2014 Materials Research Society Spring Meeting shows where research meets industry

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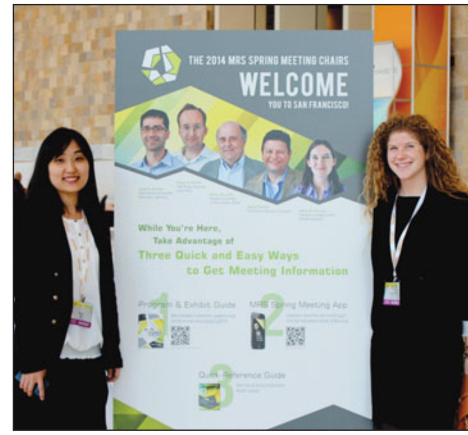
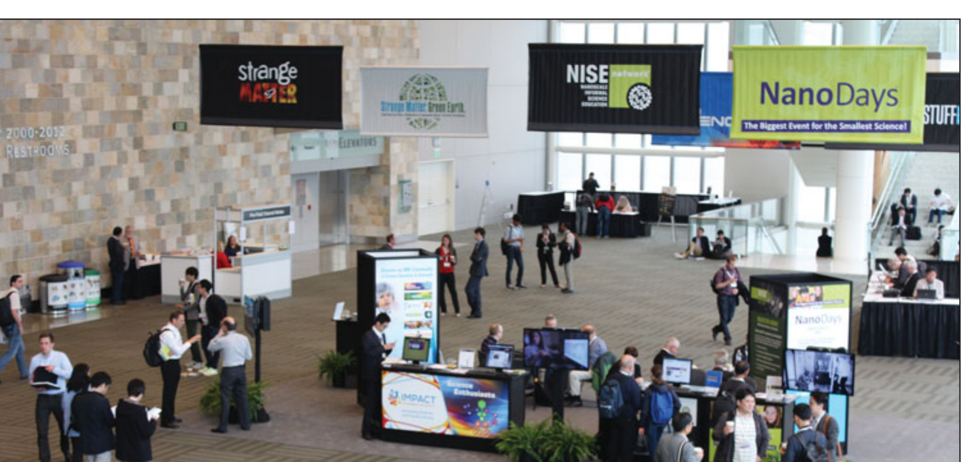


"A new material system must earn its way onto an aircraft," said plenary speaker John J. Tracy, Chief Technology Officer at The Boeing Company, at the 2014 Materials Research Society (MRS) Spring Meeting in San Francisco, Calif. Many components of today's aircraft undergo 100,000 tests before they can be approved for use, he said. This is valuable insight for materials researchers with an eye toward commercialization. Through the plenary session, the Technology Innovation Forum, and other activities at the Spring Meeting, MRS is providing perspectives from industry in a platform that facilitates interaction among researchers in different sectors of the materials community.

This year's MRS Spring Meeting—with over 5500 participants from 50 countries to fill the 57 technical symposia—was held April 21–25, 2014. The Meeting Chairs, **Jose Garrido** (Technische Universität München, Germany), **Sergei Kalinin** (Oak Ridge National Laboratory, USA), **Edson Leite** (Federal University of São Carlos, Brazil), **David Parrillo** (The Dow Chemical Company, USA), and **Molly Stevens** (Imperial College London, UK) invited Tracy to present a brief history of the aerospace industry and of Boeing's role in it.

Tracy said that fuel efficiency has improved 70% since the dawn of the jet age, and Boeing is contributing to that trend by ensuring that every new generation of jets is 15–20% more efficient than the previous one. Boeing's goal is to reach carbon-neutral growth by 2020; that is, its aircraft will emit CO_2 equal to or less than 1995 levels even though the size of the fleet will be much greater than it was in that year. Indeed, air traffic has been growing steadily at 5% per year since 1980, and today's worldwide fleet of approximately 20,000 passenger planes is expected to double in the next 20 years.

According to Tracy, materials science began to play a major role in aviation when famed University of Notre Dame football coach Knute Rockne died in an airplane accident in the 1930s. Whereas previous accidents had been attributed to weather, it was evident that Rockne's plane failed due to poor design and materials. This event launched the US Federal Aviation Administration (FAA) and soon saw the manufacture of all-metal aircraft to more demanding standards. The aerospace industry subsequently improved greatly in four areas: systems, engines, materials, and aerodynamics.



"In each quadrant, materials permeated every aspect of these improvements," Tracy said.

Composites started to play a large role in aircraft structures beginning in the 1940s, and their contribution continues to grow today. The Boeing 787 is the first aircraft in which composite materials comprise more than half of the materials in the structure; it is lighter, more durable, less susceptible to fatigue, and 20% more fuel efficient than its predecessor.

Tracy is most impressed with the contribution materials science has made to jet engines. Most recently, ceramic matrix composites in the nose cones of the engines allow higher operating temperatures than the titanium nose cones that were once the standard, leading to higher efficiency.

So why does it take so long for the aerospace industry to adopt new materials developments? Because they must be

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conservative to ensure the viability and safety of each aircraft, Tracy said. The industry is looking to replace some of its testing with more sophisticated computational methods to certify new materials, but physical testing will always have its role in the process, he said.

On Tracy's wish list is to see materials with multiple functions, such as some combination of electrical, mechanical, thermal, acoustic, and fire-retardant properties all rolled into one easily manufacturable material, although he knows that is asking for a lot. Still, he has a lot of faith in the materials research community to accept such challenges. "I believe we're at the very beginning of taking advantage of the properties of advanced materials," Tracy said.

In a separate event, Kathleen Buse of Case Western Reserve University gave a very sobering talk that included the challenges to keeping women leaders in industry. Although women currently hold almost half (47%) of all positions in the United States, they make up a very small percentage of chief executive officers (CEOs) and corporate boards of directors, Buse said in her address at the Women in Materials Science and Engineering Breakfast. Furthermore, there is an alarming flattening of both the percentage of Bachelor's degrees being awarded to women professionals and the number of women entering the engineering workforce. Despite recent societal and US government pushes, such as the Lily Ledbetter Fair Pay Act, disparities still exist in professional fields. These include negative working environments and inequality in the importance of assigned projects, which drive twice as many women as men out of engineering. The science, technology, engineering, and mathematics (STEM) fields have shown a sudden drop in participation by women when they are in the age range of mid-30s to 50s.

Buse devoted the majority of her presentation on her research regarding the characteristics women possess who remain and progress in the STEM workforce. With the efforts of scientists, government officials, and the general public in maximizing opportunity equality for women and men in employment, compensation, and opportunities for growth in STEM fields, we will see greater quality of produced research and more robust economic growth, she said.

For materials researchers looking to move their inventions into the marketplace, MRS offered a special forum on Technology Innovation, with keynote speaker Yet-Ming Chiang from the Massachusetts Institute of Technology (MIT). Chiang, who started four companies while building a world-renowned university research program as the Kyocera Professor of Ceramics in MIT's Department of Materials Science and Engineering, said that invention is not a lone activity and usually involves collaboration. Using one of his companies, A123 Systems, as a case study, Chiang described the importance of market projections and the metrics of performance that are important for a specific application (e.g., dollars per kilowatt-hour). Finding the right metric is a key first step, he said. Strategic partner funding, networking to find the right entrepreneurial

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Graduate Students Receive Gold and Silver Awards

Graduate Student Awards were announced during an evening ceremony on April 23 at the 2014 Materials Research Society Spring Meeting in San Francisco.

Gold Graduate Student Awards were awarded to (row 1, left to right): **Emily Kosten**, California Institute of Technology and **Feng Xiong**, University of Illinois at Urbana-Champaign; (row 2, left to right): **Jarad Mason**, University of California–Berkeley; **Jonathan Scholl**, Stanford University; and **Liam Collins**, University College Dublin (Ireland); and (row 3, left to right): **Martin Ebner**, ETH Zürich (Switzerland); **Jeffrey Bosco**, California Institute of Technology; and **Michael Naguib**, Drexel University.

Silver Graduate Student Awards were awarded to (row 1, left to right): **Wei Qin**, University of Chicago; **Canan Dagdeviren**, University of Illinois at Urbana-Champaign; **Simin Mehrabani**, University of Southern California; **Yiding Liu**, University of California–Riverside; and **Daniel Schauries**, Australian National University (Australia); (row 2, left to right): **Soong Ju Oh**, University of Pennsylvania; **Xiaobin Xu**, University of Texas at Austin; **Michael Layani**, The Hebrew University of Jerusalem (Israel); **Guosong Hong**, Stanford University; and **Wei Gao**, University of California–San Diego; (row 3, left to right): **Sihong Wang**, Georgia Institute of Technology; **Michael Grapes**, Johns Hopkins University; **Shawn Coleman**, University of Arkansas; **Jiangwei Wang**, University of Pittsburgh; **Letian Dou**, University of California–Los Angeles; and **Chong Liu**, University of California–Berkeley; and (row 4, left to right): **Ping-Chun Li**, University of Texas at Austin; **Samuel Felton**, Harvard University; **Anoop Rama Damodaran**, University of Illinois at Urbana-Champaign; **Andrew Akbashev**, Drexel University; and **Andrew Yankovich**, University of Wisconsin–Madison.

partners, and the importance of costs were other areas he discussed.

The keynote address was followed by two panels, one on approaches to commercializing materials research and the other on business challenges to starting a materials-based company. Some good news for entrepreneurs in academia is that many universities are becoming friendlier to licensing their intellectual property with the understanding that the university mission is to benefit society. However, the challenges to commercialization can be daunting until researchers transform their thinking to the economics of scale-up. For example, innovations at large companies can be very strong when a manufacturing problem is identified with a clear market need.

For materials technologies, entrepreneurs are competing with fast social media and Internet start-ups for investment. But there is hope. Translational funding from government sources is available. And many large companies are following open innovation processes and partnering as part of their innovation portfolio. The strategic directions and areas for the company are keys for innovators to understand.

Among some of the US government programs focused on funding basic research with commercialization in mind is the Department of Energy (DOE) SunShot Program. Lenny Tinker, representing this program, advocates for his department's approach to reducing the price of alternative solar power, which involves funding creative research and development, researching systems integration, and facilitating the process of commercialization. The main goal of the SunShot Initiative is to reduce the price of solar energy compared to other forms of energy to a target \$1/W or 6 cents per kWh without subsidy. If SunShot is successful there will be a huge projected increase in the utility-scale photovoltaic market in the United States. Part of SunShot's analytical approach is determining what critical materials are needed in order to examine the viability of those materials for inclusion in solar technology. A secondary consideration involves learning how to drive price reductions while simultaneously increasing the energy produced. The main paths to reduce prices include reducing materials cost and availability, increasing the purity of materials, and facilitating their transportation and manufacturing, Tinker said. SunShot is addressing these issues by looking into combinatorial methods for research, and trying to gain new theoretical insights. The best way to increase solar energy availability is to close the efficiency gap between silicon and other technologies, which involves understanding defects, modeling, interfaces, contacts, phase purity, and the reliability of the materials, said Tinker.

Of course, the core of the conference was the five solid days of talks on research breakthroughs and advances. For example, in Symposium R, speakers presented a broad array of novel approaches of flexible materials that can be integrated into flexible systems. Kristy Jost of Drexel University envisions seamlessly

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incorporating all electronics into "smart" garments that offer functionality, efficiency, and comfort. Obviously, communication devices and health monitors require power sources that must be integrated into clothing without sacrificing energy density or posing a risk to the wearer. Jost relies on the knitting of porous carbon yarns to directly replicate the structure of supercapacitors. Through her collaboration with the Shima Seki Company, she was able to knit together fibers from linen, bamboo, and viscose yarns—basically any fiber with linear strands that produced enhanced shape control. By welding the fibers (soaking them with ionic liquid) and pre-twisting them with steel current collectors, Jost was able to produce functional devices with high charge storage densities and sufficient mass loading to power small electronics. She briefly delved into her efforts to incorporate not only energy storage but also energy generation by describing a knitted antenna for harvesting WiFi energy. In locations saturated by WiFi signals, this approach may scavenge waste energy and give wearable electronics an extra boost, she said.

In a joint session of Symposium Z/AA on bioelectronics, Magnus Berggren of Linköping University announced his vision to regulate and record the processes in cells and tissues using organic electronics. His biomimetic approach involves the construction of artificial neurons, which can translate electronic signals to the language of chemistry. Polymers such as PSS (polystyrene sulfonate) and PEG (polyethylene glycol) can be used to enhance either the cation or anion signal. The polymers serve as a gate or ionic resistor that depends on the applied voltage. Sufficient voltage on the chip releases acetylcholine from a stored location.

However, another major challenge consists of delivering the neurotransmitter at biological speeds, Berggren said. Real neurons can release their stores in less than 2 ms. The artificial neuron built by Berggren and colleagues could release its neurotransmitter contents on the order of 50 ms, which is starting to approach biologically relevant time scales. *In vivo* experiments with the artificial neurons in guinea pig models were conducted to demonstrate enhanced hearing. Implantation of the device on the cochlea was able to deliver up to 5 mM glutamate at a highly localized site. The device was also implanted on the spinal cords of rats with one of the three sciatic nerves intact (the "spared nerve injury model") to deliver a potent dose of the neurotransmitter gamma-aminobutyric acid (GABA) on demand, suppressing pathological pain. The pain threshold was modulated by nearly one order of magnitude compared with the control rats, Berggren said.

Many presentations from the 2014 MRS Spring Meeting are available through MRS OnDemand® video capture as well as news coverage of the Meeting on MRS TV and *Meeting Scene*®. MRS Proceedings from the Meeting are also available online. Further information can be accessed at www.mrs.org/spring2014.

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CONGRATULATIONS TO THE 2014 MRS FELLOWS

MRS FELLOW

Honoring MRS Members who are notable for their distinguished research accomplishments and outstanding contributions to the advancement of materials research worldwide.

Joanna Aizenberg
Harvard University

For pioneering contributions in fundamental understanding of biological materials; and design and assembly of biomimetic architectures with controlled wetting, optical and mechanical response.

Alexander A. Balandin
University of California–Riverside

For pioneering contributions on the thermal properties of graphene and low-dimensional materials; seminal contributions to the study of quantum confinement effects in nanostructures; and leadership in materials education.

Anna C. Balazs
University of Pittsburgh

For pioneering contributions to the prediction of materials behavior, ranging from nanocomposites to self-healing materials to oscillating gels, through the development of novel computational models.

Zhenan Bao
Stanford University

For groundbreaking achievements in organic materials chemistry, including molecular design, polymer synthesis, crystallization and patterning, and carbon nanomaterials growth; and for service to the materials community.

James J. De Yoreo
Pacific Northwest National Laboratory

For pioneering research in the field of bio-inspired materials science and engineering and distinguished leadership and service to the materials community.

Leonard C. Feldman
Rutgers, The State University of New Jersey

For innovative applications of ion beam analysis; seminal contributions to the elucidation of surface and interface structures; and distinguished service to the materials community.

Nasr M. Ghoniem
University of California–Los Angeles

For seminal contributions to the theory of radiation interactions with materials; development of dislocation dynamics to describe material deformation; and service to the materials community.

David S. Ginley
National Renewable Energy Laboratory

For outstanding contributions on metal oxides for energy applications and distinguished leadership and service to the materials community.

Alfred Grill
IBM T.J. Watson Research Center

For seminal contributions in understanding friction/wear properties of diamond-like carbon and advancing its use as a protective coating for magnetic heads/disks; and for development of low-k dielectrics for on-chip interconnects.

Supratik Guha
IBM T.J. Watson Research Center

For fundamental contributions to the materials science of high-k dielectrics that enable current electronic devices and future device scaling.

Ralph B. James
Brookhaven National Laboratory

For outstanding experimental and theoretical contributions in materials research leading to the development of compound semiconductors and innovative field-portable instrumentation for detecting and imaging x-ray and gamma-ray radiation.

Quanxi Jia
Los Alamos National Laboratory

For pioneering contributions to the development of high-temperature superconducting-coated conductors; and for advancing the processing and application of multifunctional metal oxide materials.

William L. Johnson
California Institute of Technology

For the discovery of bulk, glass-forming metallic alloys and demonstrating their potential as structural materials.

Nicholas A. Kotov
University of Michigan

For foundational contributions to the understanding of nanoparticle self-assembly into anisotropic structures; and for pioneering research in the design of advanced functional nanocomposites.

David C. Larbalestier
Florida State University
& National High Magnetic Field Laboratory

For seminal contributions to advancing the understanding and development of high-current-density, high-field superconducting materials; and for application of such superconductors to high-field magnet use.

Cato T. Laurencin
University of Connecticut

For seminal contributions to the use of advanced polymer materials in the medical field and in regenerative medicine.

Seth R. Marder
Georgia Institute of Technology

For seminal contributions to fundamental understanding of the relationships between the chemical structure of organic molecules and their electronic and optical, including nonlinear optical, properties.

Michael F. Rubner
Massachusetts Institute of Technology

For pioneering research in layer-by-layer assembly of functional thin films; inspirational mentoring of two generations of materials scientists; and visionary leadership in the materials community worldwide.

Henning Sirringhaus
University of Cambridge

For inspired pioneering materials research spanning soft-matter and hard-matter electronics and opt-electronics, from fundamental measurements and processing studies to commercialized device technologies.

Susanne Stemmer
University of California–Santa Barbara

For seminal contributions to quantitative scanning transmission electron microscopy, development of new dielectrics and the science of oxide heterostructures.

Julia R. Weertman
Northwestern University

For pioneering contributions in materials research; and seminal and groundbreaking work on dislocations, fatigue, small-angle x-ray diffraction and nanostructured materials.

Su-Huai Wei
National Renewable Energy Laboratory

For outstanding contributions to electronic structure theory of materials, especially on alloys, semiconductors, nitrides and oxides; defect control in these materials; and leadership in computational materials science.

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