

MRSEC Matters

Materials Research Science and Engineering Center News

March 2011

Upcoming Events:

- April 12, 2011: Marquee Lecture, "The Future of Global Energy and Climate," presented by Jordan Goodman and Steven Rolston.
- April 13, 2011: Spring Progress Report Meeting, 3pm.
- April 30, 2011: MRSEC will be participating in Maryland Day. Don't forget to come and join in on the festivities and fun!
- May 27, 2011: 14th Annual Student Science Conference.
- June 6, 2011: MRSEC REU begins. Please help us welcome our visitors!

From the Director



Welcome to the March issue of *MRSEC Matters*. Within, you will find highlights from our latest research and education outreach, recent publications and travel, and introductions of our newest members. Our entire MRSEC team has been extremely active and successful. As you will see, MRSEC research was featured

prominently at the APS meeting with outstanding talks by MRSEC members on emergent materials properties. March MRSEC education outreach activities ranged from working with elementary-aged students to teacher workshops. This month, MRSEC celebrated the success of the fifth year of one its signature programs, *Operation Night Spy*, with the International Spy Museum. I would like to remind you to stay updated with our Center and our members by viewing our [website](#), [facebook](#), and [twitter](#) feeds.

Sincerely,
Janice Reutt-Robey

Research Highlight

Ultrafast Charge Separation at MPc - C₆₀ Interfaces

The charge-separation dynamics at CuPc:C₆₀ photovoltaic heterojunctions with well-defined molecular orientation was measured for the first time by MRSEC researchers and their NIST collaborators. Exciton formation and decay channels were monitored at molecularly abrupt interfaces, prepared by sequential physical vapor deposition and characterized by UHV-STM. A new interfacial charge transfer channel was identified and key charge-transfer rates were quantified by ultrafast two-photon photoemission techniques. These experiments show how molecular orientation and donor triplet states limit the charge-separation efficiency of organic donor-acceptor interfaces. These results provide guidance for interfacial structures that will translate to photovoltaic devices with greater efficiency. See [G. Dutton et al., Physical Review B 82, 073407 \(2010\)](#) for additional details. This work has also been selected for the [Virtual Journal of Ultrafast Science](#).

About this Newsletter:

MRSEC Matters is published monthly with the purpose of informing our community of MRSEC projects and publications and establishing communication among our members. In each newsletter, we would like to highlight a different MRSEC member; we invite you to submit names to be included. If you would like to contribute to *MRSEC Matters*, please contact us: mrsec@umd.edu

*Don't forget to check out
our website
<http://mrsec.umd.edu/>*

Publications

1. A. Calzolari, W. Jin, J. E. Reutt-Robey and M. Buongiorno Nardelli, "Substrate-Mediated Intermolecular Hybridization in Binary Phthalocyanine Superstructures." *Journal of Physical Chemistry C* **114**, 1041-5 (2010).

2. T. L. Einstein and T. J. Stasevich, "Epitaxial Growth Writ Large." *Science* **327**, 423-4 (2010).

3. A. Pimpinelli and T. L. Einstein, "Pimpinelli and Einstein Reply to Comment by M. Li, Y. Han, and J. W. Evans on "Capture-Zone Scaling in Island Nucleation: Universal Fluctuation Behavior"." *Physics Review Letters* **104**, 149602/1 (2010).

4. C. Tao, W. G. Cullen and E. D. Williams, "Visualizing the Electron Scattering Force in Nanostructures." *Science* **328**, 736-40 (2010).

5. C. J. Cheng, A. Y. Borisevich, D. Kan, I. Takeuchi and V. Nagarajan, "Nanoscale Structural and Chemical Properties of Antipolar Clusters in Sm-Doped BiFeO₃ Ferroelectric Epitaxial Thin Films." *Chemistry of Materials* **22**, 2588-96 (2010).

6. D. Kan, L. Pálová, V. Anbusathaiah, C. J. Cheng, S. Fujino, V. Nagarajan, K. M. Rabe and I. Takeuchi, "Universal Behavior and Electric-Field-Induced Structural Transition in Rare-Earth-Substituted BiFeO₃." *Advanced Functional Materials* **20**, 1108 (2010).

7. S. L. Samal, T. Magdaleno, K. V. Ramanujachary, S. E. Lofland and A. K. Ganguli, "Enhancement of magnetic ordering temperature in iron substituted ytterbium manganate (YbMn_{1-x}Fe_xO₃)." *Journal of Solid State Chemistry* **183**, 643-8 (2010).

8. T. Brintlinger, S.-H. Lim, K. H. Baloch, P. Alexander, Y. Qi, J. Barry, J. Melgailis, L. Salamanca-Riba, I. Takeuchi and J. Cumings, "In Situ Observation of Reversible Nanomagnetic Switching Induced by Electric Fields." *Nano Letters* **10**, 1219-23 (2010).

9. N. P. Butch, K. Kirshenbaum, P. Syers, A. B. Sushkov, G. S. Jenkins, H. D. Drew and J. Paglione, "Strong surface scattering in ultrahigh-mobility Bi₂Se₃ topological insulator crystals." *Physical Review B* **81**, 241301/1-4 (2010).

10. J. Quah and D. Margetis, "Electromigration in Macroscopic Relaxation of Stepped Surfaces." *Multiscale Modeling and Simulation* **8**, 667-700 (2010).

Making a Difference

Dr. Robert Briber kicked off the Marquee Lecture series with his presentation *Materials of Civilization: The Role of Materials in Our World*.



Dr. Briber's introduction to materials science included demonstrations with shape memory alloy and super absorbent polymers.

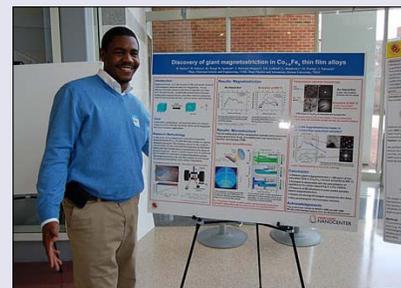
The Marquee Lectures are open to the public and based on "exploring science and technology in the context of social, economic, and ethical issues."



Right: Dr. Briber shows the polymer in a can demonstration.

Congratulations to MRSEC graduate student Dwight Hunter, who was recently recognized for having a *Best Poster* at ResearchFest.

Right: Dwight Hunter with his winning poster at ResearchFest. Photo courtesy of Dwight Hunter.



Congratulations to MRSEC graduate student Paul Patrone, who was selected for the NIST-ARAA Graduate Fellowship.

Education Outreach

Educator Workshop



Educators excited by results observed in the shape memory alloy experiment.

This March, the UMD-MRSEC provided its second annual *Science of Spying* Educator Workshop in partnership with the International Spy Museum. The workshop provides educators with the resources to infuse science, technology, engineering, and math (STEM) lessons and

activities with the excitement of spying. Educators from across the country participated and each received a resource kit that provided them with everything they need to bring the activities and lessons (which are inquiry-based and aligned with national standards) to life in their own classrooms. MRSEC staff, Donna Hammer and Alex Prasertchoung, and a team of MRSEC volunteers led educators through the hands-on activities and lessons. Robert Wallace, former director of the CIA Office of Technical Services, provided the keynote lecture and the workshop also included a *Spy Tech Tour* of the International Spy Museum.



Homeschool

The spring 2011 homeschool course introduced students to nanoscience and nanotechnology research, tools, and applications.



Students learning to create a 3D CAD model.

The course included a presentation by Dr. Bill Cullen on the operation and applications of scanning electron microscopes (SEM). A tour of the SEM laboratory was given by MRSEC graduate student Kristen Burson, who demonstrated the SEM to students by imaging the "gecko tape" samples the students made.

Students were also introduced to CAD drawing and discussed issues of nanoscience and society. Students completed regular homework assignments and presented their work at each meeting.



Left: Graduate student Kristen Burson conducting SEM lab tour.

Project Lead the Way

PLTW students from CH Flowers High school designed and constructed concrete beams with the help of MRSEC faculty and graduate students. The classroom visits were followed up by an exciting morning in the Modern Engineering Materials Instructional Laboratory. PLTW students and MRSEC researchers performed stress/strain testing of students' concrete



MRSEC Assoc. Dir. Donna Hammer and Flowers teacher Victoria Lee with Project Lead the Way students.

beams. These program activities focus on engineering design and the mechanics of materials and provides students with a motivating college-preparation experience.

Left: Graduate student Chris Long, Dr. John Cumings, and graduate student Paris Alexander led the materials testing lab.



Operation Night Spy

MRSEC thanks the dedicated volunteers who made the fifth annual *Operation Night Spy: Espionage in the Dark* program such a success. In partnership with the International Spy Museum, MRSEC provided and led spy missions designed to teach student participants the science behind spying. Please visit our [Facebook page](#) or [website](#) to view a video of this year's amazing event.



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Operation Night Spy with International Spy Museum: February 24, 2011
Photo by Nick Hammer

Research

Understanding the Structure of SiO₂-supported Graphene

MRSEC researchers recently published experimental results which explain the nature of graphene corrugation on SiO₂ down to nanometer length scales. The structure of graphene on SiO₂ has been controversial since its first measurement by STM in 2007, with conflicting reports in the literature and suggestions that the corrugation could be "intrinsic". Using non-contact AFM in ultrahigh vacuum, this work provides the first AFM measurements of SiO₂ with resolution sufficient to make a proper comparison with STM measurements of graphene.



These measurements show that SiO₂ is measurably rougher than SiO₂-supported graphene, and allow detailed quantitative analysis using theory developed for membrane physics. Using an energy balance principle, it was shown that the SiO₂ surface, while rougher at the nm scale than previously realized, is not rough enough to prevent highly conformal graphene adhesion. Qualitatively, the energy balance says that substrate adhesion favors graphene following the substrate topography, while the bending rigidity of graphene favors reduced corrugation, resulting in a structure which is slightly smoother than the substrate. The work shows that the structure of graphene on SiO₂ is extrinsic - it is regulated by the substrate, and provides a path toward "strain engineering" of graphene's electronic properties.

Measurements were performed on the UHV AFM/STM/SEM system within the MRSEC UHV SPM microscopy facility [UHV AFM/STM/SEM system](#). See W. G. Cullen et al [W. G. Cullen et. al. Physical Review Letters 105, 215504 \(2010\)](#) for full details.

Recent Travel & Talks



MRSEC at the APS March Meeting in Dallas, TX

Nick Butch, Paul Syers, Johnpierre Paglione. "Effect of high pressure on transport and structural properties of topological insulator Bi₂Se₃"

Nick Butch, Paul Syers, Johnpierre Paglione. "High field magnetotransport in high purity crystals of topological insulator Bi₂Se₃"

William Cullen, Michael Fuhrer, Jack Hellerstedt. "Van der Waals epitaxial growth and transport properties of Bi₂Se₃ thin films"

William Cullen, Michael Fuhrer, Ted Einstein. "Wrinkling of graphene membranes supported by silica nanoparticles on substrates"

Alex Curtin, William Cullen, Michael Fuhrer. "Local surface potential variations and charge puddling in graphene on SiC(0001)"

Michael Fuhrer. "Charge transport in dual-gated bilayer-graphene Corbino-disk"

Michael Fuhrer, Shudong Xiao. "Electron scattering in graphene by a correlated charged impurities"

Michael Fuhrer, William Cullen, Kristen Burson. "High Resolution measurement of SiO₂ surface potential using scanning Kelvin-probe microscopy"

Kwangmoo Kim, Ted Einstein. "Monte Carlo Study of the fish-like patterns of anthracenes on Cu(111)"

Kwangmoo Kim, Ted Einstein. "Formation of molecular networks: Tailored quantum boxes and behavior of adsorbed CO in them"

Kwangmoo Kim, Ted Einstein. "Origin of the giant honeycomb network of quinones on Cu(111)"

Paul Patrone, Ted Einstein, Dionisios Margetis. "One-dimensional model of interacting-step fluctuations on vicinal surfaces: Analytical formulas and kinetic Monte Carlo simulations"

Ray Phaneuf. "Directed self assembly and self-limiting growth (SLG) of mound formation on patterned GaAs(001) surface during MBE homoepitaxy."

Janice Reutt-Robey, Qiang Liu, John Weeks. "Electrostatic origin of meandering C60 chain formation at ZnPc interfaces"

Lourdes Salamanca-Riba, Janelle Branch, Luz Martinez-Miranda. "Liquid crystal-ZnO nanoparticle potential photovoltaics: Role of LC order and ZnO particle size and concentration"

Lourdes Salamanca-Riba, Luz Martinez-Miranda. "ZnO nanoparticles and nanowire arrays with liquid crystals for photovoltaic applications"

Qian Shao, Janice Reutt-Robey. "UHV-compatible aerosol-molecule beam deposition source for organic electronic films"

Andrei Sushkov, Dennis Drew, Nick Butch, Johnpierre Paglione. "Optical properties of novel topological insulators"

Jacob Tosado, William Cullen, Michael Fuhrer. "Development of a device-oriented UHV scanning probe microscope based on quartz sensors"

Welcoming New Members



Dr. Robert Briber
Professor & Chair of
MSE

Graduated from Cornell University with a B.S. in Materials Science & Engineering. He received his M.S. & Ph.D. in Polymer Science & Engineering at the University of Massachusetts Amherst. Dr. Briber has joined MRSEC IRG.



Dr. Farah Dawood
Postdoctoral Research
Associate

Graduated from Concordia College with a B.A. in Chemistry and received her Ph.D. in Chemistry from The Pennsylvania State University. She is currently working in MRSEC Seed Professor John Fourkas' lab.



Jack Hellerstedt
Graduate Student

Graduated from the University of Minnesota with a BS in Physics and Math. He is currently working under MRSEC Professor Micheal Fuhrer and studying the topological insulator Bismuth Selenide.



Claudia Ojeda-Aristizabal
Postdoctoral Research
Associate

Graduated from the University of Paris with a B.S. in Physics and worked in the Physics Solids Laboratory. She received her Ph.D. at the Laboratoire de Physique des solides at Orsay, France. She is currently working in MRSEC Professor Michael Fuhrer's laboratory.



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