term supporters of the Society. At the Denver meeting, three Corporate Members were recognized by ECS President **BILL SMYRL** (center). **LILI DELIGIANNI** (left) received a Diamond Level award for 50 years of support by **IBM CORPORATION**. A Bronze Level award was presented to **RALPH BRODD**, for 5 years of support from **BRODDARP OF NEVADA**. Unable to make the presentation ceremony was a representative from **DURACELL**, which will be presented with a Diamond Level award for 50 years of support.



At the Sunday evening reception and meeting of the Electronics and Photonics Division (EPD), **HOWARD HUFF** (left) was presented with a special award for his years of dedication and leadership as the lead organizer on the Silicon Materials Science and Technology symposium. Presenting the award was EPD Chair **JERZY RUZYLLO**.



**HISHAM MASSOUD** (left) received the 2006 Electronics and Photonics Division Award from Chair **JERZY RUZYLLO**. The award is given to encourage excellence in electronics research and outstanding technical contribution to the field of electronics science.

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aspects. Evidence was shown for an electrostatic origin of the corrosion protection in terms of the negative charge on the biofilm repelling the corrosion-causing chloride species from the metal surface. The data indicated this as a more plausible MICI mechanism than the release of inhibiting agents from the biofilm.

The concluding part of the award lecture focused on the bacterial battery, which consisted of Al and Cu electrodes in Luria broth (LB) containing bacterial (*Shewanella*) colonies. Strangely enough the power output of this battery *increased* with time as the bacterial interaction with the Cu surface changed its potential (ennobled it) while the Al potential did not change. Finally, Dr. Mansfield urged the audience to come listen to the talk given by his collaborators on microbial fuel cells at the meeting.

### Bio/Nanoscience and Electrochemistry

The popular “XYZ for the Rest of Us” Sunday talk series continued in Denver with a well-organized and informative tutorial lecture by Charles (“Chuck”) Martin of the University of Florida at Gainesville. The talk began with a discussion of gold nanotubes prepared by electroless Au plating on the inner walls of template pores of track-etched polycarbonate membranes. Dr. Martin demonstrated the advantage associated with having a gold surface that is amenable to a variety of chemical functionalization strategies. The nanotube diameter could also be fine-

tuned to be selective for ingress by an analyte molecule. A conical shape for the nano-sized channel enhances the electric field strength at the pore tip as brought out by digital simulations done in collaboration with Henry White’s group at the University of Utah.

Electrophoretic transit data were next discussed for phage DNA as the analyte. The shapes of the translocation profiles were shown to be diagnostic of a particular analyte in terms of both the width of the current-time pulse signals and their frequency. The effect of field strength on these profiles were displayed and shown to be consistent with expectations from electrochemical theory. The selectivity of detection between single-stranded and double-stranded DNA analytes was discussed in terms of the analyte conformational mobility in relation to the pore dimensions at the conical tip. The issue of precisely defining the tip diameter at nanometer resolution was then discussed.

The next topic under discussion was bio-functionalization of the tip. The idea is that analyte (*e.g.*, protein) binding with the tip surface (after suitable biochemical modification) would turn off the transit current and thus provide a selective and sensitive analytical probe of the protein. This was demonstrated with the ubiquitous streptavidin-biotin complex prototype that is usually deployed to demonstrate chemical or bio-selectivity of a given sensor. A sensor strategy based on the recognition agent, Protein G with a IgG antibody was then demonstrated using the nanotip sensor approach. A detoxified sample of

ricin was used as the test analyte with obvious implications for combating bioterrorism. Ricin is a highly toxic and lethal agent derived from the castor bean plant, which kills by inhibiting protein synthesis in the human body.

Professor Martin concluded his lecture by summarizing the advantages with the use of track-etch polycarbonate membranes as templates for new families of chemical and biochemical sensors. He emphasized the mechanical and chemical robustness of these sensors. This talk was well received as shown by the vigorous Q&A session that followed even as refreshments beckoned from the Sunday Evening Get-Together event next door. ■