SPRING 2008

# TECHTRACKS

MATERIALS SCIENCE AND ENGINEERING
A. JAMES CLARK SCHOOL *of* ENGINEERING

UNIVERSITY OF MARYLAND 1856

www.mse.umd.edu

A NEWSLETTER FOR ALUMNI AND FRIENDS OF THE DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING AT THE A. JAMES CLARK SCHOOL OF ENGINEERING, UNIVERSITY OF MARYLAND.

## IN THIS ISSUE:



## Templating for Directed Self-Assembly

### PHANEUF GROUP RESEARCH, PRESS RELEASE GET NOTICED

Computers don't grow on trees, but with a little prodding from engineers, nature can produce computer components.

MSE associate professor **Ray Phaneuf** has developed a template nature can follow to produce "self-assembling" structures. The template causes atoms to be arranged in a defined pattern that can serve a variety of purposes—a semiconductor in a laptop, a component in a cell phone or a sensor in a wearable device.

The idea of self-assembly in nature has long been known—crystallization is one such process; the formation of shells into spirals is another. However, researchers have been limited to the designs that nature already knows how to make. Phaneuf's work introduces a man-made template that nature then follows, addressing a number of manufacturing difficulties.

"While we understand how to make working nanoscale devices, making things out of a countable number of atoms takes a long time," Phaneuf said. "Industry needs to be able to mass-produce them on a practical time scale."

The template process can be used by device manufacturers to mass-produce tiny components rapidly and efficiently, reduce costs, shrink device sizes, and improve devices' functionality in ways previously not possible.

"The same template can be used thousands of times," Phaneuf said. "This results in enormous savings."

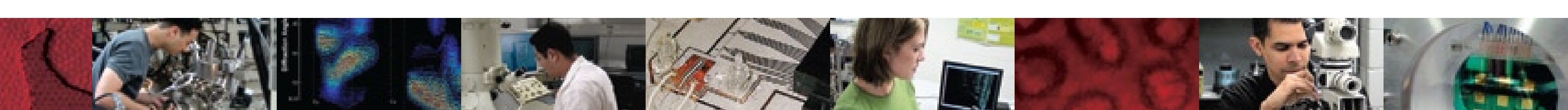
Phaneuf says his work is one step in a "cocktail" approach to computer assembly—an engineer's dream in which one could "mix up" a computer the same way one mixes a drink.

"Imagine you shake up a cocktail and spill it onto a table," Phaneuf said. "The liquid will collect in pools in a manner designated by nature.

"Now imagine that first you coated the table with wax and scraped a pattern into it. Now when you spill the liquid onto the table, it collects in the pattern you scraped into the wax—it assumes the form you want it to take. When we apply this idea to manufacturing nanoscale computer components, collections of atoms become ordered, accessible, controllable and reproducible—characteristics crucial to their use in high-tech devices."

These devices could include those used in the growing field of quantum computing, which is believed to hold promise for carrying out exceptionally difficult mathematical processes, Phaneuf said. An application of the templates might be self-assembly of coupled quantum dots to form "qubits," the building blocks of quantum computers. According to Phaneuf, templating could be used to make the manufacture of this highly complicated system more feasible: "Addressing individual qubits might be done optically, to get around the problem of trying to wire them all up."

*TEMPLATING continued on p. 2*



# chair's MESSAGE

ROBERT M. BRIBER

**2008 HAS BEEN A BANNER YEAR FOR THE DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING.** Dr. **Oded Rabin** has joined us as a new assistant professor (see p. 8), and also holds a joint appointment in the Institute of Research in Electronics and Applied Physics. Dr. Rabin received his Ph.D. from MIT in 2004 and held postdoctoral appointments at Harvard Medical School at Massachusetts General Hospital and at U.C. Berkeley. His research interests include new synthetic strategies to produce nanomaterials suitable for a range of applications including sensors, thermoelectrics, and markers for medical imaging diagnostics.

Our faculty and students continue to win honors. Professor **Luz Martinez-Miranda** was elected a fellow of the American Physical Society with the Council of the APS citing her "for sustained achievements in recruiting, mentoring, and advancing women and minorities in physics..." (see p. 8), and senior undergraduate **Maeling Tapp** was one of 20 students selected nationally to receive an Accenture Scholarship (see p. 6). **Dan Janiak**, a MSE graduate student, was named a Fischell Fellow, which will provide support for him to work his thesis project developing novel polymers that can sense specific viruses (see p. 6).

Exciting and successful research projects continue to emerge from MSE faculty labs. Professor **Ray Phaneuf**'s work on directed self-assembly was published in *Physical Review Letters* (PRL, 2007, 97, 126101) and has made headlines, including an interview on BBC Radio. Professor **John Cumings** presented an invited lecture at the 2008 March meeting of the American Physical Society on his work on artificial spin ice, a novel class of meta-materials (see p. 4). Professor **Ichiro Takeuchi** and I both gave invited lectures at the 2007 Fall MRS meeting in Boston and Professor **Mohamad Al-Sheikhly** presented his work on radiation chemistry of chlorinated biphenyls at the 25th Miller Conference on Radiation Chemistry.

Our undergraduate program has received a large boost with the opening of the new Modern Engineering Materials Instructional Laboratory, a cross-disciplinary undergraduate teaching lab in the Jeong H. Kim Engineering Building. The lab is run by the MSE department and used to teach fundamental concepts of materials science to a range of students, from freshman engineers to upperclassmen in MSE, Bioengineering and Mechanical Engineering. You can learn more about the lab and its facilities in this issue (see p. 3), and by visiting **www.memil.umd.edu**.

If you are in the Washington, D.C. area, please stop by and learn about all the new things that are happening. If you are an alumnus, please keep us informed on the changes in your career.

Robert M. Briber
Professor and Chairman, MSE

*TEMPLATING, continued from p. 1*

Phaneuf's work focuses on silicon and gallium arsenide components. Silicon is the prevalent material for components in computers while gallium arsenide is used more often in cell phones.

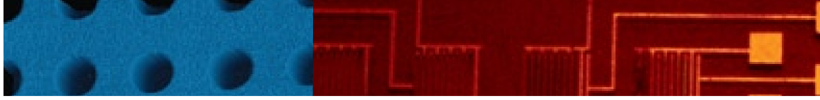
The templates are created using photolithography (a process akin to photography, in which the template is chemically developed after being exposed to light) and etching, or by "nanoscraping," in which an atomic force microscope is used to selectively scrape the pattern into the template.

Phaneuf's work has generated a buzz from across campus to "across the pond." A recent Clark School press release covering the work, titled "'Nature-Made' Computers," has received wide attention from the media. It has been picked up by over 75 online and print news outlets around the world, including *ComputerWorld, The Seattle Times, PC World, Semiconductor International, Sensor Magazine,* and PhysOrg.com. The attention led to Phaneuf being interviewed for more in-depth stories on BBC Radio, on CTV76 News (regional cable), in *Nanomaterials News,* and in the University's own newspaper, *The Diamondback.*

*For a technical overview of Phaneuf's work, please see our related research feature on page 4.*

▲ PROFESSOR **RAYMOND PHANEUF** (LEFT) IS INTERVIEWED BY CTV76'S **SAADIA VAN WINKLE** (CENTER) ABOUT HIS GROUP'S TEMPLATING RESEARCH.

MSE GRADUATE STUDENT **YI QI** FROM THE CUMINGS RESEARCH GROUP SHOWS A "META MATERIAL" TO UNIVERSITY PRESIDENT DR. **C.D. MOTE, JR.** ON THE NISPLAB'S JEOL 2100F ATOMIC-RESOLUTION FIELD EMISSION TRANSMISSION ELECTRON MICROSCOPE (FE-TEM) DISPLAY. ▶





## NISPLAB WELCOMES UMD PRESIDENT, VPS FOR RESEARCH

University of Maryland President Dr. **C. D. Mote**, Jr., Vice President for Research **Mel Bernstein** and Associate Vice President for Research Development **Ken Gertz** recently toured the Nanoscale Imaging, Spectroscopy and Properties (NISP) Laboratory, the university's premiere electron microscopy research and training facility serving the areas of chemistry, biology, geology, physics, materials science, and all of engineering. Assistant Professor **John Cumings** hosted the visits.

Cumings gave Berstein and Gertz an overview of the lab's unique capabilities and new, cutting-edge equipment, including a JEM 2100 $LaB_6$ transmission electron microscope (TEM) coupled with fiber optic, video-rate imaging, which allows scientists to observe devices and conditions both in situ and in real time; a new Hitachi SU-70 field emission scanning electron microscope (FE-SEM)—the first of its kind installed in the U.S.—equipped with an energy-dispersive x-ray spectrometer (EDS) used for elemental mapping; a JEOL 2100F atomic-resolution field emission transmission electron microscope (FE-TEM); and a JEOL JXA-89 electron microprobe equipped with a wavelength-dispersive x-ray spectrometer (WDS), used primarily in materials and geology research.

Cumings hopes their visit will contribute to the NISPLab's goals. "Our desire is to a large extent to get the word out to attract new users, new benefactors, and new funded research projects," he explains. "The Office of the Vice President for Research is a great place to centralize all of these efforts." Contacts brought in by the UMCP Division of Research help support faculty and students using the lab.

Graduate students **Yi Qi** (MSE) and **Kamal Baloch** (Chemical Physics), and postdoctoral researcher **Todd Brintlinger**, demonstrated equipment and discussed recent research with Mote during his visit. Brintlinger highlighted the new FE-SEM's ability to perform elemental mapping and capture color in realtime. Qi presented the group's development and study of a new "meta material"—a manmade crystal designed to help researchers understand the behavior of ice *(see p. 4)*—while Baloch reviewed an ongoing project in thermal electron microscopy that will allow researchers to observe nanoscale devices as they are tested under varying conditions.

## NSF BOOSTS NANOTECH CURRICULUM

MSE Lab Coordinator **Robert Bonenberger**, Ph.D., MSE Professor and Chair **Robert M. Briber**, Department of Mechanical Engineering Associate Professor **Hugh Bruck**, **Jaime Cardena-Garcia**, Ph.D., and MSE Associate Professor **Luz Martinez-Miranda** recently completed work on an NSF-funded project titled "Development of Educational Materials and Acquisition of Equipment for a Nanoscale to Microscale Engineering Laboratory." The project, supported by the NSF's Course, Curriculum and Laboratory Improvement (CCLI) program, was used to develop new laboratory experiments that effectively engage undergraduate engineering students in the scientific processes and exploration of concepts in nanotechnology. Work funded under the proposal also helped integrate significant advances in nanotechnology research with the undergraduate engineering laboratory curriculum through the development of a new teaching lab.

Two significant experimental systems were assembled to give students an enhanced laboratory experience: a pair of micro-tensile testers, used for determining the mechanical properties of micron-scale devices and materials; and an integrated nanoindentation/scanning probe microscope (SPM) testing system, used for measuring the hardness and elasticity of materials at the nanoscale, and for imaging samples.

The equipment forms the core of the new Modern Engineering Materials Instructional Laboratory (MEMIL). Located in the Jeong H. Kim Engineering Building, the 2241 $ft^2$ facility serves as a shared undergraduate lab for materials testing and characterization and is used to accommodate the needs of multiple departments within the Clark School.

Bonenberger explained the importance of the new equipment to students' educational experiences: "Materials' properties are different at the micron and nanoscales—it seems like you have to rewrite the laws of physics. Things that are unimportant at the macro scale suddenly become very relevant. This equipment allows students to understand that. It also exposes them to concepts and tools that can be used for cutting edge research. It's a hook to get them interested in materials."

## NANOCENTER HIGHLY RANKED

*Small Times* ranked the Maryland NanoCenter #5 in education and #7 in research nationwide in its annual survey of trends in nanotechnology and microtechnology in its 2007 May/June issue.

The survey highlights UMD's strengths in scanning probe microscopy, the major growth in microelectromechanical systems (MEMS) on the campus and research involving combinatorial nanomaterials engineering, nanoparticle synthesis and biotechnology. Further strengths include faculty hiring, new facilities, undergraduate work in MEMS and nano, and proximity to federal labs, according to the survey. The NanoCenter's partnership with the National Institute of Standards and Technology and the university's new Center for Nanoscale Science and Technology were also cited.

The NanoCenter is a joint initiative between the Clark School, the School of Chemical & Life Sciences and the School of Computer, Mathematical & Physical Sciences.

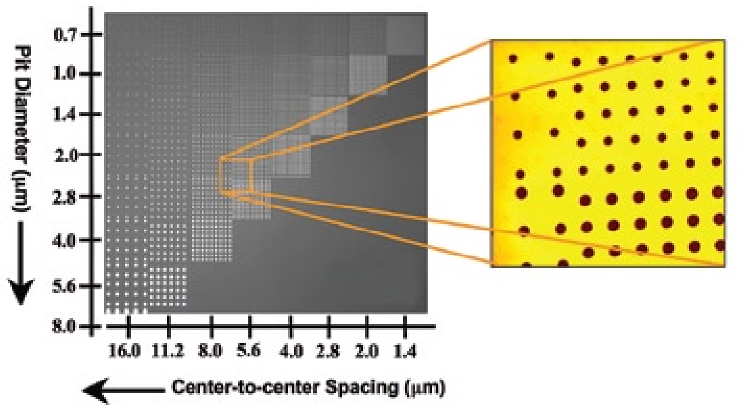
## TEMPLATING FOR DIRECTED SELF-ASSEMBLY

*Associate Professor Raymond Phaneuf*

Recognizing that nature is capable of producing extremely large numbers of small scale structures at a rapid rate, a number of scientists suggested that a solution to the problem of creating high densities of nanometer scale structures is self assembly. One of the problems with implementing self assembly for nano-engineering is that one obtains only those structures that nature will provide. The ideal solution, which many researchers, including my research group at the Laboratory for Physical Science, are now pursuing, is called directed self assembly, where a template is fabricated to guide nature in deciding how to assemble very large numbers of structures quickly.

The template can be made in a number of different ways—lithography followed by etching is one of the approaches used in my group at present. We make many different patterns on a given substrate simultaneously, allowing the effect of the pattern length scale to be explored. An example is shown in the figure below, where defined pits of varying diameters and spacings onto a gallium arsenide surface have been created. Additional GaAs is now grown onto this template, and the effect of the length scale on how new structures self-assemble during growth is observed. We find that large period structures amplify during growth: the pits effectively grow deeper, while those whose period is below a certain characteristic size relax during growth. This characteristic size moves to larger values as we grow thicker films, and so eventually even large period structures relax, but the surface shows a transient instability. We've explored the temperature dependence, and find that the nature of the instability changes beneath ~540°C; rings of material form around pits during growth beneath this. We explain this change based on competing kinetic effects: one is associated with a barrier that atoms feel on diffusing across a step from above, which is important at low temperatures. The second is a faster collection of atoms by larger terraces, important at high temperatures. In future work, we'll extend our patterns downward to nanometer dimensions.

In related experiments, we have patterned stepped silicon surfaces, and measured how the length scale of our pattern affects the self assembly of bunches of steps during heating in vacuum. Beneath a characteristic length scale bunches of straight steps form, while above this the bunches form near sinusoidal shapes, with the waviness of the bunches decaying at the same rate as the height. This length scale is set both by the stiffness of the steps and their interactions.




PATTERNED GaAs(001) SURFACE CONTAINING ARRAYS OF CYLINDRICAL PITS, 50 NM DEEP, WITH VARYING DIAMETER AND SPACING.

*References:*

*T. Tadayyon-Eslami, H.-C. Kan, L. C. Calhoun and R. J. Phaneuf, "Temperature-Driven Change in the Unstable Growth Mode on Patterned GaAs(001)." Phys. Rev. Lett. 97, 126101 (2006).*

*T. Kwon, R. J. Phaneuf and H. C. Kan, "Length-scale dependence of the step bunch self-organization on patterned vicinal Si(111) surfaces." Appl. Phys. Lett. 88, 071914 (2006).*

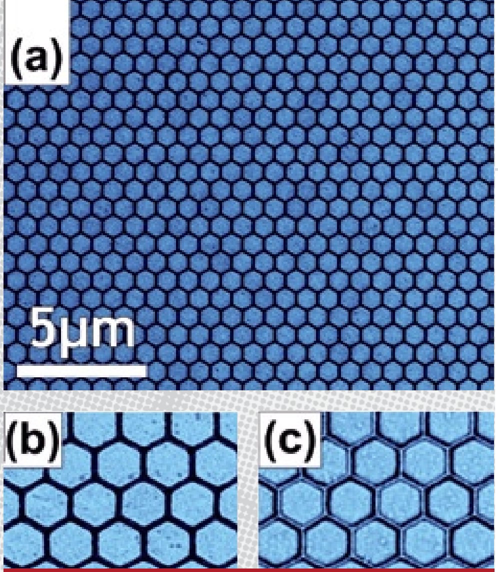
## ARTIFICIAL SPIN ICE

*Assistant Professor John Cumings*

Water, and its solid form, ice, are among the most ubiquitous materials on the surface of our planet. However, ice still carries many mysteries in its scientific understanding. For example, in its low temperature structure, the oxygen atoms show perfect crystalline order, but the hydrogen atoms (protons) are randomly arranged consistent with the so-called Bernal-Fowler rules. Briefly, these rules state that 1) two protons are strongly bound to each oxygen atom ("two in") and 2) each oxygen atom is weakly bound to two protons from neighboring water molecules ("two out"). Unexpectedly, this simple rule does not give a single simple structure. Instead, there is a vast manifold of low-energy configurations of protons that all obey the two-in two-out ice rule, and the structure will in general exhibit disorder. Unfortunately, this disorder is difficult to study directly, and many of the remaining mysteries of ice pertain to it.

In my group, we are trying to unlock some of these mysteries by studying a magnetic analog to ice, dubbed "artificial spin ice" [1]. In the artificial material, nanoscale NiFe ellipsoids behave like individual permanent bar magnets. To fabricate the artificial ice, I and my group members, **Yi Qi**, **Todd Brintlinger**, and **Stephen Daunheimer** use nanolithography to pattern the ellipsoids on a periodic lattice with the nearest-neighbors interacting at a common vertex. On the square lattice, the magnetic interactions influence the preferred magnetic configuration of nearest-neighbors to be two pointing in and two pointing out, showing the same basic ordering rules as ice. The difference is that now we can actually image the configurations directly using electron microscopy.

We have recently obtained notable results by changing from the square lattice to the triangular Kagome lattice (shown in the figure at right). On the Kagome lattice, the




(A) A TEM IMAGE OF THE ARTIFICIAL SPIN ICE CREATED BY THE CUMINGS GROUP. (B) A CLOSE-UP IMAGE OF A SMALL REGION OF THE ARTIFICIAL SPIN ICE. EACH LINK IS ONLY 500 NM IN LENGTH. (C) A LORENTZ TEM IMAGE OF THE SAME REGION AS (B). HERE THE MAGNETIC DIRECTION CAN BE DETERMINED BY THE BRIGHT AND DARK LINES IN EACH LINK. DESPITE SHOWING DISORDERED CONFIGURATIONS, EACH VERTEX OBEYS THE ICE RULE.

artificial ice is observed to perfectly obey its corresponding "ice rule" (two-in, one-out; or one-in, two-out). These results were recently published in *Phys. Rev. B* [2], and presented in lecture titled "Artificial Kagome Spin Ice" at the 2008 March Meeting of the American Physical Society. We are currently working to further understand the results through neutron scattering studies of larger arrays and by studying the effect of lattice imperfections, such as missing elements or lattice distortions. It is known that some types of lattice defects can remove the proton disorder from ice creating an ordered state, but little is known about why this occurs. In the near future, we hope to reproduce this ordering phenomenon in specially-modified artificial ice to learn why it occurs in real ice.

*References:*

*[1] R. F. Wang, C. Nisoli, R. S. Freitas, J. Li, W. McConville, B. J. Cooley, M. S. Lund, N. Samarth, C. Leighton, V. H. Crespi, and P. Schiffer, "Artificial Spin Ice." Nature, 439, 303 (2006).*

*[2] Yi Qi, T. Brintlinger, and John Cumings, "Direct Observation of the Ice Rule in Artificial Kagome Spin Ice." Physical Review B, 77, 094418 (2008).*

# invitedLECTURES

## A SELECTION OF INVITED LECTURES BY MSE FACULTY IN 2007-08

### Sreeramamurthy Ankem

"The Role of Deformation Twinning on Creep of Titanium Alloys." With P.G. Oberson. The 6th Pacific Rim International Conference on Advanced Materials and Processing, Jeiu Island, Korea, November 2007.

"The Role of Twinning on the Room Temperature Creep Behavior of Titanium Alloys." With P.G. Oberson. 11th World Conference on Titanium, Kyoto, Japan, June 2007.

### Mohamad Al-Sheikhly

"Kinetics of Remediation of Polychlorinated Biphenyls (PCBs) Induced by Electron Beam Irradiation in Aqueous and Aqueous Micellar Solutions, and Transformer Oil." 25th Miller Conference on Radiation Chemistry, Buxton, United Kingdom, April 2007.

"Radiation-Induced Destruction of Volatile Organic Compounds in Aqueous Solutions by Dual Oxidation/Reduction Mechanisms." Prospects and Challenges in Application of Radiation for Treating Exhaust Gases. International Atomic Energy Agency (IAEA), Warsaw, Poland, May 2007.

"Advances in Electron Beam Grafting of Isopropylacrylamide (IPAA) to a Poly(ethylene terephthalate) (PET) Membrane for Cell Sheet Detachment." 1st Research Coordination Meeting of the International Atomic Energy Agency on Development of Novel Adsorbents and Membranes by Radiation-Induced Grafting for Environmental and Industrial Applications, Vienna, Austria, November 2007.

### Robert M. Briber

"Soft Matter and Neutron Scattering: An Overview and Future Perspective." Plenary Talk, American Conference on Neutron Scattering, Santa Fe, NM, May 2008.

"Folding of RNA, SAXS Studies of a Model System." With S. Moghaddam, J.-H. Roh, G. Caliskan, S. Chauhan, L. Guo, D. Thirumalai, and S. Woodson. Materials Research Society, Boston, MA, November 2007.

### John Cumings

"Artificial Kagome Spin Ice." American Physical Society March Meeting, New Orleans, LA, March 2008.

### Gottlieb Oehrlein

"Plasma-Surface Interactions With Advanced Polymers For Nanoscale Patterning Of Materials." 60th Annual Gaseous Electronics Conference, AIP, Arlington, VA, October 2007.

"Studies of Plasma-Polymer Interactions For Nanoscale Patterning Of Materials." Invited talk at the 6th EU-Japan Joint Symposium on plasma processing in Okinawa, Japan, April 2008.

### Alexander Roytburd

"Domain Structure in Thin Films and Multilayers." American Physical Society March Meeting, Denver, Co., March 2007.

"Domain Evolution in Graded Ferroelectric Films." MRS Fall Meeting, Boston, MA, December 2007.

### Gary Rubloff

"Is there Vacuum in Nano?" Vacuum Technology and Coatings Exposition, Italian Vacuum Society, Milan, Italy, Oct. 2007.

"Visions of Nano and Micro." FBK-irst Colloquium, Trento, Italy, October 2007.

### Joonil Seog

"Unfolding and Refolding Behavior of Rossmann Fold Integrin I Domain Measured Directly Using Optical Tweezers." University of Tokyo, Tokyo, Japan, November 2007

### Ichiro Takeuichi

"Combinatorial Discovery of a Pb-Free Morphotropic Phase Boundary." Piezoceramic Society of Japan Meeting, Tokyo, Japan, July 2007.

"Combinatorial Investigation of Functional Thin Film Materials." Japan–U.S. Workshop on Materials Informatics and Combinatorial Sciences, University of Tokyo, Japan, July 2007.

"High-Throughput Investigation of Soft-Hard Magnetic Bilayers." MRS, Boston, MA, November 2007.

"Gradient Libraries for Development of New Functional Materials." Gordon Research Conference on Chemistry at Interfaces, Waterville Valley Resort, NH, July 2008.

## JANIAK NAMED 2007 FISCHELL FELLOW

In the not-so-distant future, you may find yourself less likely to suffer from a viral infection thanks to more plentiful vaccines, have it treated more effectively if you do get one, or possibly even have viruses filtered right out of your blood. Materials Science and Engineering (MSE) graduate student **Dan Janiak** is working to make that happen, and a proposal outlining his solution, "VIPER: Solutions for Viral Diagnostics," earned him the 2007 Fischell Fellowship in Biomedical Engineering.

The fellowship is a unique opportunity for talented and innovative graduate students interested in applied research and product design in the biomedical industry. It features a $35,000 12-month stipend, full tuition waiver, full health benefits, and is renewable for up to 5 years.

Janiak, who works in the Functional Macromolecular Laboratory and is advised by its director, Fischell Department of Bioengineering Professor **Peter Kofinas** (who is also appointed to MSE as an affiliate faculty member), is engineering polymers capable of recognizing and capturing specific peptides, proteins, and larger macromolecular structures—in his case, viruses. The polymers take the form of molecularly imprinted hydrogels, highly-absorbent, water-insoluble substances that, he explains with a laugh, "look like pieces of Jell-O." The gels are imprinted with a specific virus's shape. When molecules of that target virus are filtered though the gels, they—and only they—fit snugly into the imprint cavities and are trapped.

In diagnostic and treatment applications, the hydrogels could be used in blood tests as a means of detecting viral infection, and in hemodialysis, a process in which unwanted molecules are removed from the blood—probably best known as the waste-filtering treatment given to patients suffering from kidney failure. The hydrogels Janiak is developing could be used in new kinds of hemodialysis in which they would serve as tailor-made filters, catching blood borne viruses like HIV. Cleaned blood would be then returned to the body. While filtering cannot cure a viral illness, it can help patients feel better by removing viruses as they are produced by infected cells. This new technology could be integrated into existing medical equipment at a low cost to hospitals and other healthcare facilities.

Janiak's work could also benefit vaccine production. When a vaccine, which is made from inactive virus particles, is produced, the particles that are needed must be separated from the biomass in which they reside. Currently, this is a time-consuming and difficult process. According to Janiak, the biomass could be filtered through an imprinted hydrogel, which would trap only what is needed to make the vaccine while letting debris pass through. For this portion of his research, he is testing the effectiveness of the hydrogels on Human Parvovirus B19, a fever-and-rash illness that typically affects babies, and for which there is currently no vaccine. He takes advantage of the Functional Macromolecular Laboratory's relationship with the National Institutes of Health, using their facilities to cultivate the parvovirus capsids—non-infectious shells—he needs for his work.

When he applied for the Fischell Fellowship, Janiak took his ideas a step further by explaining how his hydrogels could be incorporated into marketable medical devices and used to improve existing procedures. The entrepreneurial nature of the Fellowship, he says, prompted him to "think outside the lab" and about the potential future of his work. He has even received business and product development advice from fellowship sponsor and alumnus Dr. **Robert E. Fischell** (M.S. '53), the inventor of numerous biomedical devices.

The most rewarding outcome of his work, Janiak says, would be to see his polymers and techniques used in an industrial research setting to aid in vaccine development. "Any time you start a project you want to have some commercial application for it, and in our case I think vaccine purification is one of best ones possible."

SAMPLES OF JANIAK'S IMPRINTED (REDDISH-BROWN) AND NON-IMPRINTED (WHITE/CLEAR) HYDROGELS. THE IMPRINTED HYDROGEL OBTAINS ITS REDDISH-BROWN COLOR FROM THE TARGET MOLECULE, BOVINE HEMOGLOBIN.

DAN JANIAK ▶

## TAPP WINS ACCENTURE SCHOLARSHIP

MSE senior **Maeling Tapp** is one of fewer than 20 students nationwide to be named the recipient of an Accenture Scholarship. Accenture is a company that provides consulting, technology, research and outsourcing services to a variety of industries around the world.

According to the Accenture web site, the Accenture Scholarship Program For Minorities "was created to encourage minorities to pursue degrees in engineering, computer science, and a variety of programs related to information systems and decision or management sciences." Recipients of the merit-based $2500 scholarships are chosen based on their GPAs, majors, extracurricular activities, and the quality of the essays they write as part of the application process.

## BANERJEE SELECTED FOR FUTURE FACULTY PROGRAM

MSE graduate student **Parag Banerjee** (advised by Professor **Gary Rubloff**) was one of only 20 students from throughout the Clark School chosen to participate in this year's Future Faculty Program. Banerjee will be part of the program's second cohort of students.

The Future Faculty Program (FFP), launched in 2007, was created to prepare students for academic careers in top-50 engineering schools by helping them hone their skills in areas such as technical and grant writing, curriculum development, teaching, research, oral presentations, and interviewing. The program includes seminars, a teaching practicum, and a research mentoring practicum, and takes 3-5 semesters to complete. Participants are known as Future Faculty Fellows, and receive a supplementary stipend of up to $10,000 over the course of the program. One half of the funds are reserved for travel to attend professional conferences.

Banerjee was motivated to apply to the program by its uniqueness. "None of the [other graduate] schools I applied to actually had such a program in place," he says. "People talk a lot about going into academia, but when you ask them [about it], there's a lot of tacit knowledge that they bring along with them, but that they were never trained in."

MAELING TAPP

Banerjee, who studies energy harvesting and energy storage devices in the Laboratory for Advanced Materials Processing, may seem to be on a path to professorship less taken: after earning his M.S., he worked in industry for 6 years. But, he explains, he had wanted to become a professor all along, and the delay was part of his plan: "Engineering is a very applied profession and if you want to become a good teacher you really have to appreciate how technology is put into practice in the real world. It was very important for me to go out and get some industrial experience, and then come back for the Ph.D. I think it will make me much more effective." Participating in the Future Faculty Program is another part of his plan to become the best professor he can be. "I think this is a very powerful program that's going to help us out in the long run."

## GRADUATE SOCIETY RECEIVES MRS CHARTER

MSE Professor **Lourdes Salamanca-Riba** and graduate student **Enrique Cobas** accepted a Certificate of Charter on behalf of the Department's Materials Science Graduate Society (MSGS) at the 2007 Materials Research Society (MRS) Fall Meeting. The charter officially recognizes MSGS, which is advised by Salamanca-Riba and MSE Assistant Professor **John Cumings**, as a university chapter of the society.

Membership in MRS, a national professional society, provides the group with a variety of benefits, including travel support for student members to attend society meetings, distinguished speaker support, special project grants, access to video archives, networking opportunities, and promotional materials for use at events.

"This charter is a great milestone for the MSG Society," said its president, MSE graduate student **Erin Robertson**. "We have been an active society for two years now. We've been involved with setting up seminar speakers, inviting prospective employers to speak, hosting prospective student open house events, bike trips to Harper's Ferry, and many others. Being an MRS chapter will open up new avenues for our members in terms of jobs, contacts, and access to research journals. We hosted a new membership drive in January 2008. I am very excited to see where the future of the MSG Society will go."

MSE Professor and Chair **Robert M. Briber** credited Robertson and MSGS's vice president **Susan Beatty Buckhout-White**, who were involved in the founding and organization of MSGS, with laying much of the groundwork for the society's success.

PARAG BANERJEE

MEMBERS OF THE "NEW AND IMPROVED" MRS UNIVERSITY STUDENT CHAPTER. TOP, L-R: PROFESSOR LOURDES SALAMANCA-RIBA (ADVISOR), SUSAN BEATTY BUCKHOUT-WHITE (VICE PRESIDENT), ERIN ROBERTSON (PRESIDENT), ENRIQUE COBAS (STUDENT MEMBER). BOTTOM, L-R: CHRIS METTING (TREASURER) AND PARAG BANERJEE (SECRETARY).

## RABIN JOINS FACULTY

The Department is pleased to welcome its newest faculty member, Assistant Professor **Oded Rabin**. Rabin holds a joint appointment with the Institute for Research in Electronics and Applied Physics (IREAP).

ODED RABIN

Rabin received his Ph.D. from the Massachusetts Institute of Technology (MIT) in 2004. His research program focuses on nanoscale structures and their interaction with their chemical and physical environment. His Materials and Interface Nanotechnology Lab will develop synthetic strategies to make useful nanoparticles, nanowires, and nanostructured thin films.

Rabin's research interests include chemical sensing and molecule-nanoparticle interactions; advanced materials for thermoelectric energy generation; applications of nanoparticles as biomarkers for imaging, diagnosis, and repair; porous anodic alumina scaffolds; and molecular and nanoparticle transport in microfluidic devices.

Before joining the Clark School, Rabin held postdoctoral positions with the Harvard Medical School at Massachusetts General Hospital, and with the University of California, Berkeley.

LUZ MARTINEZ-MIRANDA

## MARTINEZ-MIRANDA ELECTED APS FELLOW

Associate Professor **Luz Martinez-Miranda** (also affiliated with the Maryland NanoCenter and Graduate Program in Bioengineering) has been elected to Fellowship in American Physical Society (APS). The Council of the APS cited Martinez-Miranda "for sustained achievements in recruiting, mentoring, and advancing women and minorities in physics; for engaging K–16 students in the excitement of research; and for being a superb role model through her elegant research to understand liquid crystal systems and further their application."

Founded at Columbia University in 1899, APS has 46,000 members and is the publisher of *Physical Review Letters,* the top physics journal in the nation. APS Fellows constitute no more than one half of one percent of the total membership.

Martinez-Miranda's primary areas of research are in liquid crystals for biological studies and general engineering applications (displays and other devices), and X-ray scattering techniques of liquid crystal and other materials. She is currently studying the interaction of liquid crystal with nanoscale materials. Since nanometer-sized liquid crystal phases are found in the cell walls of all living creatures, her studies have implications in the healthcare field and the study of biological interactions, particularly where nanoparticles are used as carriers for the delivery of treatment.

Martinez-Miranda joined MSE (then the Department of Materials and Nuclear Engineering) in 1995, and contributed to the creation of its undergraduate program, including the design of two of its junior year materials labs. She has continued her involvement with MSE undergraduates, serving as one of the department's advisors, and is active in mentoring-oriented programs such as the University's Materials Science and Research Engineering Center's Research Experience for Undergraduates (MRSEC REU), and the Alfred P. Sloan Foundation's efforts to increase and support underrepresented American minority Ph.D. students in math, science and engineering. She was part of a team that recently completed a NSF-funded project to develop new laboratory experiments that effectively engage undergraduate engineering students in the scientific processes and exploration of concepts in nanotechnology. *(See related story, p. 3.)*

ROBERT M. BRIBER

## BRIBER TEACHES NEW "MARQUEE COURSE"

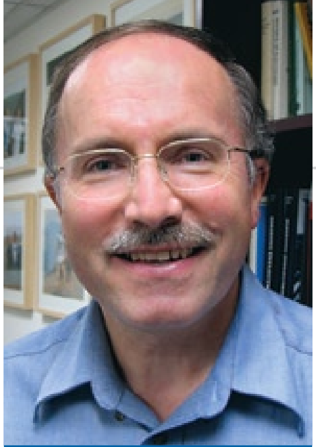
MSE professor and Chair **Robert M. Briber** is teaching one of the University of Maryland's new Marquee Courses in Science and Technology. The primarily 100-level courses, which fulfill undergraduate CORE requirements, are aimed at non-science majors and examine science and technology's roles in historical and contemporary issues, including energy, the environment, and medicine.

Briber's course, ENMA 150: The Materials of Civilization, covers the role of materials throughout history to the modern day, providing students with an understanding of the basic science that controls material properties and insight into the future of technology based breakthroughs in the materials that are driving the fields of nanotechnology, nano-medicine, microelectronics and biomaterials. The course includes a variety of hands-on demonstrations and guest speakers.

"Teaching this course is really enjoyable," says Briber. "I have a broad selection of students in my class and every lecture is a stimulating experience, with wide ranging questions and a lot of discussion. We're exploring how advances in materials are often directly coupled to advances in civilizations throughout history. It's a combination of learning about materials and the development of technology."

For more information on the Marquee Courses, visit **marqueecourses.umd.edu**.

## OEHRLEIN STUDIES PLASMA/WALL INTERACTIONS ON SABBATICAL



GOTTLIEB OEHRLEIN

Professor **Gottlieb Oehrlein** was a guest faculty member of the Materials Research Division at the Max-Planck Institut für Plasmaphysik (IPP) in Garching, Germany during his 2007 sabbatical. He was invited to participate in a project conducting research on plasma-materials interactions for fusion reactor design because of his expertise in plasma-surface interactions.

In nuclear fusion, two deuterium atoms (hydrogen isotopes) fuse to form helium atoms while simultaneously releasing energy. The creation of fusion reactors used to provide a clean, inexhaustible source of energy and has been a goal of physicists around the world for over 50 years. Progress, Oehrlein explains, has been slow but steady. Current approaches being considered involve the use of two hydrogen isotopes called deuterium and tritium, which fuse to produce helium and a neutron. Deuterium, derived from water, and tritium, derived from a neutron/lithium reaction, are plentiful. Tritium, while radioactive, has a distinct advantage over elements currently used in nuclear fission: its half-life is only 12 years. While that may seem like a long time, it's an instant compared to the half-lives of various isotopes of plutonium (about 25,000 years for plutonium-239) and uranium (greater than 240,000 years).

In 2008 the construction of the International Thermonuclear Experimental Reactor (ITER) began in Cadarache, France. The ITER project is an international collaboration performed under the auspices of the International Atomic Energy Agency, and is scheduled to begin plasma operation in 2016. The ITER reactor is not meant to produce energy for commercial consumption, but to enable systematic studies of a fusion plasma reactor under conditions that are required for future fusion-based power plants.

The materials used for crucial components of its design, however, have not been finalized. In order to produce its projected 500 megawatt output of energy, its hydrogen gas fuel must be superheated into plasma, establishing conditions similar to that inside of a star. In research conducted so far, contamination of the plasma and plasma interaction with the reactor walls—in particular with carbon fiber-based plasma-facing components—have presented challenges for the scientists working on the project.

Oehrlein's extensive experience studying plasma-surface interactions with hydrocarbon-based photoresists in his plasma etching research at the Laboratory for Plasma Processing of Materials made him a natural choice for a project team member, and, he says, he will be able to continue some of the work at the University of Maryland.

Oehrlein chose his sabbatical project for its potential, quality and challenge. "The Max-Planck Institut für Plasmaphysik is one of the leading centers in the world focused on the development of suitable materials and plasma-facing components for fusion reactors," he said. "My sabbatical enabled me to gain an overview of an important technology that has some connection with my current work, and understand the scientific questions that matter. Working with my colleagues at Garching has enabled me to make a very important scientific contribution in this new, promising area. My stay at IPP also enabled me to become familiar with important international activities and current problems relevant to fusion devices, and could provide an evolutionary path for my research."

"I am very thankful to the University of Maryland for enabling this sabbatical," Oehrlein added, "and also to the IPP for hosting me. It is difficult to imagine a research institute that would have been more welcoming, fun and suitable for achieving my goals."

inDEPTH

### OEHRLEIN'S PLASMA-SURFACE INTERACTION STUDIES

IN ONE SET OF EXPERIMENTS PERFORMED BY **PROFESSOR OEHRLEIN** AND COLLEAGUES **T. SCHWARZ-SELINGER, K. SCHMID, M. SCHLÜTER** AND **W. JACOB** AT MAX-PLANCK-INSTITUT FÜR PLASMAPHYSIK, GARCHING, GERMANY, THE INTERACTION OF QUANTIFIED DEUTERIUM (HYDROGEN) ATOM BEAMS WITH HARD A-C:H (A-C:D) FILMS WAS STUDIED AT A SUBSTRATE TEMPERATURE OF 320 K. THE RESULTS OF THIS WORK PROVIDE NEW INSIGHTS ON THIS ASPECT OF THE INTERACTION OF A DEUTERIUM PLASMA WITH PLASMA-FACING COMPONENENTS (PFC) BASED ON CARBON. FILM MODIFICATION AND EROSION WERE INVESTIGATED IN REAL-TIME BY ELLIPSOMETRY IN AN ULTRAHIGH-VACUUM PARTICLE-BEAM SETUP AT GARCHING. THE CHANGE OF DEUTERIUM (D) AREAL DENSITY AS A FUNCTION OF D (H) ATOM BEAM EXPOSURE TIME WAS MEASURED *EX SITU* BY NUCLEAR REACTION ANALYSIS WITH $^{3}$HE IONS AT 690 KEV.

OEHRLEIN AND COLLEAGUES WERE ABLE TO DISTINGUISH THREE SEQUENTIAL STAGES OF D (H) INTERACTION WITH HARD A-C:H (A-C:D) FILMS. THE FIRST STAGE IS ISOTOPE EXCHANGE OF THE HYDROGEN ISOTOPES IN THE FILM WITH THOSE FROM THE BEAM. THE FIRST STAGE IS RELATIVELY FAST AND EXTENDS TO A DEPTH OF ≈1.5 NM FROM THE SURFACE. IT IS COMPLETED AFTER AFTER A TOTAL HYDROGEN FLUENCE OF $\approx 2x10^{18}$ $CM^{-2}$ AND CORRESPONDS TO AN EXCHANGE OF $\approx 5x10^{15}$ ATOMS $CM^{-2}$. THE CROSS-SECTION OF ISOTOPE EXCHANGE DETERMINED IS EQUAL TO THAT OF HYDROGEN ABSTRACTION FROM AN A-C:H SURFACE. THIS IS FOLLOWED BY CREATION OF ADDITIONAL C-D (C-H) BONDS AT AN AREAL DENSITY OF $\approx 3x10^{15}$ $CM^{-2}$ IN THE NEAR-SURFACE REGION. A SOFT A-C:D LAYER WITH A THICKNESS OF ≈1.5 NM IS FORMED, AND ITS FORMATION IS COMPLETE AFTER A TOTAL HYDROGEN FLUENCE OF ABOUT $2x10^{19}$ $CM^{-2}$. DURING THE THIRD STAGE, STEADY-STATE EROSION OF THE A-C:H FILM IS SEEN. IN THIS PHASE, THE SOFT A-C:D LAYER WITH ROUGHLY CONSTANT THICKNESS (≈1.5 NM) REMAINS AT THE FILM SURFACE AND IS DYNAMICALLY REFORMED AS THE UNDERLYING HARD A-C:H (A-C:D) BECOMES THINNER. THE CURRENT RESULTS ON D (H) ATOM/A-C:H (A-C:D) FILM INTERACTIONS PROVIDE NEW INSIGHTS ON THE CONSEQUENCES OF LONG-TIME PLASMA EXPOSURES OF PFCS WHICH ARE RELEVANT TO FUTURE PLASMA SYSTEMS OPERATED UNDER STEADY-STATE CONDITIONS.

### MSE FACULTY CONTINUES TO PRODUCE "RESEARCH LEADERS"

MSE professors **Robert M. Briber**, **John Cumings**, **Ray Phaneuf**, **Gary Rubloff**, and **Lourdes Salamanca-Riba** were among the university faculty members recently recognized for their efforts in bringing sponsored research dollars to campus. This is the second year in a row that MSE has produced five Research Leaders—one-third of its full-time faculty.

Briber (MSE Chair) was recognized for his project with the National Institute of Standards and Technology Center for Neutron Research on using cold neutron scattering spectroscopy to characterize a range of advanced materials. These materials encompass functional materials, hydrogen storage materials, fuel cell membranes, nanoparticles, and soft materials, as well as many others.

Cumings receives funding from Agilent Corporation, the National Science Foundation, and the University of Maryland's Materials Research Science and Engineering Center (MRSEC). His research focuses on using electron microscopy to uncover the behavior of nanomaterials and nanodevices. The electron microscopes recently acquired by the NISPLab make his work possible. In particular, the new JEOL-2100 microscope has the capability to image magnetic fields in nanostructures in real-time while dynamic processes, such as passing electrical current though the structures, occur.

Phaneuf received a grant from the National Science Foundation to extend his studies of patterning in probing unstable growth on GaAs surfaces down to the nanometer scale using electron beam lithography. This will be complimented by kinetic Monte Carlo simulations to determine the atom-scale mechanism leading to the transient instabilities he and his group have identified. Phaneuf has continuing support through the NSF on a NIRT project with MSE Professor **Gottlieb Oehrlein**, Professor **David Graves** at UC-Berkeley, and Professor **Grant Willson** at UT-Austin on resist-plasma interactions; and the UM-MRSEC on quasi-1D organic electronic interfaces. He is supported by the Laboratory for Physical Sciences to carry out work using metal nanoparticles to enhance interactions with light, including fluorescence, energy harvesting, and metamaterials.

Rubloff (MSE, ISR and Director, Maryland NanoCenter) is one of a group of Clark School faculty members that continues to receive funding from the Robert W. Deutsch Foundation to develop a nanoscale, microfluidic biochip that can serve as a tiny drug discovery laboratory. He and a cross-disciplinary team of colleagues were also recently awarded the National Science Foundation's newest and most competitive grant for Emerging Frontiers in Research and Innovation in Cellular and Biomolecular Engineering (EFRI-CBE). Rubloff has also been responsible for a number of large awards in his role as NanoCenter Director, including multi-investigator Federal grants and the State's Sunny Day funding.

Salamanca-Riba is a member of the NSF-funded Materials Research Science and Engineering Center (MRSEC). Her research at the center focuses on the characterization of ferroelectric and ferromagnetic materials, including nanocomposites. She was also the PI of the Materials Research Instrumentation proposal for the acquisition of analytical instrumentation for the electron microscopes in the NISPLab. She uses the microscopes extensively for research and teaching.

### AL-SHEIKHLY INVITED TO INTERNATIONAL CONFERENCE

The Brazilian Association for Nuclear Energy (ABEN) invited MSE professor **Mohamad Al-Sheikhly** to be a guest speaker at a "triple conference" that included the 2007 International Nuclear Atlantic Conference, the 8th Meeting on Nuclear Applications, and the 15th Meeting on Reactor Physics and Thermal Hydraulics. The event was held September 30th to October 5th, 2007, in Santos, SP, Brazil.

Al-Sheikhly participated in a Round Table titled "Future Trends of Nuclear Applications: Nanotechnology, Nuclear Medicine, Radiation Processing and Radioisotope Technology."

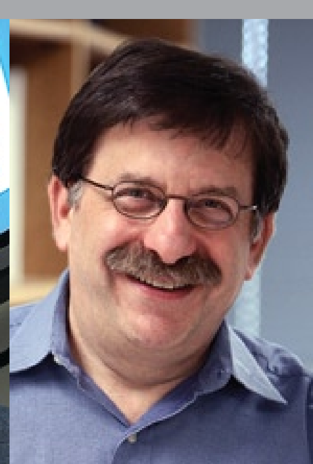
### RUSH ELECTED NSSA FELLOW

Adjunct professor Dr. **John J. Rush** was chosen as one of nine inaugural Fellows of the Neutron scattering Society of America (NSSA), out of over 1000 members. The citation reads: "For a career of visionary scientific leadership in promoting the field of neutron science in the U.S." For the past two years, Rush has been engaged in joint research with scientists at the NIST Center for

AL-SHEIKHLY

CUMINGS

RUBLOFF



SALAMANCA-RIBA

Neutron Research (NCNR) investigating the key properties of metal hydrides and new coordination framework compounds.

### CHRISTOU DESIGNS BETTER LASERS FOR THREAT DETECTION

MSE Professor **Aris Christou** has developed a new way of building solid state, tunable surface emitting lasers capable of detecting multiple biological and chemical threats in the atmosphere. The lasers could be used to improve existing environmental safety devices, and can be mass-produced at current manufacturing facilities.

The lasers Christou works with are built at the nano- and micron scales, and are similar to those used in fiberoptic networks and small electronics. The light they emit is in the infrared range, invisible to the human eye.

Christou uses a technique called molecular beam epitaxy to "grow" his lasers from the bottom up by depositing one molecular layer of material at a time. Ultimately, thousands of tiny lasers, called "mesas" because of their shape, rise up from the surface of an indium-gallium-arsenide wafer to a height of one micron—thinner than a sheet of paper.

Christou's new lasers overcome two major stumbling blocks: spanning 3-6 microns in wavelength, they make headway into the critical 3-20 micron range required to detect chemical and biological agents; and are individually tunable, meaning their wavelengths can be adjusted. This could greatly improve the flexibility and effectiveness of the devices people use to scan for hazardous materials.

Christou and his colleagues presented their work in late 2007 at the SPIE Europe Remote Sensing Conference in Florence, Italy. Christou was also invited to present his work as a late paper at the Photonics West conference. The project was funded by the NASA Space LIDAR Technology Center under the UMD-NASA Cooperative agreement.

## recentGRADUATES

### 2007-2008 B.S. GRADUATES

- Elyse Canosa
- Joshua Davis
- Michael Dollinger
- Colin Heikes
- Abiodun Osho
- Christina Senagore
- Maeling Tapp
- Alvin Wilson

### 2007–2008 PH.D. GRADUATES

**Jason Hattrick-Simpers:** A Combinatorial Investigation of Magnetostriction. Advisor: Ichiro Takeuchi

**Alia Weaver:** Ionizing Radiation-Induced Copolymerization of 2-Ethylhexyl Acrylate and Acrylic Acid and Ionomer Formation. Advisor: Al-Sheikhly

**Joon Hyuk Yang:** The Attachment and Characterization of DNA Probes on GaAs-Based Semiconductor Surfaces. Advisor: Al-Sheikhly

**De-Hao Tsai:** Understanding Electric Field-Enhanced Transport for the Measurement of Nanoparticles and Their Assembly on Surfaces. Advisor: Zachariah

**Jung-Chul An:** Synthesis, Characterization and Kinetic Studies of Ionizing Radiation Induced Intra and Inter Crosslinked Polyvinyl (Pyrrolidone) Nanohydrogels. Advisor: Al-Sheikhly

## studentAWARDS

### UNDERGRADUATE AWARDS FOR 2007-2008

Learn more about these students at: www.mse.umd.edu/undergrad/profiles

**Chairman's Outstanding Senior Award:** Maeling Tapp

**Outstanding Materials Student Service Award:** Christina Senagore

**The Department of Materials Science and Engineering Student Research Award:** Colin Heikes

# alumniNEWS

## MSE ALUMNI PRESENT AT WIE CONFERENCE

MSE alumni **Erin Flanagan** (B.S. '06) and **Chandler McCann** (B.S. '05) spoke to a standing-room-only crowd about their experiences in the Department's undergraduate program and as employees of Micron Technology, Inc., which manufactures memory and other components for a variety of electronic devices.

Their presentation, part of a larger session called "Engineers Make Things Better," was part of the First Annual Women In Engineering DREAM Conference, which has been established to recruit, retain and advance women in engineering; and to provide a forum at which to share the innovations, applications and opportunities engineering has to offer with female high school students and their families.


FLANAGAN (LEFT) AND McCANN (RIGHT)

Flanagan and McCann discussed how they became interested in materials science and engineering, how the MSE program prepared them for their current positions, the career outlook for materials scientists, and why they felt young scientists should consider majoring in MSE.

ALUMNI: PLEASE SEND *YOUR* NEWS TO bioechemmse@umd.edu OR flevine@umd.edu.

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THE RED IMAGE USED ON THE COVERS IS A TEMPLATED PATTERN OF ISLANDS AND HOLES IN A THIN BLOCK COPOLYMER FILM WHICH HAS FORMED ON A CHEMICALLY MODULATED SUBSTRATE. YOU CAN LEARN MORE ABOUT CURRENT FACULTY RESEARCH IN ARTICLES THROUGHOUT THIS NEWSLETTER.

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