FALL 2010

TECHTRACKS

MATERIALS SCIENCE AND ENGINEERING

A. JAMES CLARK SCHOOL *of* ENGINEERING

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:

"Smart" Alloy Could Make Cooling Systems 175% More Efficient

TAKEUCHI, WUTTIG PART OF DOE ARPA-E GRANT-WINNING TEAM

If a new "smart" metal could help cool your home or refrigerate your food 175 percent more efficiently than current technology, imagine what that would do for your electric bills.

Department of Materials Science and Engineering (MSE) professors **Ichiro Takeuchi** and **Manfred Wuttig** have received a $500,000 Department of Energy (DOE) Advanced Research Projects Agency—Energy (ARPA-E) grant to develop a new "thermally elastic" metal alloy for use in advanced refrigeration and air conditioning systems. The technology promises far greater efficiency and reductions in greenhouse gas emissions.

Takeuchi and Wuttig have partnered with Dr. **Frank Johnson** and Dr. **Ching-Jen Tang** (General Electric Global Research) and MSE adjunct professor Dr. **Jun Cui** (Pacific Northwest National Laboratory) on the project.

"Air conditioning represents the largest share of home electric bills in the summer, so this new technology could have significant consumer impact, as well as an important environmental benefit," says Professor **Eric Wachsman**, director of the University of Maryland Energy Research Center (UMERC).

"[The team's] approach is expected to increase cooling efficiency 175 percent, reduce U.S. carbon dioxide emissions by 250 million metric tons per year, and replace liquid refrigerants that can cause environmental degradation in their own right," he adds.

Takeuchi, Wuttig and their colleagues have developed a solid coolant to take the place of fluids used in conventional refrigeration and air conditioning compressors. Their system represents a fundamental technological advance, they say.

In the next phase of research, the team will test the commercial viability of their smart metal for space cooling applications. The 10kg prototype is intended to replace conventional vapor compression cooling technology. Instead of fluids, it uses a solid-state material—their thermoelastic shape memory alloy.

This two-state alloy alternately absorbs or creates heat in much the same way as a compressor-based system, but uses far less energy, the team explains. It also has a smaller operational footprint than conventional technology, and avoids the use of fluids with high global warming potential.

The team's ARPA-E grant—one of only 43 awarded nationwide and the first awarded to the University of Maryland—is part of a program designed to spur U.S. innovation by bringing "game-changing" technologies to market. The grants are funded with money from the federal American Recovery and Reinvestment Act, and stem from a recommendation contained in the 2006 National Academies report *Rising Above the*

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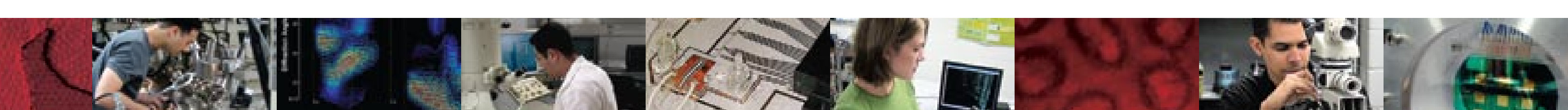


chair's MESSAGE

ROBERT M. BRIBER

THE THEME OF ENERGY IS DOMINATING THE DEPARTMENT'S CURRENT RESEARCH ACTIVITIES.

This issue's lead story is about the exciting work by Professors **Ichiro Takeuchi** and **Manfred Wuttig** on using a thermally-elastic alloy for efficient refrigeration, and is followed by an article on the DOE-supported research by Professor **John Cumings** to measure the transport of thermal energy by carbon nanotubes. We also report on advances in photovoltaics and biofuel production *(see p. 4)*.

The field of MSE is at the heart of the push for new energy technologies. Many of the solutions for more efficient energy use and storage are limited by the currently available materials used to manufacture them. Materials scientists will lead the way to the solutions to these problems.

Our undergraduate enrollment has been steadily growing. We have reached the high 60s for the Fall 2010 semester and will soon break 70. This is the first time since the start of the B.S. program in 1999 that our undergraduate enrollment has exceeded our Ph.D. enrollment. The Department has been very active in recent years in promoting the field of MSE through open houses *(see p. 12)*, visits to local schools and presentations to students. These activities are bringing new students to the University to major in the exciting field of materials science and engineering.

Now more than ever, these talented new students need your support. Even a few hundred dollars can make the difference between a student obtaining a Terp education or not. A variety of meaningful and fun ideas for any budget can be found online at **eng.umd.edu/giving/giving_creative.html**. You can also help our students by establishing a scholarship in honor of a family member or friend. For more information, visit the **Give to MSE** link on the Department homepage at **www.mse.umd.edu**.

If you enjoy *Techtracks*, please take a moment to visit our website at **www.mse.umd.edu** and read through the news—we are continuously posting new stories about our students and faculty winning awards, publishing new research, and presenting their work at conferences across the country and around the world. You can also browse our lineup of great seminars, which you are welcome to attend.

Please encourage the potential future scientists and engineers you meet to think about materials science and engineering as a career. If they choose MSE, they will be at the center of some of the most exciting developments that we will see in the next decade. The future of engineering depends on the underlying materials that form the building blocks of our modern society.

If you are in the Washington, D.C. area, please consider a visit to the Department to learn about developments in research and education. If you are an alumnus, please keep us informed on the changes in your career—you can contact us any time at **mse@umd.edu.**

Robert M. Briber
Professor and Chair, MSE

ARPA-E GRANT, continued from page 1

Gathering Storm, co-authored by University of Maryland President **C.D. Mote, Jr.**

"These grants are highly competitive and require a demonstration that the technology has genuine commercial potential," Wachsman explains. "This represents a significant investment in the state of Maryland and the development of its 'green' economy."

Story adapted from the original University of Maryland press release by ***Neil Tickner****.*

CUMINGS RECEIVES DOE GRANT TO STUDY THERMAL RESISTANCE OF CARBON NANOTUBES

Assistant Professor **John Cumings** has received a four-year, $552,000 grant form the Department of Energy (DOE) for a proposal titled "Interfacial Thermal Resistance of Carbon Nanotubes."

Despite having a width 1000 times smaller than a human hair, carbon nanotubes are up to 100 times stronger than steel at only 1/6 the weight. They have an electrical conductivity that can exceed that of copper and a thermal conductivity near that of diamonds. This combination of qualities makes them ideal for the creation of nanomechanical and nanothermal structures, but their properties are still not completely understood. For example, despite their high thermal conductivity, some studies show that samples composed of nanotubes can behave as good thermal *insulators* due to interfacial thermal resistance, a common phenomenon in which an interface between two materials doesn't transport as much as either material would alone.

"It's a big problem in thermal transport," says Cumings. "The DOE is very interested in this since most streams of energy spend at least part of their life as heat energy before getting to the end consumer. Having the ability to efficiently remove heat from where it's not wanted and transporting it to where it can do beneficial work, such as through heat exchangers in cooling towers, could result in measurable improvements in efficiency for everything from computer processors to fuel-powered turbine generators. Carbon nanotubes show the promise of substantial improvements in this area if we can figure out how to control and reduce their interface resistance."

The goal of Cumings' project is to uncover the mechanisms by which heat is transferred into and out of the nanotubes by measuring the interfacial thermal resistance at many different temperatures and comparing these results with various mathematical predictions.

Cumings will perform the measurements using a thermal imaging technique invented in his lab called Electron Thermal Microscopy (ETM; see image, upper right). ETM was created to perform nanoscale thermometry (measuring a system's temperature or ability to transfer heat) by imaging nanoscale devices in real-time while they are observed in a transmission electron microscope. The Cumings Group will test carbon nanotubes in characteristic environments that could be employed in the manufacture of nanoscale devices in an effort to discover new mechanisms of heat transfer in the process.

The research will be conducted in the Nanoscale Imaging, Sprectroscopy and Properties (NISP), part of the Maryland NanoCenter. *(Visit **nisplab.umd.edu** and **nanocenter.umd.edu** for more information about these facilities.)*

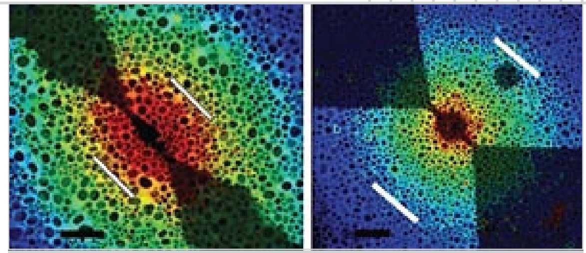
TAKEUCHI, MULTI-UNIVERSITY GROUP LEAD MATERIALS RESEARCH

Professor **Ichiro Takeuchi** and his collaborators have been awarded millions of dollars in funding from the Department of Defense (DOD) and Department of Energy (DOE) to advance the discovery of new materials for use in energy, transportation, defense and industrial applications.

A key factor in these studies is Takeuchi's expertise in combinatorial materials science ("combi"), a highly specialized area of materials research that allows scientists to rapidly screen and analyze a large number of compositionally varying samples to determine if any have the characteristics the researchers desire, saving time and money in the process. The Takeuchi Group and its related laboratories, including the Keck Laboratory for Combinatorial Nanosynthesis and Multiscale Characterization, equipped with seven thin-film devices and multiple rapid characterization and screening tools, represent one of the largest combi efforts in the world.

The first project, titled "Broad-Based Search for New and Practical Superconductors," is being conducted in collaboration with PI Professor **Richard Greene** (Department of Physics) and is funded by a five-year DOD Multi-disciplinary University Research Initiative (MURI) grant of up to $5 million. The project's goal is to discover new high-temperature superconductors that could be used in maglev transportation, energy generation and storage, and ultrasensitive sensors and measuring devices. A new high-vacuum combinatorial pulsed-laser deposition system was constructed specifically for the research.

THE NEW HIGH-VACUUM COMBINATORIAL PULSED-LASER DEPOSITION SYSTEM CONSTRUCTED TO FACILITATE THE SEARCH FOR NEW SUPERCONDUCTORS. THE FACE SHOWS THE COMBI FLANGE WHERE THE SUBSTRATE IS MOUNTED. THE MASK GLIDES OVER IT, BACK AND FORTH, DRIVEN BY THE CHAIN.



JOHN CUMINGS WILL BE USING ELECTRON THERMAL MICROSCOPY, SHOWN IN THE IMAGES ABOVE, TO STUDY THE HEAT CONDUCTION ABILITIES OF CARBON NANOTUBES. THE TECHNIQUE, WHICH UTILIZES ELECTRON MICROSCOPES IN THE MARYLAND NANOCENTER'S NISP LAB, ALLOWS SCIENTISTS TO SEE HEAT FLOW AT THE NANOSCALE, DETECTING HEAT LEAKS A MILLION TIMES SMALLER THAN THOSE FROM A TYPICAL WINDOW PANE. THIS WILL ALLOW THE ENGINEERING OF CARBON NANOTUBES INTO NEW, HIGHLY CONDUCTING MATERIALS FOR USE IN HEAT SINKS AND HEAT EXCHANGERS. REPRINTED WITH PERMISSION FROM **KAMAL H. BALOCH**, **NORVIK VOSKANIAN**, AND **JOHN CUMINGS**, "CONTROLLING THE THERMAL CONTACT RESISTANCE OF A CARBON NANOTUBE HEAT SPREADER," *APPL. PHYS. LETT.* **97**, 063105 (2010), AMERICAN INSTITUTE OF PHYSICS.

"Currently, superconductors need to be cooled by cryogens such as liquid nitrogen or liquid helium in order for them to function," says Takeuchi. "That's inconvenient and can be expensive. Discovering a superconductor that can function at room temperature would be the ultimate achievement, but anything we can do to increase the temperature at which they function would be a step in the right direction."

The second project, titled "Beyond Rare Earth Magnets" and conducted in collaboration with the DOE's Ames Laboratory and PIs across multiple universities, will receive up to $10 million over five years to fund the development of new permanent (non-electro-) magnets that do not contain rare earth elements such as neodymium (Nd) or samarium (Sm).

Permanent magnets are capable of storing energy, converting mechanical to electrical energy, and directing and controlling ion beams. They are found in mechanical devices that are used everywhere in industrialized society, including generators, alternators, motors, speakers, and relays.

"All of the best permanent magnets contain rare earth elements," Takeuchi

continues next page

MATERIALS, continued from page 3

explains. "The problem is, as the name suggests, they're scarce and expensive. Most of the world's known deposits of rare earth metals are located in China. The DOE is concerned about the possibility of shortages. My colleagues and I have been asked to start the search for new, high-energy permanent magnets that are just as good or better than traditional rare earth products."

BRIBER, WATSON RECEIVE MIPS FUNDING FOR WORK WITH ZYMETIS

MSE Professor and Chair **Robert M. Briber** has received a $108,085 award from the Maryland Industrial Partnerships Program (MIPS) to advance research on a project he, Professor **Steve Hutcheson** (Department of Cell Biology and Molecular Genetics [CBMG]), and MSE graduate student **Brian Watson** (co-advised by Briber, Hutcheson, and MSE Associate Professor **Isabel Lloyd**) carry out for Zymetis, Inc., a College Park-based company developing a unique, low-cost solvent system used during the production of ethanol and other biofuels.

Zymetis' product degrades the crystallinity of cellulose, an important step in the biofuel production process. It accomplishes the task faster and at a lower cost than the enzymes currently used in biomass digestion. The product is capable of breaking down the cellulose found in any plant matter, which would allow biofuel manufacturers to use waste products usually headed for landfills—like corn cobs, agricultural waste and paper—as raw materials in the production of ethanol.

Zymetis was launched by Hutcheson and Professor Emeritus **Ron Weiner** (CBMG) in 2006, and is currently part of the university's Technology Advancement Program, a venture incubator that matches startup companies with entrepreneurs. In 2009, Zymetis was named to the GoingGreen list of the top 50 companies in green technology. In April 2010 the company was profiled on Washington, D.C. CBS affiliate WUSA-9 news in a segment called "Scientists Work To Turn Trash Into Fuel."

Founded in 1987, MIPS, an initiative of the A. James Clark School of Engineering's Maryland Technology Enterprise Institute (Mtech), supports university-based research projects that help Maryland companies develop technology products.

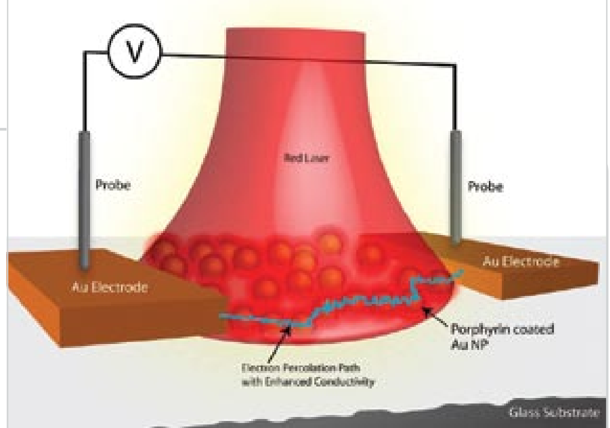
A SOLAR-POWERED CIRCUIT, BUT NO SOLAR CELL REQUIRED

MSE graduate student **Parag Banerjee**, advised by Professor **Gary Rubloff**, is the first author of a paper describing a nanoscale photovoltaic (solar-powered) circuit that could be used to power a wide range of optical and electronic devices. The circuit could also be adapted for data storage, replacing the traditional binary system ("ones and zeros") with one in which data corresponds to different wavelengths of light.

Banerjee led the experimental effort as part of a two-month, on site internship with Professor **Dawn Bonnell**'s research group at the University of Pennsylvania's Nano/Bio Interface Center. It is one of the first demonstrations of light-powered electrical circuits that generate their own energy rather than relying on batteries or solar cells to function.

By attaching single molecules similar to those used by plants for photosynthesis to an array of gold nanoparticles, Banerjee and his colleagues have been able to direct light and make the molecules change their electrical properties.

"When light falls on gold nanoparticles, it is captured and refocused to regions in between them," Banerjee explains. "The refocused light is of very high intensity and is a result of the free electrons, already present in metals, oscillating at the surface of the nanoparticles. If we can attach a molecule between two gold nanoparticles that can give up its electrons easily when hit with the light, it's possible to produce a current in the circuit without the need to use solar cells as means to first convert light into electricity.



A SCHEMATIC OF A HYBRID MOLECULAR DEVICE SHOWS METAL ELECTRODES CONNECTED BY A PERCOLATION PATHWAY COMPOSED OF DITHIOL-PZn_3-COATED AU NANOPARTICLES.

"The neat thing about this discovery," Banerjee adds, "is that in the future it could change the way we power our devices. Imagine a desktop computer enclosed in a clear case. It has no power cord and the room light is sufficient to make it run."

At present, the energy generated by the circuits is not sufficient to power a device such as a computer or iPod. Banerjee's collaborators are working on ways to scale up the technology to produce a one amp, one volt circuit that is an inch long and the width of a human hair.

"The demonstration of the phenomenon, as described in our paper, is only the first step," says Banerjee. "In order to make these circuits feasible, we need to determine how to control the distance between the gold nanoparticles to enable the control of the wavelength of focused light, and we also need to design newer molecules that, when attached to the nanoparticles, maximize the production of electrons when exposed to light."

The paper, titled "Plasmon-Induced Electrical Conduction in Molecular Devices," appears in *ACS Nano,* 2010, 4(2). It has already received media attention from *Popular Science,* Discovery.com, and *Science Daily,* and was cited in the Materials Research Society's May 2010 issue of the *MRS Bulletin.*

Banerjee's internship was funded by his John and Maureen Hendricks Energy Research Fellowship (awarded by the University of Maryland Energy Research Center) and his Future Faculty Fellowship (awarded by the A. James Clark School of Engineering). The solar-powered circuit research is funded by the National Science Foundation and the U.S. Department of Energy.

FEODOR LYNEN FELLOW JOINS MSE AND IREAP

The Department of Materials Science and Engineering is pleased to welcome visiting scientist and Feodor Lynen Fellow Dr. **Evelina Vogli** to the A. James Clark School of Engineering and the University of Maryland. MSE professor **Gottlieb Oehrlein** (joint, Institute for Research in Electronics and Applied Physics [IREAP]), director of the Laboratory for Plasma Processing of Materials, and Professor **James F. Drake** (Department of Physics/IREAP) will serve as her hosts. Dr. Vogli is the Senior Engineer and Head of the Coatings Technologies Research Group at the University of Dortmund, Germany.

The prestigious Feodor Lynen Research Fellowship, which serves a similar purpose as a Fulbright Scholarship, offers outstanding researchers from all disciplines the opportunity to engage in a six- to 18-month research project at a foreign academic institution of their choice. The fellowship is awarded by the Alexander von Humboldt Foundation, which promotes academic cooperation between experienced researchers and group leaders from Germany and around the world by offering a wide variety of awards, professorships and fellowships for scholars at all levels of their careers. Fellows are hosted by a worldwide network of over 24,000 "Humboldtians," alumni and fellows of these programs.

"I chose the University of Maryland because [it] is among the top engineering programs in U.S.A.," says Vogli. "Both Professor Oehrlein and Professor Drake are nationally and internationally renowned in [the fields of] plasma and plasma-surface interactions. I was also very impressed with how many collaborative efforts there are between the Department [of MSE] and nearby national labs and industry."

Vogli will be studying surface modifications and functionalization of carbon and polymer coatings using low pressure and atmospheric pressure plasma. The customization of coatings is an important aspect of many manufacturing processes. By controlling or adjusting their surface properties, manufacturers can optimize a product's performance by enhancing its resistance to corrosion, scratching, heat, water, biohazards, friction, or wear. The precise use of plasma, and electrified gas, in the production of these customized coatings is key to achieving the desired results. Industrial demand for new and enhanced plasma surface treatment techniques has more than doubled in the past ten years, and more than quadrupled since 1995. Vogli's results could further advance manufacturing options and efficiency.

"This research stay offers me the possibility to gain valuable experience that will further my academic and scientific careers," says Vogli. "At Dortmund University I worked on the design and development of DLC and nano coatings as well as thermal sprayed coatings for wear, friction and corrosion protection at different fields of applications as well as sensor layers in machining tools. The work to be done at the University of Maryland will help me become acquainted with new methods and techniques, establish new contacts, exchange experiences with scientists from other countries, and become acquainted with cooperating partners. The research I intend to perform is a combination of my prior research work—plasma depositions and plasma treatment—and a new research field, plasma treatment of polymers. I hope to solve problems and obtain many positive results in UMD's very international environment."

inBRIEF

ELECTROSTATIC NANO-CAPACITORS NAMED A UM INVENTION OF THE YEAR

THE ELECTROSTATIC NANOCAPACITORS CREATED BY PROFESSOR **GARY RUBLOFF** AND HIS COLLABORATORS, WHICH WE FIRST PROFILED IN OUR SPRING 2009 ISSUE, HAS RECEIVED AN INVENTION OF THE YEAR AWARD FROM THE UNIVERSITY'S OFFICE OF TECHNOLOGY COMMERCIALIZATION.

THE INVENTION, WHICH HAS BEEN FEATURED IN *NATURE NANOTECHNOLOGY,* IS A NANOSCALE VERSION OF THE COMMON ELECTROSTATIC CAPACITOR. THE NEW NANOCAPACITORS STORE UP TO 10 TIMES MORE ENERGY, AND COST FAR LESS TO MANUFACTURE. THEY ARE CREATED USING THE SELF-ASSEMBLY OF NANOPORES DURING THE ELECTROCHEMICAL FORMATION OF ANODIC ALUMINUM OXIDE (AAO) FROM ALUMINUM.

THE PROJECT'S ONGOING SUCCESS HAS LEAD TO THE CREATION OF A NEW A DOE ENERGY FRONTIER RESEARCH CENTER CALLED NANOSTRUCTURES FOR ELECTRICAL ENERGY STORAGE (**www.efrc.umd.edu**).

RUBLOFF'S RESEARCH GROUP INCLUDES GRADUATE STUDENT **PARAG BANERJEE**, ALUMNUS AND POSTDOCTORAL RESEARCH ASSISTANT **LAURENT HENN-LECORDIER** (PH.D. '09), ASSOCIATE PROFESSOR **SANG BOK LEE** (DEPT. OF CHEMISTRY & BIOCHEMISTRY), AND **ISRAEL PEREZ** (PH.D. '09).

LEFT TO RIGHT: DR. **EVELINA VOGLI**, PROFESSOR **JAMES F. DRAKE**, AND PROFESSOR **GOTTLIEB OEHRLEIN.**

PERTMER APPOINTED MANAGING DIRECTOR OF RADIATION FACILITIES

Department of Materials Science and Engineering and Keystone Professor **Gary Pertmer** was appointed managing director of the Clark School's radiation facilities, effective August 2, 2010.

For the past ten years, Pertmer has served as the Clark School's Associate Dean of Undergraduate Recruitment, Outreach and Special Programs. Under his guidance, the average GPA and SAT scores for incoming freshman have soared, the numbers of admitted female and underrepresented minority students have substantially increased, and several academic departments have successfully renewed or achieved ABET accreditation.

In his new role, Pertmer, a nuclear engineer, will be responsible for managing three radiation facilities including the nuclear training reactor, the cobalt-60 laboratory, and the high-energy linear accelerator (LINAC). He will also be responsible for issues related to compliance, safety, security, financial management of the facilities, and direct interactions with both on-campus and off-campus officials.

The Clark School's graduate program in nuclear engineering, offered both on campus and online, is growing to meet the national need for nuclear engineers. *(See related story below.)*

NRC FUNDS DEVELOPMENT OF NEW GRAD-LEVEL CORROSION COURSES

The Nuclear Regulatory Commission (NRC) has awarded Professors **S. Ankem** (MSE), **Aris Christou** (MSE and Director, Graduate Program in Nuclear Engineering), and **Mohammad Modarres** (Department of Mechanical Engineering and Director, Graduate Program in Reliability Engineering) a one-year, $100K education grant to develop new modules on the corrosions of metals for graduate level courses in the Clark School's Nuclear Engineering, Reliability Engineering, and Sustainability Engineering programs. The material will emphasize forms of corrosion, eliminating corrosion, and making nuclear reactors safe.

The new additions to the curricula are geared toward nuclear industry professionals, materials science students, mechanical engineers, and NRC and Department of Energy staff. To reach more students in the professional community, the coursework will also be offered as part of the new, fully-online M.S. programs in Nuclear and Sustainability Engineering beginning in academic year 2011-2012.

The educational research project will produce three separate course modules that can be integrated into existing courses, or combined into a new course called "Corrosion Degradation."

The first new course module, on probabilistic risk assessment of corrosion and risk prediction methods of corrosion, will be developed for direct insertion into two existing courses, Probabilistic Risk Assessment & Risk Management and Materials Degradation. The second will add a laboratory section to the Materials Degradation syllabus, including a hands-on corrosion testing experience. The third will address the physics of failure of the corrosion phenomena. The course modules will consist of a combination of video presentations, Powerpoint presentations, and special lecture notes which will be made available to current and future students.

The new course, "Corrosion Degradation," is designed to instruct graduate students in the fundamentals of materials-environment interactions. The course outline includes liquid-solid interactions, direct dissolutions mechanisms, electrochemical corrosion, the kinetics of corrosion, and corrosion prevention. Gas-solid interactions will emphasize the reaction products, kinetics and wear mechanisms. Students will study specific examples of corrosion modeling as well as failure analysis and *in-situ* corrosion testing within an environmental scanning electron microscope. Students will also learn how to prevent the corrosion, what risk factors should be used to assess safety and, in the case of nuclear reactors, how to decide when a shutdown is warranted.

DELAWARE RESIDENTS NOW ELIGIBLE FOR IN-STATE TUITION TO STUDY MSE AT UMD

Undergraduate students living in the state of Delaware can now pay in-state tuition to earn a Bachelor of Science degree in materials science and engineering (MSE) at the A. James Clark School of Engineering, University of Maryland, thanks to the program's approval by the Southern Regional Education Board's (SREB) Academic Common Market.

The SREB Academic Common Market helps students from participating states pursue degrees not offered by public schools in their own states by attending an out-of-state public university that does, by allowing them to pay in-state tuition. The program makes it possible for students whose academic choices would otherwise be limited by higher out-of-state tuition costs to obtain the education and degrees they want. Students must be a resident of one of SREB's 16 participating states, select an approved program available to their home states, and meet residency and admissions requirements.

"We're really excited to be able to offer this opportunity to prospective students from Delaware," says MSE Professor and Chair **Robert M. Briber**. "It's a great way for them to get a more affordable degree from a highly-ranked public school in a great location. A degree in materials science and engineering can lead to many different career paths, and job opportunities and starting salaries are good. We've got an excellent program here that includes smaller class sizes, research opportunities for undergraduates, state-of-the-art labs, and specialization areas including a minor in nanotechnology."

NEWS BROADCAST HIGHLIGHTS HOVERCRAFT COMPETITION, KEYSTONE PROGRAM

Reporter **Holly Morris** broadcast live from the spring ENES 100: Introduction to Engineering Design autonomous hovercraft competition as part of Washington, D.C.'s Fox5 Morning News' coverage.

Each semester, teams of freshmen engineering students from all majors design and build hovercraft equipped with fans, a steering system, an on-board computer, and sensors. The vehicles, which average about three feet in length, are not remote controlled, but must instead guide themselves through a course by "seeing" and following a black line around a number of turns. They must also trigger a gate to open. Each team tries to program its hovercraft to complete the course within ten minutes without bumping into the side walls.

The hovercraft competition is part of the Clark School's Keystone program, which is dedicated to excellence in the teaching of fundamental engineering courses. The program serves as a national model for increasing engineering student retention and graduation rates.

"The philosophy behind Keystone is that you try to expose the students to the most challenging and engaging engineering concepts early on," MSE faculty member and Keystone Professor **John Cumings** explains. "Part of the motivation behind the program was to increase retention not by making things easier, but paradoxically by making things more difficult, more challenging, and more engaging. The hovercraft competition helps students improve their collective problem solving skills."

The program benefits the faculty as well. "Personally I find it really inspiring to see some of the solutions the students come up with—things I wouldn't have predicted or even guessed would have worked!" says Cumings. "It reminds me why I became an engineer."

FIRST MEASUREMENT SCIENCE FELLOWSHIP POSITIONS ANNOUNCED

Applications are now being accepted for the first positions offered by the new National Institute of Standards and Technology–American Recovery and Reinvestment Act (NIST-ARAA) Measurement Science and Engineering Fellowship Program. Currently, there are openings for undergraduate and graduate research assistants, postdoctoral research associates, and research scientists or research professors. Applicants from a wide variety of science and engineering disciplines are encouraged to apply.

The new program, which was announced in February, is made possible by a $15.5 million award from NIST to the University of Maryland, based on a proposal written by co-PI MSE Professor and Chair **Robert M. Briber**, PI Professor **Daniel Lathrop** (director, Institute for Research in Electronics and Applied Physics; Physics) and co-PI Professor **Ellen Williams** (Physics). It will bring some 50 fellows per year over three years to work at NIST laboratories in Gaithersburg, Md., and Charleston, S.C., providing new research collaborations among students, faculty and NIST scientists. The goal is to further develop a future scientific talent pool with extensive training in measurement science and engineering.

For more information and position descriptions, visit the NIST-ARAA web site at **www.nistfellows.umd.edu**.

BRIBER, OEHRLEIN COURSES SELECTED FOR I-SERIES

Two courses taught by MSE faculty have been designated for the University's "I" series, the pilot of the proposed General Education program that represents the evolution of the traditional CORE course requirements. Professor and Chair **Robert M. Briber** and Professor **Gottlieb Oehrlein** will be sharing their expertise with undergraduates from majors throughout campus as part of a university initiative to expose non-science majors to the roles of science, engineering, math and technology in historical and contemporary issues, as well as in addressing the world's most challenging problems.

Briber's course, ENMA 150: The Materials of Civilization, is already being taught as part of the university's two-year-old Marquee Courses in Science and Technology program. ENMA 150 covers the role of materials throughout history to the modern day, and explores the relationship between advances in materials and advances in civilization. The course fulfills one of the A. James Clark School of Engineering's strategic plan initiatives to increase the technological literacy of all students by encouraging its faculty to develop and teach courses for non-engineering undergraduates. *(See "Non-Majors Delve Into Materials Science,"* Techtracks, *Spring 2010.)*

The challenge of making informed decisions about how we develop and implement technology is what inspired Oehrlein to create his I-Course, titled "Bigger, Faster, Better: The Quest for Absolute Technology."

Oehrlein's course will address the applied science and engineering concepts necessary to understand important technological advances and breakthroughs; the motivations behind pursuing technology-based world records; the political, economic, required societal contexts, personal decisions and driving forces that produce major technological advances; historical breakthroughs, failures in the adoption of new technologies; and critical, differentiated evaluations of novel technologies to determine how they will improve or potentially damage our lives.

"The technologies we use are constantly becoming obsolete," says Oehrlein. "We're racing faster and faster toward a place that we don't really know, and many implications of new technologies aren't immediately clear. What I hope to do is stimulate students to think about the technology choices we have as we move forward and consider the potential benefits and consequences ahead of time."

METTING AND HSIEH TAKE 2ND, 3RD IN ACNS POSTER COMPETITION

MSE graduate student **Chris Metting**, co-advised by Dr. **Brian Maranville** and Dr. **Julie Borcher**s (National Institute of Standards and Technology [NIST]) and MSE Professor and Chair **Robert M. Briber**, received 2nd prize in the student poster competition at the Materials Research Society's 2010 American Conference on Neutron Scattering (ACNS) in Ottawa, Canada. Fellow graduate student **Ping-Yen Hsieh**, advised by MSE affiliate professor Dr. **Mark Green** (NIST) and Briber, won 3rd prize.

ACNS highlights the latest research in neutron science, including work in the areas of soft and hard condensed matter, liquids, biology, magnetism, spectroscopy, crystal structure, physics, and instrumentation.

Metting's poster, "Characterization and modeling of off-specular neutron scattering for analysis of two dimensional ordered structures," demonstrated advances in the use of off-specular neutron reflectometry as a materials characterization technique. Off-specular neutron reflectometry is not widely used in materials and other research due to the lack of a complete, user friendly, broadly-distributed modeling software package. Metting, Briber, and their colleagues at the NIST's Center for Neutron Research (NCNR) and the National Science Foundation-funded Data Analysis for Neutron Scattering Experiments (DANSE) project, are developing a software component for fitting multilayer two dimensionally-structured samples, a tool that could make off-specular neutron reflectometry accessible to a broader scientific community. Metting's presentation discussed the team's progress in the modeling of data.

Hsieh's poster, titled "The gas adsorption behaviors in chiral holmium metal-organic framework materials," described a reliable method of condensing hydrogen for use in fuel cell technology, a key issue that must be addressed in order to make it viable on a commercial scale. Hsieh and his colleagues at NIST have been working on ways to improve the performance of metal-organic frameworks (MOF), high surface-area, porous materials that are used as "hydrogen sponges" capable of trapping and storing hydrogen at higher densities. In their study, different dimensional MOF crystal structures were successfully synthesized, and a series of high resolution powder neutron diffractions were performed to identify the adsorption positions in the 3-D MOF network. The results showed the "optimal" pore size constructed by a carbon-based organic ligand can dramatically enhance the MOF's H_2 adsorption capacity, resulting in extremely high packing densities. A unique "helical hydrogen" adsorption trajectory was also observed in this 4-fold chiral crystal system, implying a prominent influence from its noncentrosymmetric architecture.

LEFT TO RIGHT: PROFESSOR **SIMON BILLINGE** (COLUMBIA UNIVERSITY), VICE PRESIDENT OF THE NEUTRON SCATTERING SOCIETY OF AMERICA; DR. **KEN HERWIG** (OAK RIDGE NATIONAL LAB), CHAIR OF THE PRIZE SELECTION COMMITTEE; AND MSE GRADUATE STUDENT **CHRIS METTING**.

ADAM KARCZ (LEFT) AND **PARAG BANERJEE** (RIGHT).

BANERJEE, KARCZ HONORED IN DEAN'S DISSERTATION AND THESIS COMPETITIONS

Graduate students **Adam Karcz**, advised by Assistant Professor **Joonil Seog** (joint, Fischell Department of Bioengineering), and **Parag Banerjee**, advised by Professor **Gary Rubloff** (joint, Institute for Systems Research and Director, Maryland NanoCenter) were finalists in the Clark School's 2010 Dean's Master's Student and Doctoral Research Award Competitions.

Clark School Dean and Farvardin Professor **Darryll Pines** created the competitions in 2009 to give top graduate student researchers special recognition that will be valuable in launching their careers, and to show all students the importance of high quality engineering research. Students submit their work through competitions at the department level, with winners from each advancing to the Dean's finals.

Karcz took second place in the Dean's Master's Student Research Award Competition for his thesis, "Probing Gene Delivery Mechanisms Using Optical Tweezers." Optical tweezers use the optical forces generated by a laser to capture, or "tweeze", single-molecule samples such as proteins, peptides or DNA. Tiny amounts of force gently stretch and relax the sample, or hold it still, allowing researchers to observe its dynamics in real time. Karcz was instrumental in setting up the relatively uncommon device used in Seog's lab, which has been specially customized to be more compact, reduce noise and vibratory interference, and eliminate labor-intensive calibration steps.

"Setting up our optical mini tweezers was a very challenging task," says Seog. "Adam confronted many challenges in the beginning, but he overcame every difficulty. The research results he has obtained with the tweezers provide direct evidence for the potential mechanism of DNA release inside the cell. His observation of two completely different behaviors at the single molecule level depending on the structure of DNA carriers may provide rational design parameters for enhanced gene delivery carriers. Enhancing gene delivery efficiency is very important since it can reduce toxic side effects of some carriers and the total amount of treatment required."

Banerjee was awarded third place in the Dean's Doctoral Research Award Competition for his dissertation, "Nano-Energy Devices." Banerjee, a John and Maureen Hendricks Energy Research Fellow, has worked extensively on nanostructured devices capable of storing and delivering energy, particularly from sources such as solar and wind, at much greater capacities than currently available. He also specializes in improving manufacturing techniques aimed to make alternative energy components smaller and more affordable. His work with the Rubloff Group and the University of Maryland Energy Research Center has been widely published and recognized in top journals such as *Nature Nanotechnology* and *ACS Nano* *(see related stories, pp. 4-5).* In 2009, he won the Microscopy Society of America's (MSA) Presidential Student Award for a paper titled "Crystallization Behavior of HfO_2 Nanotubes in Different Environments," which he presented at the MSA's Microscopy & Microanalysis Meeting in Richmond, Va. The award recognizes papers first-authored by students that reflect excellence in research.

ORLOFF WINS AWARDS FOR RESEARCH, TEACHING

Graduate student **Nathan Orloff** (Department of Physics), advised by MSE professor **Ichiro Takeuchi**, was named the runner-up in the competition for the Block Award for Best Experimental Poster Presentation at the International Workshop on Fundamental Physics of Ferroelectrics and Related Materials, held at the Aspen Center for Physics.

Orloff was recognized for his paper and presentation, titled "Strained-induced Ferroelectricity in Ruddlesden-Popper $Sr_{n+1}TinO_{3n+1}$." The project, a collaboration among colleagues at the Clark School, Cornell University, Penn State, and the National Institute of Standards and Technology (NIST)–Boulder, is exploring the development of novel ferroelectric materials which do not exist in nature. Orloff, working with **James Booth** at NIST–Boulder, carried out the state-of-the-art broadband dielectric measurements that show the new materials can be driven into a ferroelectric state.

Orloff also recently received the 2009-2010 Michael J. Pelczar Award for Excellence in Graduate Study, which provides $1,000 to a doctoral candidate who has served at least one academic year as a teaching assistant with a commendable performance, and who has demonstrated excellence beyond his or her coursework.

GRADUATE STUDENT DELIVERS MICRO/NANO SEMINAR AT MIT

Graduate student **Konstantinos (Kostas) Gerasopoulos**, advised by Professor **Reza Ghodss**i (Department of Electrical and Computer Engineering and Director, Institute for Systems Research), was a featured speaker in the Micro/Nano Seminar Series, presented by the Massachusetts Institute of Technology's Department of Mechanical Engineering.

Gerasopoulos' seminar, titled "Nanostructured Materials Using the Tobacco Mosaic Virus: Applications in Batch Nanomanufacturing and Electrochemical Energy Storage," provided an overview of his group's research into the development, device integration and applications of Tobacco Mosaic Virus (TMV)-templated nanomaterials, including the design of sensors and lithium ion batteries with improved electrochemical performance.

TMV, one of the most studied viruses and widely used in research, is a biological, rod-shaped nanostructure that has evolved the ability to self-assemble into defined architectures. Gerasopoulos and his colleagues have been able to genetically enhance its ability to bind to metal ions and control the form into which it self-assembles. The customized TMV structure, attached to a substrate, is coated with metal ions to form nanowires that can serve as the basis of a new device, including micro-batteries. When prepared for use in batteries, the nanowires create a large surface area on which electrodes and electrolytes can interact, resulting in a higher energy storage capacity and more power than what is found in currently available products.

JANE CORNETT

Compared to other nanofabrication techniques, using TMV to manufacture devices is simpler, far less expensive, sustainable, and easily scaled. The products created are generally lighter and more durable than their commercial counterparts.

Gerasopoulos, who is currently a Ph.D. candidate, received his M.S. in electrical engineering from the Clark School in 2008. He conducts his research in Ghodssi's MEMS Sensors and Actuators Laboratory (MSAL). He is a member of the IEEE, MRS and AVS, and was recently selected to join the 2010 cohort of the Clark School's Future Faculty Program.

CORNETT TAKES 1ST PLACE AT RESEARCHFEST 2010

Graduate student **Jane Cornett**, advised by Assistant Professor **Oded Rabin**, took first prize at the 2010 ReserchFest. Cornett's winning poster and oral presentation, "Thermoelectric Figure of Merit Calculations for Nanowires–Moderate Confinement Regime," described her use of Matlab scripts to model the thermoelectric properties of semiconducting (Si, InSb) nanowires. Cornett conducts her research in Rabin's Materials and Interface NanoTechnology Laboratory.

continues next page

RESEARCHFEST, continued from page 9

ResearchFest is an annual event that highlights the best undergraduate and graduate research from the Department of Chemical and Biomolecular Engineering (ChBE), the Department of Materials Science and Engineering (MSE), and the Fischell Department of Bioengineering (BioE). It allows students to share their work in a casual setting with faculty, staff and students from their own and other departments. The event is sponsored by all three departments, and features guest judges, prizes, and a reception.

ResearchFest 2010 was organized by graduate students **Neville Fernandes** (BioE), **Shilpa Nargund** (ChBE), and **Richard Suchoski** (MSE). This year's judges were Dr. **Ivan Lee** (Army Research Laboratory) and Professor **F. Joseph Schork** (ChBE).

Participants are judged on the quality of their oral presentations, quality and clarity of their hypothesis, originality, methods and analysis, presentation of data, supporting material and conclusions, and the significance or potential impact of their work.

HIJJI, LIDIE NAMED SENIOR MARSHALS FOR COMMENCEMENT

MSE and the A. James Clark School of Engineering extend their congratulations to seniors (now alumni) **Karam Hijji** and **Ashley Lidie** (B.S. '10), who were selected to serve as Senior Marshals at the Spring 2010 University of Maryland Commencement ceremony.

The Senior Marshal program, founded in 1991, recognizes graduating seniors who have demonstrated the highest levels of scholarship, service to the campus community, extracurricular involvement, and personal growth. They are nominated campus-wide by faculty, administrators and staff and selected through an application process. Senior Marshals help facilitate and guide Commencement's student processional, and are recognized at the ceremony. Marshals also attend a luncheon held in their honor, hosted by University of Maryland President Dr. **C. Dan Mote.**

MSE CAPSTONE 2010

MSE seniors gathered for the presentation that represented the culmination of their undergraduate experience at the Capstone finale in May. Capstone, a course taken in the senior year, is one of the most important parts of the Clark School's engineering program. In it, teams of students utilize what they have learned throughout their undergraduate studies to create their own engineering designs from concept to product.

The team of ten students—**Abigail Boyle**, **Steven Crist**, **Mike Grapes**, **Karam Hijji**, **Alex Kao**, **Stephan Kitt**, **Paul Lambert**, **Christine Lau**, **Ashley Lidie** and **Marshall Schroeder**—created a dynamic microelectromechanical systems (MEMS) microphone for their final project.

Tiny MEMS-based microphones are commonly used in devices such as cell phones, video recorders, laptops, and hearing aids. MEMS devices provide better quality audio capture than the more common, macro scale electret condenser microphones (ECMs), covering the entire range of human hearing (30Hz-30KHz) while consuming less power.

Most of the research and development of MEMS microphones to date has been on those of the condenser variety, which require a power source in order to function. Dynamic microphones, however, do not because they use a permanent magnet and a mobile induction coil to capture sounds. If incorporated into MEMS devices, dynamic microphones would eliminate the need for an outside power source, making them smaller and more efficient. The availability of these systems could potentially open the door to new applications, including threat location detection and energy harvesting from noise. The Capstone team was inspired by the mass-market potential of a dynamic MEMS microphone, which has not yet been developed.

Over the course of their presentation, the seniors described how they used analytical modeling to design a cantilever-based actuator with very flat frequency response across the audible frequency range. They also described the multi-step process they developed in attempting to make a usable prototype device, and some of the pitfalls they encountered during its fabrication in the Clark School's FabLab, a world-class cleanroom facility.

"They were able to work through a design with many interconnected tasks, including optimization of the magnet array shape parameters and of the mechanical actuator," says Professor **Ray Phaneuf**, who advised the Capstone project. "This was an impressive effort by a strong, multifaceted team."

HENDLEY WINS SMART SCHOLARSHIP

MSE undergraduate **Coit Hendley IV** has been awarded a Science, Mathematics And Research for Transformation (SMART) Scholarship by the Department of Defense (DOD). The highly selective SMART program was established to support the education of the nation's future scientists and engineers, and to increase the number of civilian scientists and engineers employed by the DOD.

Undergraduate and graduate students in Science, Technology, Engineering and Mathematics (STEM) majors who are accepted into the program receive a full scholarship,

CAPSTONE CLASS, 2010. BACK ROW, LEFT TO RIGHT: **MARSHALL SCHROEDER**, **STEPHAN KITT**, **ALEX KAO**, AND **PAUL LAMBERT**. MIDDLE ROW, LEFT TO RIGHT: **KARAM HIJJI**, **ASHLEY LIDIE**, **ABIGAIL BOYLE**, AND **MIKE GRAPES**. FRONT ROW, LEFT TO RIGHT: **CHRISTINE LAU** AND **STEVEN CRIST**.

a cash award of $25,000–$41,000, health insurance and textbook allowances, and mentoring. While earning their degrees, SMART Scholars are assigned to a DOD laboratory, in which they serve paid summer internships. After graduation, they continue to work for the DOD as civilian employees engaged in theoretical or applied research for a period of at least one year.

alumniNEWS

Shenqiang Ren (Ph.D. '09), formerly advised by Professor **Manfred Wuttig**, received a 2009 Chinese Government Award for Outstanding Students Abroad. He was one of 130 current and former Chinese Ph.D. students in the U.S. to receive the prestigious, merit-based honor. Dr. Ren currently works at the Massachusetts Institute of Technology (MIT) as a postdoctoral associate involved in developing third- and fourth-generation bulk heterojunction (BHJ) solar cells.

Maeling Tapp (B.S. '08) tells us she can hardly believe two years of graduate school are behind her. She has successfully completed her proposal defense and has been admitted to Ph.D. candidacy at the Georgia Institute of Technology. She presented her research in a poster session at the Society for Biomaterials conference held in Seattle in April. "It was a great experience being able to share and discuss my work with others and to see the diverse areas being pursued in the world of biomaterials," she says. Maeling presented her work again at the National Institutes of Health in Bethesda, Md. in June.

recentGRADUATES

MAY 2010 B.S. GRADUATES

Abigail Boyle
Steven Crist
Michael Grapes
Karam Hijji
Alex Kao
Stephan Kitt
Christine Lau
Ashley Lidie
Marshall Schroeder

MAY 2010 M.S. GRADUATES

Zane Wyatt

MAY 2010 PH.D. GRADUATES

Erin Robertson Cleveland: "Atomic Layer Deposition Conformality and Process Optimization: Transitioning from 2-Dimensional Planar Systems to 3-Dimensional Nano-structures." Advisor: Gary Rubloff.

Jennifer Nguyen Wolk: "Microstructural Evolution in Friction Stir Welding of Ti-5111." Advisor: Lourdes Salamanca-Riba.

Ming-Shu Kuo: "Rational Design of Non-Damaging Capacitively Coupled Plasma Etching and Photoresist Stripping Processes for Ultralow K Dielectric Materials." Advisor: Gottlieb Oehrlein.

Robert (Bobby) Bruce: "Influence of Polymer Structure on Plasma-Polymer Interactions in Resist Materials." Advisor: Gottlieb Oehrlein.

studentAWARDS

Congratulations to the following students, who have all demonstrated outstanding performance and have made contributions to the Department and field. Complete award citations are available on our web site at: **www.mse.umd.edu/news/news_story.php?id=4849**

Chairman's Outstanding Senior Award: **Michael Grapes**

Outstanding Materials Student Service Award: **Karam Hijji** and **Christine Lau**

The Department of Materials Science and Engineering Student Research Award: **Stephen Kitt** and **Ashley Lidie**

A. James Clark School of Engineering Dean's Award: **Ashley Lidie**

MSE Master's Thesis Award: **Adam Karcz** *(see story, p. 8)*

MSE Doctoral Thesis Award: **Parag Banerjee** *(see story, p. 8)*

▼ PROF. **GOTTLIEB OEHRLEIN** HOODS **BOBBY BRUCE**. *PHOTO BY DR. TIMOTHY KOETH.*

▲ LEFT TO RIGHT: **ERIN ROBERTSON CLEVELAND, LAURENT HENN-LECORDIER** (12/09), **SUSAN BUCKHOUT-WHITE** (12/09), & **PROF. GARY RUBLOFF.** *PHOTO BY DR. KATHLEEN HART.*

▼ PROF. **ROBERT M. BRIBER** (LEFT) AND **KARAM HIJJI** (RIGHT). *PHOTO BY DR. TIMOTHY KOETH.*

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ABOUT THE COVER IMAGE

THE RED IMAGE USED ON THE COVERS, FROM THE RESEARCH GROUP OF PROFESSOR **LOURDES SALAMANCA-RIBA**, SHOWS A SELF-ASSEMBLED NANOCOMPOSITE OF $CoFe_2O_4$–$BaTiO_3$ MULTIFERROIC MATERIALS AT ATOMIC SCALE. THE SAMPLE WAS PRODUCED AND IMAGED IN THE NANOSCALE IMAGING, SPECTROSCOPY AND PROPERTIES LABORATORY (NISPLAB).

TECHTRACKS is published for alumni and friends of the Department of Materials Science and Engineering at the A. James Clark School of Engineering. Your alumni news and comments are welcome. Please send them to:

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Editor: Faye Levine

openHOUSE!

SPECIAL EVENTS FOR STUDENTS WHO WANT TO LEARN MORE ABOUT MATERIALS SCIENCE!

We are hosting open house events this fall for undecided freshman engineering majors and other students thinking of changing majors; and one or more spring open houses for prospective students and their families. Attendees learn about the discipline of materials science and engineering, career paths, our department and curriculum; meet faculty, staff and students; try hands-on demonstrations of materials in action; and take lab tours.

FOR MORE INFORMATION:

VISIT:
www.mse.umd umd.edu/openhouse

CONTACT DR. KATHLEEN HART:
hart@umd.edu

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DO YOU KNOW SOMEONE WHO WOULD LIKE TO LEARN MORE ABOUT MATERIALS SCIENCE & ENGINEERING?

WHETHER IT'S A STUDENT PLANNING FOR COLLEGE, AN UNDERGRADUATE CONSIDERING HIS OR HER MAJOR OR GRADUATE SCHOOL, FRIENDS, FAMILY OR ANYONE INTERESTED IN SCIENCE, WE HAVE A PLACE FOR THEM TO LEARN WHAT MATERIALS ARE ALL ABOUT! VISIT THE NEW "WHAT IS MSE?" SECTION OF OUR WEB SITE AT:

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