



SPRING 2012

# TECHTRACKS

MATERIALS SCIENCE AND ENGINEERING

A. JAMES CLARK SCHOOL of ENGINEERING

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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.

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## Rabin Wins NSF CAREER Award for Spectroscopy Research

A proposal that combines optics, chemistry, and nanoparticle engineering techniques to identify and separate materials based on their molecular structure has earned Department of Materials Science and Engineering (MSE)

assistant professor **Oded Rabin** a five-year, \$540,000 National Science Foundation (NSF) Faculty Early Career Development (CAREER) Award.

Rabin, who holds a joint appointment with the Institute for Research in Electronics and Applied Physics (IREAP), was recognized by the NSF as an outstanding junior faculty member who effectively integrates research and education.

His proposal, titled "Plasmonics with a Twist—Chiral Nanostructures for Advanced Spectroscopy," describes how nanostructures engineered with unique optical properties can be used to enhance spectroscopy, a collection of techniques that

allow researchers to identify and quantify chemicals based on how they scatter or absorb light.

The work focuses on molecules described as chiral, a term applied to those that exhibit

a "handedness." Like hands, chiral molecules are found in "left" and "right" configurations. And like a person's left and right hands, they may not perform the same task in the same way or as effectively. Proteins, DNA and most molecules that naturally occur in all living things are chiral.

Being able to tell and separate "left" from "right" becomes crucial in drug production, where one configuration could have a beneficial effect while the

other has none, or even a toxic one. It is very difficult and very expensive to synthesize completely pure drugs whose molecules exhibit a single configuration.



NATURE IS ABUNDANT WITH STRUCTURES EXHIBITING CHIRALITY OR "HANDEDNESS," FROM MOLECULES LIKE DNA TO MACROSCOPIC STRUCTURES LIKE MAGNIFICENT SEASHELLS AND CACTI (ABOVE). PROFESSOR **ODED RABIN**'S GROUP USES NANOFABRICATION TOOLS TO PRODUCE CHIRAL NANOSTRUCTURES MADE OF METALS (INSET) THAT GIVE INTERESTING OPTICAL RESPONSES.

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ROBERT M. BRIBER

**U.S. NEWS & WORLD REPORT RECENTLY RELEASED ITS 2013 RANKING OF THE NATION'S BEST GRADUATE SCHOOLS, AND WE'RE PLEASED TO REPORT WE'VE MOVED INTO THE TOP 25 MSE PROGRAMS IN THE COUNTRY.**

Many factors affect where a

school lands in the ranking. Personally, I attribute our latest jump to the success of our junior faculty, who have won three NSF CAREER awards in the past two years (see our cover story); the growth of our research program, which has seen its expenditures increase from \$7.5 to \$13.1M over the past 5 years; and the placement of recent graduates of our doctoral program in faculty

positions at great universities, including Washington University in St. Louis, the University of South Carolina and the University of Kansas.

The Department is leading new research efforts in the University and the A. James Clark School of Engineering in the areas of energy, biomaterials and nanotechnology. Many of the roadblocks to advances in technology from batteries and fuel cells to medical implants depend on advances in materials. On the back cover of this issue is a story about how new magnetostrictive alloys are being developed that do not use rare-earth elements, and there is active departmental research along similar lines for new high strength magnets and new superconductors.

The Department runs exciting and informative open houses twice per semester for high school students interested in learning about the field of MSE. If you know students who might be interested, please send them to our

web site, where they can get the latest information about upcoming dates: [www.mse.umd.edu/openhouse](http://www.mse.umd.edu/openhouse). If they choose a career in MSE, they will be at the center of some of the most exciting developments in engineering and science that we'll 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 visiting us to learn about the latest developments in research and education, meet our new faculty and tour the new facilities. If you are an alumnus or alumna, keep us informed of the changes in your career by joining the "MSE UMD" Facebook group or e-mailing us at [mse@umd.edu](mailto:mse@umd.edu).

Robert M. Briber  
Professor and Chair, MSE

## NSF CAREER AWARD, continued from page 1

Rabin and his group want to enhance the sensitivity and accuracy of the optical measurement tools used to determine the identity, ratio, and concentrations of left and right molecules in a sample.

In prior research, Rabin investigated the use of plasmonic (metallic and highly conductive) nanoparticles—in that case silver nanocubes—to enhance the sensitivity of Raman spectroscopy.

In the new study, Rabin and his group have designed novel plasmonic nanoparticles that resemble pinwheels oriented to the left and right. After these particles have been mixed with chiral molecules, the whole sample is exposed to a beam of circularly polarized light, which, like the chiral molecules, has "left" or "right" attributes.

"When light is circularly polarized, it means that its electric field is spinning around, clockwise or counterclockwise, as

the beam travels," Rabin explains. "It's like throwing a football. The ball travels along a path, and spins as it goes."

When the circularly-polarized light illuminates the sample, it sets off sophisticated and selective interactions. Molecules with a left configuration will absorb the "screw-like" light differently than those with a right configuration, just like a left hand will fit more comfortably in a left-handed glove than a right-handed one. The nanoparticles make this selectivity more pronounced, allowing the spectrometer to detect and identify the target molecules at much lower concentrations.

While pharmaceutical companies would benefit most from Rabin's technique in the near term, it could also help researchers observe and study the progression of diseases such as Mad Cow disease, in which proteins, chain-like molecules which need to fold in a precise manner in order to function, refold in an incorrect and ultimately deadly way.

Rabin is the third MSE faculty member in the past year to receive a CAREER Award, preceded by assistant professors **John Cumings** and **Joonil Seog** in 2011.

## WANT FUEL CELLS? THINK OUTSIDE THE HYDROGEN TANK

When most people hear the words "fuel cell," they think of eco-friendly, hydrogen-powered cars that emit nothing more than water.

And that, says MSE Professor **Eric Wachsman**, director of the University of Maryland Energy Research Center (UMERC), is one of the reasons we're all not driving one.

The U.S. Department of Energy's (DOE) recent decisions about how to fund fuel cell research, he says, are putting the country at risk of falling behind in the development and implementation of the most efficient means of converting fuel to electricity.

"There is a problem in the perception of the public and policy makers, and in



the funding of our fuel cell programs, that hydrogen and fuel cells are linked,” says Wachsman. “Hydrogen-based fuel cells are the technology that has gotten all of the press and as a result we’re still waiting for a future hydrogen infrastructure. Yes, fuel cells can run off hydrogen, but they don’t *have* to.”

Another problem, Wachsman says, is America’s fixation on vehicles. “It will take decades to create a nationwide hydrogen distribution and storage system, and to convert every gas station into a hydrogen filling station. That reality has turned fuel cells into a ‘future technology’ and has resulted in a drastic reduction in the funding of fuel cell research by the DOE in favor of developing electric cars. In fact, fuel cells can be used right now in many stationary and mobile applications, including centralized power distribution and power generation for homes, businesses, and industry.”

Most people are unaware that there are two kinds of fuel cells. The one in the public eye, the proton exchange membrane (PEM) fuel cell, uses hydrogen to generate power. The type of fuel cell Wachsman and his colleagues have worked to perfect, the solid oxide fuel cell (SOFC), has a distinct advantage over its PEM-based sibling.

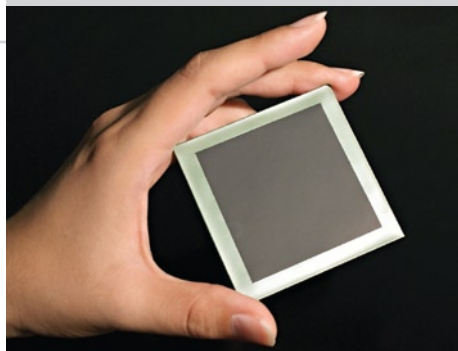
“Solid oxide fuel cells are unique because they can oxidize *any* fuel,” Wachsman explains. “They can run off of gasoline, diesel and natural gas today, and biofuels and hydrogen in the future, whenever that infrastructure is in place.”

## Hot Technology

Still, nothing’s perfect, and Wachsman can sum up the reason why SOFCs aren’t in large-scale production in a word: temperature.

“That is *the* issue,” he explains. “It’s the reason why the automotive companies are using PEM fuel cells. PEM fuel cells operate at around 80° C, which allows them to start up fairly quickly. Current solid oxide fuel cells operate at about 800° C, so it takes a long time for them to warm up, making them more applicable to stationary power generation.”

Wachsman and his colleagues are working to change that. In the November 18,



2011 issue of *Science*, the team outlined the technology behind a new world record power density SOFC that generates two watts of power per square centimeter at 650° Celsius. The cell uses a bi-layer electrolyte developed by Wachsman that is more than 100 times more conductive than the conventional zirconia-based electrolyte operating at the same temperature—also a world record. When the cells are assembled into a stack they should produce three kilowatts of electricity per kilogram of material, more than an internal combustion engine at approximately one-third the size.

The paper lays out a strategy to further lower temperature. The team believes its improvements to SOFC electrolytes and nanostructured-electrode designs could ultimately reduce the cells’ operating temperature to only 350° C. At that temperature they could start up fast enough for automotive applications, and make them more efficient and more affordable because they could be manufactured from less expensive materials.

## Progress At Risk

The DOE’s 2012 budget request, however, does not include funding for the SOFC program, effectively eliminating it from the agency’s research priorities and greatly reducing funding options for groups like Wachsman’s. This decision, he believes, was made without a complete understanding of recent significant advances in SOFC technology.

In a paper in *Energy and Environmental Science*, Wachsman and his colleagues, **Craig A. Marlowe** and **Kang Taek Lee**, make the case that SOFCs should be an integral part of U.S. energy policy because they meet all of the DOE’s six key energy strategies: they deploy clean electricity, make use of alternative fuels, help modernize the power

grid, will help gradually electrify the vehicles we drive, increase vehicle fuel efficiency, and increase building and industrial efficiency.<sup>1</sup>

“We don’t have to wait for hydrogen,” says Wachsman. “SOFCs represent a solution for everything that you can think of in terms of producing electricity and power today.”

*This story, originally produced as a press release, was featured in or generated further stories by publications including Scientific American, FutureCars.com, the American Ceramic Society, MSNBC, Physorg.com, SlashGear, and MIT’s Technology Review.*

<sup>1</sup> *Department of Energy Quadrennial Technology Review Framing Document, U.S. Department of Energy, 2011.*

For more information, see:

“Role of solid oxide fuel cells in a balanced energy strategy.” *Energy Environ. Sci.*, 2012, 5, 5498-5509.

“Lowering the Temperature of Solid Oxide Fuel Cells.” *Science*, 2011, 334(6058), 935.

## PROTECTING CULTURAL HERITAGE

The Department of Materials Science and Engineering (MSE) is teaming up with the Smithsonian Institution’s Museum Conservation Institute (MCI) for a feasibility study of a device that could be used to assess buildings, monuments and artifacts in danger of deterioration from the effects of moisture.

Professor **Mohamad Al-Sheikhly** and Adjunct Professor **Richard Livingston** are working on the yearlong project, funded by a University of Maryland (UMD)/Smithsonian Seed Grant, to develop a portable prototype system that uses prompt gamma neutron activation (PGNA) for the nondestructive measurement of moisture in porous construction materials such as brick, sandstone, and marble. The professors are partnering with Smithsonian Senior Objects Conservator **Carol A. Grissom** and Smithsonian Fellow **Emily M. Aloiz**, who will lead efforts to design, construct and characterize test samples representative of the masonry used in the museum’s buildings.

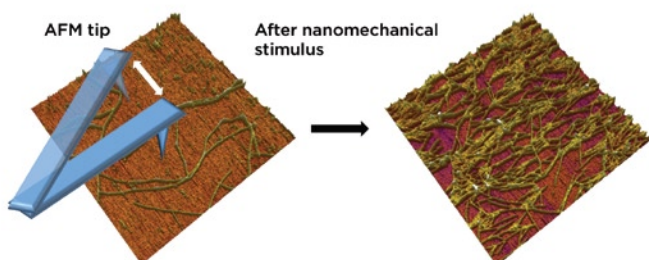
The samples, which will contain varying predetermined levels of moisture, will be measured with the UMD nuclear

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## GUIDING SELF-ASSEMBLY OF NANOFIBERS USING NANOMECHANICAL STIMULUS

Assistant Professor Joonil Seog

Self-assembly is one of the most important mechanisms that nature exploits to build a complex structure. Numerous research groups are focusing on controlling the self-assembling process to develop nanostructures of periodic



patterns. The spontaneous organization often occurs in a hierarchical manner in a wide range of length scales, creating a higher-order structure which is built from a pre-assembled structure in a stepwise fashion. During

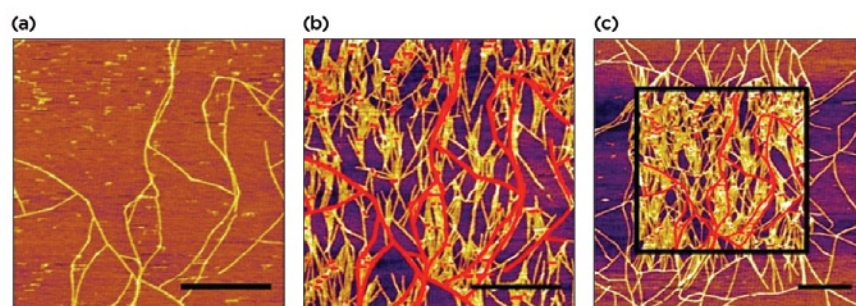
this process, the preformed substrate often provides crucial cues in facilitating a subsequent assembly step. These cues are composed of local geometric constraint and mostly non-covalent interactions such as hydrogen bonding, hydrophobic or electrostatic interactions. The formation of 1-dimensional

peptide based self-assembled nanostructures on the substrate has been reported. However, in these cases controlling location and direction of the nanostructures on the substrate to create a well-defined 1-dimensional nanoscale pattern has been quite challenging. Here, we report on applying nanomechanical forces in a local

manner to initiate the self-assembly of peptide-based nanofibers at specific locations with control over their growth direction without using any local geometric constraint, such as a preformed surface pattern. This method may provide a simple way to prepare a well-ordered nanofiber substrate

which can serve as a building template for functional nanoscale devices.

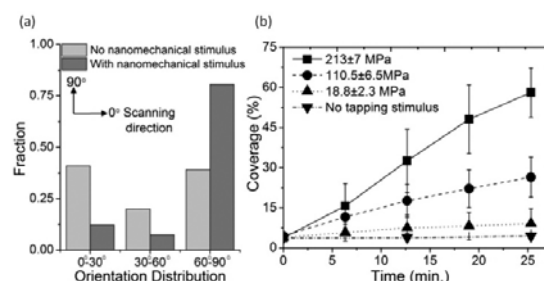
Self-assembling peptides have received a significant attention from nanotechnology for bottom-up fabrication and biomimetic structure. The silk-elastin like peptide polymer (SELP) is a genetically engineered block copolymer made of silk-like blocks (Gly-Ala-Gly-Ala-Gly-Ser) from *Bombyx mori* (silkworm) and elastin-like blocks (Gly-Val-Gly-Val-Pro) from mammalian elastin. The



**FIG. 1. AFM IMAGES OF SELP-815K NANOFIBERS OBTAINED IN A TAPPING MODE. (A) THE FIRST SCANNED IMAGE, (B) THE SECOND SCANNED IMAGE OF THE SAME AREA, (C) THE ZOOMED OUT IMAGE THAT INCLUDES THE SECOND SCANNED AREA. THE SCALE BARS CORRESPOND TO 1  $\mu\text{M}$  AND THE RED LINES ARE ORIGINAL FIBERS AND AT SAME HEIGHT SCALE.**

repeating unit of the SELP-815K contains eight silk (S) and fifteen elastin (E) units and one lysine (K) modified elastin.

Figure 1a (above) is the first scanned image using atomic force microscopy (AFM) which shows some nanofibers formed on a mica substrate during incubation. When the same area was scanned again after 6 minutes, the density of nanofibers significantly



**FIG. 2. (A) HISTOGRAM OF NANOFIBER ORIENTATION DISTRIBUTION WITH AND WITHOUT NANOMECHANICAL STIMULUS BY AFM, (B) PERCENT INCREASE OF NANOFIBER COVERAGE MEASURED UNDER VARIOUS TAPPING PRESSURES AS A FUNCTION OF TIME (N=5). THE COVERAGES UNDER A SPECIFIC PRESSURE WERE OBTAINED BY IMAGING THE SAME AREA REPEATEDLY AT DIFFERENT TIME POINTS. THE COVERAGES WITH NO TAPPING STIMULUS WERE OBTAINED FROM FIRST SCANNED IMAGES AT SPECIFIC TIME POINTS.**

increased (Figure 1b). The red lines in Figure 1b represent the nanofibers imaged in the first scan. The drastic effect of the AFM scan on nanofiber growth is clearly visible in the zoomed out image in Figure 1c, where a sharp contrast in nanofiber density was clearly observed between the area scanned once (outside the square) and the area scanned twice (inside the square). This remarkable difference clearly indicates the strong effect of the AFM tapping force on the self-assembly of nanofibers. Furthermore, the newly

grown nanofibers, as a result of AFM scanning, seemed to have a strong preference in their growth direction. We used the ImageJ software to analyze the orientation of each nanofiber with respect to the AFM scanning direction (horizontal in the AFM images), shown in Figure 2a (above right).

The orientation of the nanofibers formed during incubation (without any mechanical stimulus) was evenly distributed between 0° and 90°, indicating that the crystal plane of the mica had no effect on their growth direction. In sharp contrast, 80% of the newly grown fibers after nanomechanical stimulus by AFM showed preferred orientation between



60° and 90°. This suggests preferential growth perpendicular to the AFM scanning direction, and confirms the effect of tapping mode imaging on self-assembly.

To investigate the novel effect of nanomechanical stimulus on self-assembly further, the ratio of the amplitude setpoint and the free amplitude in tapping mode AFM were varied. In this mode of imaging, the AFM tip intermittently contacts the surface, exerting a momentary impact. By varying the setpoint amplitude and the free amplitude, the tapping force level was adjusted systematically. To quantify the tapping force exerted on the surface, the tapping mode imaging process was simulated using a 2-eigenmode cantilever model. The calculated force level was normalized by the nominal radius of the AFM tip to obtain an approximate pressure in each condition. The coverage of nanofibers under calculated tapping pressures varying from 18.8 MPa to 213 MPa was then measured at five different time points (Figure 2b). Overall, coverage increased as a function of time under the range of pressures tested. The rate of percent coverage change was increased from ~ 0.2 %/min. at 18.8 MPa to ~2 %/min. at 213 MPa. This observation clearly highlights the effect of local nanomechanical pressure on enhancing the self-assembly of SELP-815K nanofibers.

In conclusion, we demonstrated that the local tapping pressure exerted by AFM tip can initiate and promote the peptide self-assembly on mica surface in a force dependent manner. The growth direction of the nanofiber was largely perpendicular to scanning direction, indicating that this novel method can be utilized to create a 1-dimensional nanostructure patterned surface using nanomechanical stimulus.

#### References:

W. Hwang, B. Kim, R. Dandu, J. Cappello, H. Ghandehari, and J. Seog. "Surface induced nanofiber growth by self-assembly of a silk-elastin-like protein polymer", *Langmuir*, 2009, 25(21); 12682-12686.

J. Chang, Xiu-Feng, Peng, K. Hijji, J. Cappello, H. Ghandehari, S. D. Solares, and J. Seog. "Nanomechanical Stimulus Accelerates and Directs the Self-Assembly of Silk-Elastin-like Nanofibers" *Journal of the American Chemical Society Communications*, 2011, 133(6); 1745-1747.

#### SMITHSONIAN COLLABORATION, continued from page 3

reactor's neutron beam, and the data collected will be used to accurately calibrate the new device.

Moisture, whether it occurs naturally in the form of humidity, rain or groundwater, or is the result of a leak, vandalism, or pollution, is a threat to the preservation of both art and architecture. Corrosive chemical reactions, cracking, staining, erosion and the growth of bacteria and mold represent some of the serious and sometimes irreversible damage it causes.

Repairing the damage is only part of the solution. In order to build an effective preservation strategy, conservators need to understand the source of the moisture, how much it has penetrated, and the mechanisms by which it causes damage, all of which may vary by object, material, and location. The ability to accurately measure moisture in an object over space and time is crucial to these efforts, but presents its own challenge: No one wants to drill or cut into an object for a sample, but existing nondestructive methods for measuring moisture can be inaccurate.

The MSE/Smithsonian team's strategy is to improve a device called a neutron probe, which uses prompt gamma neutron activation for elemental analysis. Its core components are a neutron-emitting source and a gamma-ray detector. Neutrons from the device penetrate the subject and interact with the nuclei of its elements, which either scatter or capture them, producing gamma rays in the process. The probe's detector sends these signals to its analyzer. Many elements produce gamma rays of a specific energy, and the device is able to provide a visual representation of the gamma ray spectrum produced by the subject. This spectrum can be analyzed for the characteristic peaks revealing the composition, condition, and moisture content of the material. The probe is capable of taking direct moisture measurements from depths of up to 20cm (about 8 inches) into masonry without causing any damage.

"Our improved version of the PGNA system now in development makes use of an electronic collimator subsystem to improve the directionality of the gamma rays and reduce background noise," explains Livingston, who has extensive experience with the original version of the probe on previous projects, including evaluating salt damage to an historic brick smokehouse in Colonial Williamsburg, Va., and in St. Mark's Basilica in Venice, Italy.

The collimator subsystem uses two detectors operating in tandem. The first limits the field of view, only allowing those gamma rays traveling in a specific direction to be counted. The second detector then collects the energy spectrum of these selected gamma rays in order to detect those characteristic of the element the team wants to know about (in this case, hydrogen).

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AN ASSORTMENT OF STONES AND BRICK USED IN SMITHSONIAN BUILDINGS, AS WELL AS MASONRY FROM THE NATIONAL CATHEDRAL, THE ARLINGTON CEMETERY AMPHITHEATER, AND THE JEFFERSON MEMORIAL, AT THE SMITHSONIAN INSTITUTION'S MUSEUM CONSERVATION INSTITUTE. THE MATERIAL WILL BE USED TO MAKE TEST SAMPLES WITH CONTROLLED PROPERTIES. THESE WILL IN TURN BE USED TO CALIBRATE A NEW DEVICE CAPABLE OF ASSESSING BUILDINGS, MONUMENTS AND ARTIFACTS IN DANGER OF DETERIORATION FROM THE EFFECTS OF MOISTURE. PHOTO COURTESY OF EMILY ALOIZ, MUSEUM CONSERVATION INSTITUTE.



SMITHSONIAN, continued from page 5

The project's ultimate goal is to produce a portable, prototype PGNA instrument calibrated for moisture measurement in porous materials.

"This is a very exciting opportunity," says Aloiz. "Bringing our two institutions together maximizes the technology and expertise needed to tackle a multifaceted problem like this. Of particular interest to the Smithsonian Institution is the systematic analysis of masonry used in its own buildings. The data we collect will add another layer to our understanding of our historic structures."

The National Institute of Standards and Technology (NIST) recently agreed to assist the team in characterizing the stones by subjecting the masonry samples to hyperspectral image analysis. "It will provide very detailed, quantitative information about the mineralogy and microstructure of each type of Smithsonian building stone, tell us how moisture will damage them, and give us a better understanding of how our PGNA device will perform when used on them," says Livingston.

The collaboration with NIST will also involve the NIST Stone Test Wall, which contains samples of many commercial building stones, including several used in Smithsonian buildings, and has been exposed to the environment for over 60 years. In addition to providing information about how different stones respond to moisture, the Wall can also provide the first field test for the PGNA system.

The team hopes the development of the prototype will open up new avenues of research and conservation at both the University of Maryland and the Smithsonian. The portability of the system will allow MCI staff to evaluate local artifacts, buildings and monuments, as well as provide consultation services to conservators around the country. The technology is also expected to facilitate collaborations among faculty specializing in geology, nuclear engineering and civil engineering, particularly in studies of the stability of concrete structures used in buildings, transportation, and nuclear power plants.

## BRIBER NAMED 2012-2013 DISTINGUISHED SCHOLAR-TEACHER

MSE professor and chair **Robert M. Briber** has been named a 2012-2013 Distinguished Scholar-Teacher by the University of Maryland. The program honors faculty members who have demonstrated outstanding achievement in their fields and as educators. Scholar-Teachers bring a passion for learning to their colleagues and students, and represent what a professor at a world-class university should be.

"Rob is truly a special faculty member," says Clark School Dean **Darryll Pines**. "Not only is he an excellent educator, he is also a first rate researcher and a highly respected department chair. I am quite pleased that he has been recognized by his colleagues at the university for his exceptional talent."

Briber, who specializes in the thermodynamics of complex polymer systems, structural solutions of novel molecules, and neutron scattering spectroscopy, has been routinely recognized by the university as a "Research Leader" for his efforts in bringing sponsored research dollars to campus.

Throughout his career, Briber has been on a mission to promote the field of materials science and engineering, which despite its broad and fundamental applications is often unknown to prospective students and the general public. He is one of a team of MSE faculty and staff members whose recruiting and outreach efforts have resulted in a threefold increase in the department's undergraduate enrollment over the past four years.

In 2010, he was part of a team awarded \$15.5 million by the National Institute of Standards and Technology to develop and implement a national measurement science and engineering fellowship program that will provide extensive postdoctoral training to the nation's future scientific talent pool.

In 2007, Briber was one of the original group of faculty that proposed and taught the university's Marquee Courses in Science and Technology, which are designed to promote scientific and technological literacy among non-science and non-engineering majors. These courses went on to form the

basis of the I-Series courses, part of the university's new general education program. Briber is also the creator of the Marquee Lectures in Science and Technology, which invite the general public to campus to explore science and technology's roles in historical and contemporary issues, including energy, the environment, economics, ethics, and medicine.

During his tenures as the vice president and president of the Neutron Scattering Society of America (NSSA), he regularly addressed Congress on the need to support scientific research and education.

Briber is one of only six Maryland professors awarded with the Distinguished Scholar-Teacher title this year. Nominees are selected by their peers; the winners are chosen by a panel of former Distinguished Scholar-Teachers. Winners receive a cash award to support instructional and scholarly activities, and make a public presentation in the fall semester on a topic of scholarly interest.

## COMMUNITY COLLEGE FACULTY PROGRAM: PHASE 1

Over the summer of 2011, eight regional community college professors and their Clark School research mentors completed the first phase of a new program designed to both strengthen relationships between their schools and the University of Maryland, and boost the enrollment and retention of students in science, technology, engineering, and mathematics (STEM) majors.

The Research Experiences for Teachers (RET) program, called "Connecting with Community Colleges," is unique in that it serves faculty from associate degree-granting programs. RETs typically draw their participants from middle schools and high schools.

MSE associate professor **Isabel Lloyd** is leading the three-year, NSF-funded program with co-PI Dr. **Leigh Abts**, the Clark School's director of STEM education.

The inaugural participants attended a six-week, interdisciplinary summer program in which they conducted research with Clark School faculty and discussed ways to bring new technological concepts into their existing courses. They also attended



seminars on curriculum development; lectures on topics including ethics, entrepreneurship, intellectual property, and informed discovery; and round-table discussions with Clark School faculty and staff about promoting interest in STEM majors and ensuring a smooth transition for those who transfer from community colleges to the university.

Each faculty member was assigned to a Clark School laboratory and at least one research project, with topics including graphite coatings, insect-inspired flight mechanisms, statistics and data collection and analysis, and aerosolized nanoparticles for quantifying lung function.

At the end of the program, the participants presented the results of their research as well as the curriculum elements they had developed for their courses. Guided by the process outlined in **Grant Wiggins'** and **Jay McTighe's** book, *Understanding By Design*, some were hands-on assignments directly influenced by the participants' research, while others were entirely original. One professor, who teaches a freshman engineering design course, was inspired by his time in an aerospace engineering lab to create a new project for his students, the design and control of an unmanned aerial vehicle. Another used his Clark School research lab's 3-D prototype printer to create plastic models that will be used to help students understand the differences

between plant, animal and bacterial cells, and the relationship between their structure and function.

Other new course elements included a strategy for explaining the real-world applications of differential equations; the building, testing and analysis of a Wheatstone bridge electrical circuit; and adding a design element to a typically analysis-driven statics class. Another new exercise has students take on the roles of independent researchers who must design an experiment to determine which of four aerosol products is most detrimental to human health, and effectively communicate their results to other classmates playing the role of the EPA.

Both participants and research mentors hope to define best practices for teaching STEM concepts, design better ways to evaluate whether students have met educational objectives, and determine how the strategies used in engineering design and problem solving can influence how we educate future scientists.

"Our participants came up with a broad range of creative ways to apply what they'd done here to their individual courses, and put what they'd learned into a mechanism they could use to communicate something important to their students," says Lloyd. "I think they're all going to be able to reach a wide range of students, encourage them to consider STEM careers like engineering, or at least

convince them to become more technology literate if they don't."

The second phase of the program, conducted during the academic year, includes discussions about curriculum implementation, outside evaluations, and two half-day workshops. Lloyd and the RET's NSF program manager,

**Mary Poats**, plan to attend as many class sessions as possible in which the new curriculum elements are implemented.

To learn more about the RET program, contact Professor Isabel Lloyd at [illoyd@umd.edu](mailto:illoyd@umd.edu) or visit [www.mse.umd.edu/ret](http://www.mse.umd.edu/ret).



ARIS CHRISTOU

## CHRISTOU TAPPED FOR CONDENSED MATTER PHYSICS PANEL

MSE professor **Aris Christou** has been selected to serve on a panel of experts in condensed matter physics. The panel is one of ten established under the new European Union-funded Aristeia Research Program, managed by Greece's National Council for Research and Technology (ESET). Aristeia will support fundamental research conducted in Greece.

"[My] panel will select from the areas of physics and astronomy, noteworthy proposals in the area of materials science and materials physics which may eventually result in breakthroughs for future products," says Christou.

## CUMINGS WINS CLARK SCHOOL'S JUNIOR FACULTY OUTSTANDING RESEARCH AWARD

MSE assistant professor **John Cumings** is the recipient of the A. James Clark School of Engineering's 2011 Junior Faculty Outstanding Research Award. The award was instituted in 2010 by Dean **Darryll Pines** to recognize exceptionally influential research accomplishments by junior faculty.

Cumings was cited for his development of a novel *in-situ* thermal electron microscopy imaging technique, his design of multiferroic device structures with unique functionalities, and his leadership role in a project that synthesized one-of-a-kind lithiated silicon nanostructures for future advanced batteries.

**RESEARCH EXPERIENCES FOR TEACHERS: LEFT TO RIGHT: MS. BEKKI ZEIGLER (PRINCE GEORGES COMMUNITY COLLEGE), DR. MARJORIE RAWHOUSER (ANNE ARUNDEL COMMUNITY COLLEGE [ACC]), DR. VEDHAM KARPAKAKUNJARAM (MONTGOMERY COMMUNITY COLLEGE [MCC]), DR. CHARLES KUNG (MCC), DR. GABRIEL AYINE (HOWARD COMMUNITY COLLEGE [HCC]), MR. JAY BENSON (ACC), MR. MARK EDELEN (HCC), AND DR. ISABEL LLOYD, (DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING, UMD). IN FRONT: FARY SAMI (HARFORD COMMUNITY COLLEGE).**





JOHN CUMINGS

*CUMINGS, continued  
from page 7*

Cumings, who earned his Ph.D. in physics from the University of California at Berkeley in 2002, joined MSE in 2005 and was quickly recognized for his successful and innovative research program.

In 2006 and 2007, he received rare back-to-back invitations to present his work on paramagnetic semiconductors and artificial spin ice at the American Physical Society's annual national meeting. He has been active in the growth of the Nanoscale Imaging, Spectroscopy and Properties (NISP) Laboratory, the university's premiere electron microscopy research and training facility, and leads the University of Maryland Energy Frontier Research Center's nanowire team. His work has been sponsored by grants from the Agilent Corporation, the National Science Foundation (NSF), the Nuclear Regulatory Commission and the U.S. Department of Energy. In 2011 he received a NSF CAREER Award.

"Since his arrival at the university, Professor Cumings has had a tremendous impact on the research programs in the department," says MSE Professor and Chair Robert M. Briber. "His expertise in understanding the physics of materials at the nanoscale and making direct measurements of material properties while simultaneously observing them at high resolution in the electron microscope is a remarkable accomplishment."

Outside of the lab, Cumings has been active in improving the education of students and young scientists ranging from undergraduate to postdoctoral levels. As a Keystone Professor, he is part of a team of faculty members dedicated to excellence in the teaching of fundamental engineering courses and the retention of first year students. In 2010 he was a co-PI on a

proposal that brought a \$15 million National Institute of Standards and Technology grant to the Maryland NanoCenter to develop and implement a Postdoctoral Researcher and Visiting Fellow Measurement Science and Engineering Program.

Cumings' colleague, MSE affiliate professor **Michael Zachariah** (Departments of Mechanical Engineering and Chemistry & Biochemistry), is the recipient of the Clark School's 2011 Senior Faculty Outstanding Research Award.

### MARTÍNEZ-MIRANDA NAMED FULBRIGHT SPECIALIST

MSE Associate Professor **Luz J. Martínez-Miranda** has been named a Fulbright Senior Specialist by the J. William Fulbright Foreign Scholarship Board, the U.S. Department of State's Bureau of Educational and Cultural Affairs and the Council for International Exchange of Scholars (CIES).

Applicants who are accepted into the Fulbright Specialists Program are first appointed as candidates to the Fulbright Specialists Roster, which helps connect qualified experts with international research programs in need of collaborators. The CIES provides travel grants and stipends to selected roster members, who are then designated Fulbright Senior Specialists, to fund their participation in short-term overseas projects and related educational activities.

Martínez-Miranda has already been matched with Associate Professor **Eduardo Soto-Bustamante**, a member of the University of Chile at Santiago's Department of Chemistry, who invited her to visit his research group in spring 2012. Soto-Bustamante, an organic synthetic chemist, has been working with liquid crystal polymers, while Martínez-Miranda's recent work has included liquid crystal/nanoparticle interactions, particularly for use in photovoltaics. She expects to contribute her expertise in the physics of the particles' interactions with liquid crystals, while Soto-Bustamante will define their chemical effects.

"Liquid crystal polymers are better than monomeric liquid crystals because they have

polymers' properties, and this gives them a lot more mechanical integrity," Martínez-Miranda explains. "Applications of our work could include creating solar cells with elastomeric properties that are more stable and last longer."

She is looking forward to the trip. "I'm delighted about the collaboration because I haven't previously had a chemist working with liquid crystals working with me," she says. "I also hope to teach a short course on the physical properties of liquid crystals at the University of Chile. Ultimately, Professor Soto-Bustamante and I want to develop a program in which we can exchange graduate students from our research groups, which would be a win-win result for both them and our respective research programs."

### RUBLOFF TALKS ATOMIC LAYER DEPOSITION WITH C&EN

MSE professor and Maryland NanoCenter director **Gary Rubloff** was one of several experts featured in a recent article in *Chemical and Engineering News (C&EN)*, the weekly news magazine of the American Chemical Society (ACS).

"Making Films One Layer At A Time" discusses the wider applications of atomic layer deposition (ALD), a technique for creating thin films and coatings most often associated with semiconductors and the electronics industry. Emerging products that can be created with ALD include flexible displays, batteries, photovoltaics, lighting, textiles and nanoscale devices. Rubloff is one of a number of Clark School faculty members applying his knowledge of thin films to the development of devices that facilitate communication between biological and microfabricated electronics components.

The *C&EN* story also features the work of MSE graduate student **Konstantinos Gerasopoulos**, who along with his colleagues and his advisor, MSE affiliate professor and Institute for Systems Research director **Reza Ghodssi**, is using ALD to coat the tobacco mosaic virus in layers of metal, creating a nanowire-like structure that can be used as an electrode in millimeter- or sub-millimeter-sized lithium-ion batteries.





## WEADOCK HELPS LEAD UMD SOLAR DECATHLON TEAM TO VICTORY



NICK WEADOCK

When Secretary of Energy **Steven Chu** announced that the University of Maryland's WaterShed solar house (*below*) had placed second in the final component of the Department of Energy's ten-part Solar Decathlon—the mar-

ket appeal contest—everyone cheering in the main tent in West Potomac Park, Washington, D.C., knew that taking first place overall was all but assured for Maryland.

That's exactly how it played out: third place for New Zealand, second for Purdue University, and first place for Maryland in a competition involving twenty teams from around the world. The elated Maryland team received the big silver trophy, which team members passed from person to person, citing the contributions made by each. Celebrations continued when the team returned to WaterShed, the 800 square foot solar-powered home they had designed and built over the preceding two years to reach this moment.

Among them was MSE junior **Nick Weadock**, who joined for the team in 2009 to pursue his interest in sustainability engineering. As one of the project's Engineering Team leaders, he was responsible for designing and installing the house's mechanical systems. Throughout it all, Weadock balanced the project with his studies. During the competition in Fall 2011, he worked on the transportation and reassembly of the house in D.C., helped keep it in top shape and gave tours to the public during seven days of cloudy and wet weather—and still managed to get to his classes back on campus.

Weadock worked with over 200

students, faculty members and staff members from all over campus, representing departments and units including architecture, engineering, agriculture and natural resources, mathematical and computer sciences, libraries, and UMD's National Center for Smart Growth & Education and Center for the Use of Sustainable Practices. The team was advised by mentors specializing in architecture, construction, interior design, electrical power, media and communications, HVAC, controls, and other disciplines. External sponsors included Constellation Energy, the Whiting-Turner Contracting Company, Clark Construction, and Maryland Custom Home Builders, Inc.

Weadock plans to pursue a career in alternative energy research. His materials science and engineering coursework and experience with WaterShed will provide a great start in that direction.

*To learn all about the decathlon and the Maryland WaterShed house, see [solardecathlon.gov](http://solardecathlon.gov) and [2011.solarteam.org](http://2011.solarteam.org).*

## GAITHER WINS NRC POSTDOC RESEARCH ASSOCIATESHIP

Recent MSE alumnus **Michael Gaither** (Ph.D. '11), formerly co-advised by MSE professor **Isabel Lloyd** and MSE adjunct professor **Robert Cook** (National Institute of Standards and Technology [NIST]) has been awarded a NRC Postdoctoral Research Associateship by the National Academies. The highly selective program funds two- to three-year appointments at federal research laboratories and agencies.

In January, Gaither began his appointment at NIST's Materials Measurement Laboratory, where he works in the Ceramic Division's Nanomechanical Properties Group under the direction of **Frank DelRio**. Gaither will be examining silicon fatigue.

"Currently, there is ongoing debate in the literature about if and how silicon fatigues," Gaither explains. "My

project will focus on the investigation of silicon fatigue in newly designed resonator structures to understand the mechanisms of fatigue and failure in the silicon components. With all of the advanced measurement technology at NIST, it provides a unique location to fully investigate this problem."

Gaither built a relationship with NIST during his time at Maryland, when he worked on the development of a novel micro-scale test structure to determine relationships between the processing, structure, and properties of materials and techniques used in the fabrication of microelectromechanical systems (MEMS). The goal of the work was to establish ways of manufacturing more reliable MEMS devices. After presenting his work at the 2010 Fall Meeting of the Materials Research Society, Gaither was invited to publish his results in the October 2011 issue of the *Journal of Materials Research*.

## GREGORCZYK WINS SECOND L-3 FELLOWSHIP

MSE graduate student **Keith Gregorczyk**, advised by Professor **Gary Rubloff** (joint, Institute for Systems Research), has been awarded his second L-3 Graduate Fellowship by Clark School Corporate Partner company L-3 Communications. The fellowship is one of many graduate and undergraduate awards made possible by a \$1 million gift to the Clark School by the company in 2010 as part of an effort to increase awareness of itself among Clark School students and encourage recruitment of graduates into its ranks.

Gregorczyk's research focuses on using atomic layer deposition (ALD) for the fabrication of heterostructured nanomaterials. His goal is to show that that this technique, and the materials that can be made using it, will offer significant improvements in the way batteries store and distribute energy. He is currently working on his second paper, which will describe the electrical behavior of the electrodes he and his colleagues fabricate, and is also developing the ALD process that will be used to create energy storage components.

*continues next page*



L-3, continued from page 9

"Getting the fellowship renewed is very exciting," he says. "Energy research is a very competitive area right now and I know I was up against some stiff competition...It was very reaffirming and lets me know I'm on the right track, trying to push the boundaries of how energy devices are fabricated."

L-3 Graduate Research Fellowships annually support Ph.D. candidates in the last three years of their studies who conduct research at either the Institute for Systems Research, the Maryland Robotics Center, the University of Maryland Energy Research Center, the Unmanned Autonomous Vehicles Laboratory, the Alfred Gessow Rotorcraft Center, the Center for Advanced Life Cycle Engineering, or in the field of cybersecurity. The award includes a \$25,000 stipend, \$1000 to fund travel to conferences, and a five-credit tuition waiver. An additional \$4000 in discretionary funds and \$5000 to support an undergraduate researcher to work with each fellow is provided to their advisors.

### SPOSITO NAMED L-3 UNDERGRADUATE SCHOLAR

MSE senior **Alex Sposito** has been named a 2011-2012 L-3 Undergraduate Scholar by Clark School Corporate Partner Company L-3 Communications. The \$4,150 merit-based scholarship is one of several funded by a \$1 million gift to the Clark School from the company in 2010. The scholarships support students majoring in materials, electrical and computer, mechanical, and aerospace engineering, and are designed to encourage the recruitment of Clark School graduates into L-3 Communications' ranks.

For the past year, Sposito has worked as a research assistant in the Clark School's MEMS and Microfluidics Lab, directed by Department of Mechanical Engineering and MSE affiliate professor **Don DeVoe**. There, he and his colleagues are using microfluidic technology to synthesize novel macroporous polymer microbeads, which they hope to functionalize for use in biosensing and explosive detection systems. Sposito is the co-author of a paper on the work he presented at the

15th International Conference on Miniaturized Systems for Chemistry and Life Sciences in Seattle, Wa. in October 2011.

"Alex's success can be attributed to the unusual combination of creativity, enthusiasm in working at the interface of multiple disciplines, and a strong entrepreneurial bent that helps him see the potential of the research output in serving real-world needs," says DeVoe.

Sposito has been active in research and internships off-campus as well. In the summer of 2011, he was an intern in General Electric Healthcare's Operation Management Leadership Program. He has also participated in consulting projects for Science Application International Corporation, in which he outlined emerging technologies and markets in the alternative energy and nanotechnology sectors. He spent the Fall 2011 semester working as an Intern Analyst for Lux Research, a firm that provides strategic advice to companies utilizing emerging technologies, while studying abroad at Nanyang Technological University in Singapore.

Sposito, who minors in technology entrepreneurship, is a member of the Hinman CEOs program. In 2010, the venture he co-founded with his Hinman team was among the top five in the University of Maryland's



PHOTO BY JIM YANKER

Dingman Center for Entrepreneurship's China Business Plan Competition, held in partnership the Guanghua School of Management at Peking University in Beijing.

After graduation, Sposito plans to pursue a graduate degree in mechanical engineering to continue his research in MEMS and microfluidics. "Eventually," he says, "I hope to use my background in both engineering and entrepreneurship to spin off a business venture from my research."

### MSE STUDENTS TOUR MICRON

Fourteen MSE students recently toured Micron, one of the world's leading producers of computer memory and semiconductor systems. The trip to the company's Manassas, Va. facility was sponsored by the department's Materials Science Graduate Society (MSGS) and conducted in collaboration with Materials D.C., the Washington chapter of ASM International. Micron's **Zuzana Steen** hosted the visit.

The group attended presentations by two of Micron's engineers, who discussed silicon industry trends and explained the company's economic significance as the last remaining producer of computer memory with production facilities in the U.S. Group members were also treated to a guided window tour of the company's fabrication facilities.

MSGS president **Richard Suchoski**, who organized the trip, says the students found it very informative, and were particularly excited to see the scale-up of



MSE SENIOR ALEX SPOSITO (SECOND FROM LEFT) WITH HIS HINMAN CEO TEAMMATES AT A BUSINESS PLAN COMPETITION IN BEIJING, CHINA IN 2010.



ideas and products to an industrial level after having worked on campus in the smaller, academic setting of the Maryland NanoCenter's FabLab.

"What we do here on campus is research," he explains. "We write a paper and we send that out into the academic ether. But then somebody in industry picks up that paper and says, 'Hey, this will work,' and they put it into production. Seeing that process in effect, seeing what happens once a paper leaves our hands, was very interesting."

Suchoski hopes to organize similar trips in the coming semesters.

#### SHAHAMAT: WHITE HOUSE SCIENCE AND TECHNOLOGY POLICY INTERN

Nuclear engineering Ph.D. candidate **Layla Shahamat** is using her expertise to help the members of the nation's highest offices make informed decisions about how advances in science and technology are funded, implemented and managed.

Since September 2011, Shahamat, advised by Department of Materials Science and Engineering professor **Mohamad Al-Sheikhly**, has been an intern in the White House Office of Science and Technology Policy's (OSTP) student volunteer program, providing input to senior policymakers on a variety of projects in the OSTP's divisions of Technology and National Security & International Affairs.

The OSTP's mission is to provide the President with analysis and judgment of federal science and technology programs, develop and implement related budgets, and work with private industry to ensure those initiatives contribute to the nation's security, economy, and environment.

Shahamat pursued the internship, which combines science and policy work, out of her desire to be a more effective champion of her own field.

"I've observed that government policies affect the field of nuclear energy tremendously: construction of nuclear power plants, reprocessing of fuel, and research funding," she says. "This has motivated me to take a closer look at how [nuclear] policies are formed...how

## alumninEWS

**Adam Taff** (B.S. '04, nuclear engineering) joined HF Financial in Charlotte, North Carolina, a General Agency of Massachusetts Mutual Life Insurance Company (MassMutual), as a Financial Services Professional. Taff holds a MBA from George Mason University, and prior to joining HF Financial worked in the Washington Navy Yard.

Former Fischell Fellow **Dan Janiak** (B.S. '04 and Ph.D. '09) has joined the staff of DFJ Mercury, a seed-stage venture capital firm based in Houston, Tx., specializing in technology transfer and incubation.



#### KEEP IN TOUCH!

Did you land a great new job? Get married? Have a baby? Win an award? Patent a new process or product? Have you used your engineering skills and experience to make a difference? Let us know! Find us on Facebook or e-mail [mse@umd.edu](mailto:mse@umd.edu).

funding is allocated and how the government decides on what steps to take next."

At the OSTP, she has contributed to reports on future research directions for nuclear nonproliferation plans, accidents and risk analysis. She is working with the Obama administration's Advanced Manufacturing Partnership, which helps coordinate government, industrial and academic efforts to create high quality manufacturing jobs in the U.S. Her duties also include concerns beyond our own borders, including organizing multinational meetings focused on technology collaboration and science and technology-oriented student exchange programs.

"I've found this internship an exciting experience and a great opportunity," says Shahamat. "I work side by side with senior White House science and technology advisers to confront the challenges that science faces globally."

Her service at the White House has also had a positive influence on her future plans. "After this invaluable experience, I am considering working in the policy [field]," she says. "I realized that there is a great need for people with strong technical backgrounds and passion for public policy. Such activity is likely to make a big difference not only to the future of the nation, but of the world."

## recent GRADUATES

#### AUGUST 2011 M.S. GRADUATES

**Adam Karcz**  
**Aloysius Obodoako**  
**Tong Renn**

#### DECEMBER 2011 B.S. GRADUATES

**Michael Carrier**  
**Linmaris Santiago**

#### DECEMBER 2011 M.S. GRADUATES

**Michael Carrier**  
**Linmaris Santiago**

#### DECEMBER 2011 PH.D. GRADUATES & DISSERTATIONS

**Hyunsuk Chun:** "Abnormal Grain Growth in Magnetostrictive Galfenol Rolled Sheet." (Advisor: Alison Flatau, Department of Aerospace Engineering)

**Michael Gaither:** "Ultra-Small Scale Mechanical Properties Measurement." (Co-Advisors: Isabel Lloyd and Robert Cook [NIST])

**Kwan Lee:** "Synthesis and Characterization of Functional One-Dimensional Nanostructures." (Advisor: Min Ouyang, Physics)

**Florian Weilnboeck:** "Plasma Interactions with Masking Materials for Nanofabrication." (Advisor: Gottlieb Oehrlein)

**Zane Wyatt:** "The Effect of Phase Constitution and Morphology on Room Temperature Deformation Behavior of Binary Titanium Alloys." (Advisor: Sreeramamurthy Ankem)





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## ABOUT THE COVER IMAGE

THE RED IMAGE USED ON THE COVERS SHOWS A CACTUS THAT EXHIBITS CHIRALITY, OR “HANDEDNESS.” STRUCTURES WITH “LEFT” AND “RIGHT” CONFIGURATIONS ARE ABUNDANT IN NATURE, FROM THE MACROSCALE TO THE NANOSCALE. ASSISTANT PROFESSOR ODED RABIN IS USING CHIRAL, PLASMONIC NANOPARTICLES TO ENHANCE THE SENSITIVITY OF RAMAN SPECTROSCOPY, WORK FOR WHICH HE RECEIVED A NSF-CAREER AWARD. FOR MORE INFORMATION, SEE OUR COVER STORY.

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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## TAKEUCHI, HUNTER IN *NATURE COMMUNICATIONS*

In a paper published in the November 2 issue of *Nature Communications*, a team of researchers led by Department of Materials Science and Engineering (MSE) professor **Ichiro Takeuchi** and alumnus **Dwight Hunter** (Ph.D. '11, formerly advised by Takeuchi), reported the discovery of large magnetostriction in an iron/cobalt alloy—in other words, the alloy shows a mechanical strain when a magnetic field is applied.

This property is sought after in materials with good mechanical properties for microelectromechanical systems (MEMS), sensors and actuators. However, magnetostrictive materials are usually based on rare or

difficult-to-obtain materials, so scientists have been looking for alternatives based on common, cheap and widely available elements.

The team was able to enhance the magnetostriction of the alloy by more than a factor of 3, and it appears that the mechanism by which they were able to enhance the magnetostriction can be used to discover even better magnetostriction properties in alloys of common metals.

Takeuchi and Hunter's co-authors included MSE professor **Manfred Wuttig**, MSE graduate student **Richard Suchoski** and former MSE postdoctoral research associate **Ryota Takahashi**; **Will Osborn**, **Ke Wang**,

alumnus **Jason Hattrick-Simpers** (Ph.D. '07), and **Leonid A. Bendersky**, representing NIST; **Apurva Mehta** (Stanford University); **Nataliya Kazantseva** (Urals Branch of the Academy of Sciences, Russia); **Marcus L. Young** (Oregon State University); and **Sam E. Lofland** (Rowan University). The research was also featured on Physorg.com.

*Story courtesy of and adapted from the original by Bronwyn Barnett, SLAC Communications, Stanford University), [bronwynb@slac.stanford.edu](mailto:bronwynb@slac.stanford.edu).*

*For more information, see:*

*Hunter et. al. “Giant magnetostriction in annealed Co<sub>1-x</sub>Fe<sub>x</sub> thin-films.” *Nature Communications*, 2 November 2:518 Doi: 10.1038/ncomms1529 (2011).*