2015 MRS Spring Meeting highlights innovations and discoveries

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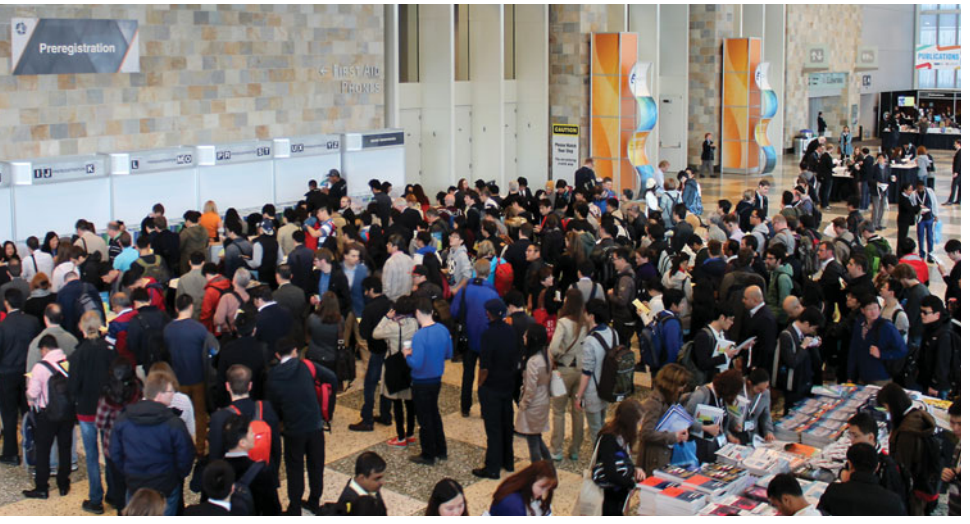
The 2015 Materials Research Society (MRS) Spring Meeting in San Francisco—held April 6–10—drew over 5500 attendees from 50 countries with 5000 presentations. The Meeting Chairs **Artur Braun** (Empa—Swiss Federal Laboratories for Materials Science and Technology), **Hongyou Fan** (Sandia National Laboratories), **Ken Haenen** (Hasselt University and IMEC), **Lia Stanciu** (Purdue University), and **Jeremy A. Theil** (QuantumScape Corporation) put together 51 technical symposia, including many emergent areas of materials research as well as some well-established ones. The topics were represented across five categories: Materials for Energy; Nanomaterials; Materials for Electronics and Photonics; Soft and Biomaterials; and General Cluster—Fabrication and Characterization. To complement the scientific sessions, 12 tutorials were offered that covered a variety of topics, and over 120 exhibitors were on-site.

Symposia presentation highlights

One of the hot topics at the Meeting was perovskite solar cells. In his Symposium C presentation, Seong Il Seok, from the Korea Research Institute of Chemical Technology, highlighted the advantages of both organic and inorganic materials to create hybrid solar cells. His research team used antimony-based materials for electron transport with mesoporous titanium oxide in tandem with a blend of conjugated polymers and PCBM on the hole–transport side. The resulting device was 6.3% efficient. His team has been working on perovskite solar cells with great success. Some of the work includes modification of small molecules used as hole–transport materials. The researchers have also been experimenting with the influence of different cation mixtures on device performance. They found that adding small amounts of $MAPbBr_3$ to predominantly $FAPbI_3$ had a remarkable outcome. At 15% $MAPbBr_3$, SEM showed a dramatic decrease in the roughness of the films, and a concomitant increase in crystallinity was seen by x-ray diffraction. This hybrid device showed no hysteresis in the *J–V* curves, in sharp contrast to the purely $MAPbI_3$ system. The best device was certified at 20.2% efficiency.



In a Symposium HH talk, Norma K. Minar discussed how she and her colleagues from the University of Munich are trying to combine the two worlds of C_{60} fullerenes and mesoporous sol-gel materials. She drew inspiration from a quote attributed to Buckminster Fuller himself, who stated, "Don't fight forces, use them." Now the team is using the forces from covalent interactions to create covalent fullerene frameworks. Although there are many examples of fullerene self-assembly, these typically rely on weak interactions, such as van der Waals forces. Using 9,10-dimethylanthracene and C_{60} as starting materials, the fullerene was hexa–functionalized. This was evidenced by the high degree of symmetry found by ^{13}C NMR, which revealed only three unique sp^2 carbons. The periodicity of the structure was determined by small-angle x-ray scattering, which showed a defined *d*-spacing. The structural integrity persisted even after removal of the template and by baking at 300°C. BET measurements indicated a surface area of 494 m^2/g with a pore size of 7.5 nm. A thin-film field-effect transistor device was created in order to test the electronic properties of the new material. Even though the C_{60} framework did not show any onset of current, the dielectric constant was determined to be 3.0, making it a possible candidate for microelectronic applications.

Top-down approaches have been successful in producing bulk quantities of graphene nanoribbons, but the processes often leave the materials damaged. "This is a key message from my point of view," said Klaus Müllen, Max Planck Institute for Polymer Research, during his Symposium T presentation. "Chemical knowledge is still needed here." Applying their insights as organic chemists to materials science, the Müllen group has developed a method for producing nitrogen-doped graphene with increased charge carrier density. These *N*-doped graphenes have found great utility so far in energy applications. By wrapping cobalt oxide with a graphene sheet, the high capacity of the inorganic material is married to the superior morphological properties of graphene, making

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an excellent battery material. *N*-doped graphene has also been very useful in the oxygen reduction reaction inside fuel cells, with catalytic activity superior to platinum in both acidic and basic media. This is very promising since platinum is too expensive for mass production. While the energy applications of graphene have largely been realized, graphene has not been very useful in transistor applications because it lacks a bandgap. "Unless you are happy with a switch that will never be off, you must do something about it," Müllen said. Using the molecular precursors synthesized in his group, many types of atomically precise graphene nanoribbons have been made with perfect edge structures.

Silicon photovoltaics (PVs) are optimized for use on rooftops. Large cities with skyscrapers and tall buildings preclude the use of Si PVs, since the rooftop area is low. Applying PVs to the sides of a building allows use of a much larger area, but this requires PVs to be integrated with windows, demanding transparency and thermal insulation. To address this, Sergio Brovelli, University of Milano Bicocca (Symposium R), designed PVs with a blend of chromophores in glass that absorb light and reemit it to be captured by PV cells at the edges of glass windows. However, these chromophores re-absorb their emitted light, which means much light is lost before being absorbed by the PV cells. To improve this device, Brovelli's group replaced the chromophores with core–shell quantum dots, with a thick copper indium selenide sulfide (CuInSeS) shell, used for light absorption, and a zinc sulfide (ZnS) core, used for light emission at a wavelength that the shell cannot absorb. This results in complete suppression of reabsorption of light, which was shown experimentally. The efficiency of these PVs is 3.2%, which may seem low, but calculations show that covering a skyscraper in these PVs and assuming that 50% of the incident sunlight is captured would generate 900 kW of power—enough to power 300 apartments.

2015 MRS Spring Meeting Poster Awards

Tuesday Poster Awards

- *Relationship between Molecular Weight and Morphology in Polymer-Polymer Blends: A General Strategy for Improving All-Polymer-Based Optoelectronic Devices*
  Nanjia Zhou, Northwestern University, USA
- *Mechanical Energy Harvesters with Extended Current Pulse Duration Based on Electrochemically Alloyed Electrodes*
  Sangtae Kim, MIT, USA
- *Optical and Structural Nano-Characterization of Ordered Core-Shell GaN Micropillars*
  Marcus Mueller, Otto-von-Guericke–University Magdeburg, Germany; NIST, USA
- *Novel Routes to Strain Engineer Domain Structures and Properties in Epitaxial $PbZr_{1-x}Ti_xO_3$ Thin Films*
  Shishir Pandya, University of California–Berkeley, USA

Wednesday Poster Awards

- *Pteridine Redox Centers Inspired by Biological Energy Metabolism for Sustainable Rechargeable Batteries*
  Jihyun Hong, Seoul National University, South Korea
- *Electronic Transport Studies of Hematite Nanoparticles for Photovoltaic Application*
  Jan Mock, Institute of Energy and Climate Research, JPUs
- *Terahertz Split Ring Resonators Using Displacement Current*
  Shao Liu, University of Minnesota, USA
- *Process Path Functions in Rolling and Heat Treating of Meta-Stable Cubic Zr-18Nb Alloy*
  Ali Tabei, Georgia Institute of Technology, USA

Thursday Poster Awards

- *Ag-Pd Nanocubes with Combined Catalytic and Plasmonic Properties*
  Jumei Li, Georgia Institute of Technology, USA
- *Domain Wall Interface Density Control for Tunable Thermal Conductivity*
  David A. Scrymgeour, Sandia National Laboratories, USA
- *Large-Area Heteroepitaxial Stacking and Stitching of Hexagonal Transition-Metal Dichalcogenide Monolayers*
  Hoseok Heo, Center for Artificial Low Dimensional Electronic Systems, Institute for Basic Science, POSTECH, Korea

Recognitions

On Wednesday evening, MRS Vice President/President-Elect Kristi S. Anseth recognized the recipients of the MRS Postdoctoral Award endowed by the Jiang Family Foundation and MTI Corporation: Dustin W. Janes, The University of Texas at Austin, and Yuan Yang, Massachusetts Institute of Technology. Anseth recognized the Outstanding Young Investigators: Karena W. Chapman of Argonne National Laboratory and Ali Javey of the University of California–Berkeley. She then recognized Seth R. Marder (Georgia Institute of Technology) for the Mid-Career Researcher Award endowed by Aldrich Materials Science, and John M. Carpenter (Argonne National Laboratory) for the Innovation in Materials Characterization Award endowed by Toh-Ming Lu and Gwo-Ching Wang.

Plenary Address and Symposium X presentations

Samuel I. Stupp, Northwestern University, presented the Plenary Address on "Bio-inspiration and energy landscapes in soft materials design." He began his presentation by noting that

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Science As Art

Congratulations to the Science as Art first place winners: **Shang-Hsuan Wu**, Academia Sinica, for "Nano Peony Flower"; **Jiayu Wan**, University of Maryland, for "Graphene Tide"; and **Yanwen Yuan**, Nanyang Technological University, for "Graphitic Carbon Nitride under UV Light."

supramolecular materials—assemblies of molecular structures—are newcomers to the group of soft materials that traditionally have included polymers, organic and liquid crystals, and gels. As examples, he mentioned the polar stacking of mushroom-shaped units via self-assembly to produce piezoelectric films and the vision of the self-assembly of device-like structures for photovoltaics with up to one million molecules per assembly. These materials can mimic the structures and physical properties of biological systems and therefore offer a rich platform for bioinspired materials design, drawing on collagen matrices, protein complexes, ribosomes, chromosomes, and extracellular filaments—highly dynamic "parts" of cells that make life possible.

The biomimetic potential of supramolecular matter gives it the ability to reconfigure, adapt, order, and respond. Just as muscle responds to chemical fuels by contracting, a biomaterial could reconfigure to optimize signaling at a cell surface. Such dynamic materials offer the prospect of self-healing of defects, low-energy recycling, fast biodegradation, directional charge transport, integration of multiple functions in a single material, and more.

Stupp took a brief look at future prospects for supramolecular materials, emphasizing the need to draw on computational materials science to accelerate the discovery of new supramolecular materials functions, such as materials that are reversibly responsive, dynamic, adaptable, or capable of integrating synergistic functions. These features emulate biological structures such as cells.

For the Symposium X: Frontiers of Materials Research presentations, Alexandra Navrotsky, University of California–Davis, showed how her work on nanoscale energetics bridges three areas among which she sees very few boundaries: geochemistry, environment, and materials. Nanomaterials, she said, are everywhere, and play important roles in everything from plants to planet formation. At the heart of her presentation was the power of thermodynamics to understand and predict materials function. Lionel Vayssieres, International Research Center for Renewable Energy, discussed his dream for a low-cost and sustainable way to generate hydrogen as a green energy source using only a cheap semiconductor and the two most abundant and geographically balanced free resources available on this planet—the sun and seawater. This is a major challenge facing today's materials researchers: the development of new materials that lead to new technologies, which lead to new industries accompanied by better jobs and improved living conditions.

Daniël Vanmaekelbergh, University of Utrecht, presented a view of research on colloidal nanocrystals, focusing on his work using nanocrystals to create two-dimensional superlattices. Vanmaekelbergh discussed his work on PbSe nanocrystals, which come together in either a square geometry (bonding at the {100} facets) or a honeycomb geometry (bonding at the {110} facets). Via cation exchange, the PbSe superlattices can be transformed into CdSe superlattices, which have particularly desirable semiconducting properties.

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Awards

In celebrating 30 years of publication of the *Journal of Materials Research* (*JMR*), MRS President Oliver Kraft announced the inaugural *JMR* Paper of the Year Award: "Thermophysical properties of SnO_2-based transparent conductive films: Effect of dopant species and structure compared with In_2O_3-ZnO-, and TiO_2-based films," by Nobuto Oka and Saori Yamada of Aoyama Gakuin University, Takashi Yagi and Naoyuki Taketoshi of the National Metrology Institute of Japan, and Junjun Jia and Yuzo Shigesato of Aoyama Gakuin University (*JMR* 29(15), 2014).

New happenings

A variety of attendees, from students preparing to publish their first papers, to early-career researchers hoping to polish their publishing skills, or those with questions about the publishing process, attended the "Essentials of Getting Your Work Published—I've Done My Research, Now What?" session. A panel consisting of the MRS journal editors-in-chief, Gary L. Messing, Peter F. Green, and David S. Ginley, each gave a brief talk about the three MRS journals: *Journal of Materials Research* (Messing), *MRS Communications* (Green), and *MRS Energy & Sustainability—A Review Journal* (Ginley).

Presented in partnership with Cambridge University Press, the session focused on:

- How to select a journal
- A primer of article types—research articles, review articles, letters, and more
- How to write a clear title and abstract
- What to expect from the peer review process
- Common pitfalls and how to avoid them.

The session ended with a question and answer period.

The Career Development Sessions introduced attendees to a wide range of rewarding careers in materials science. Attendees were able to gain a broader understanding of the science and technology practiced in industry, government labs, and academia; hear from an industry leader on what it takes to move a product from conception to market; hear what recruiters are looking for in young scientists; get tips on how to write an attention-grabbing resume; and learn how to prepare for an interview.

Many presentations from the 2015 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/spring2015.

Graduate Students Receive Gold and Silver Awards

Graduate Student Awards were announced during an evening ceremony on April 8 at the 2015 Materials Research Society Spring Meeting in San Francisco.

Gold Graduate Student Awards. Row 1: **Yiyang Li**, Stanford University; **Chenjie Zeng**, Carnegie Mellon University; **Edward Sachet**, North Carolina State University; **Maria Lukatskaya**, Drexel University; **Jihyeon Yeom**, University of Michigan. Row 2: **Zi Jing Wong**, University of California–Berkeley; **Jorik van de Groep**, FOM Institute AMOLF (The Netherlands); **Valerio D'Innocenzo**, Istituto Italiano di Tecnologia (Italy); **Neelkanth Bardhan**, Massachusetts Institute of Technology.

Silver Graduate Student Awards. Row 1: **Duc Duong**, Stanford University; **Jinxing Li**, University of California–San Diego; **Yingjie Zhang**, University of California–Berkeley; **Anshul Sharma**, Kent State University; **Suchol Savagatrup**, University of California–San Diego; **Yiding Liu**, University of California–Riverside. Row 2: **Hongjie Peng**, Tsinghua University (China); **Nanjia Zhou**, Northwestern University; **Zhi Wei Seh**, Stanford University; **Xi Yin**, University of Illinois at Urbana-Champaign; **Deep Jariwala**, Northwestern University. Row 3: **Chenghao Wu**, University of California–Berkeley; **Jihyun Hong**, Seoul National University (South Korea); **Priyank Kumar**, Massachusetts Institute of Technology; **Yahua Liu**, City University of Hong Kong (Hong Kong); **Simiao Niu**, Georgia Institute of Technology. Row 4: **Matteo Bianchini**, Institut Laue-Langevin (France); **Jairo Diaz**, Purdue University; **Yong Lin Kong**, Princeton University; **Po-Chun Hsu**, Stanford University; **Assaf Ben-Moshe**, Tel Aviv University (Israel). Missing: **Hadiseh Alaeian**, Stanford University.

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