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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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Rubloff Team Wins \$2.8M Army Grant PROJECT WILL ADDRESS CHALLENGES IN QUANTUM COMPUTING

Professor **Gary Rubloff** (joint, Institute for Systems Research, and director, Maryland NanoCenter) is the co-PI on an interdisciplinary research collaboration with the Joint Quantum Institute (JQI) that has been awarded a five-year, \$2.8 million grant from the Intelligence Advanced Research Projects Activity (IARPA) through the Army Research Office (ARO) to devise, fabricate, study and test a new kind of key component for quantum computing.

Rubloff is joined on the project by JQI Fellows Victor Galitski and PI Chris Lobb (both from the Department of Physics); Kevin Osborn (Laboratory for Physical Sciences); and co-PI Charles Musgrave (Chemical and Biological Engineering, University of Colorado at Boulder). The team will work on novel methods of constructing the crucial, ultra-thin insulating barrier that lies between two superconductors to form a "Josephson junction." A network of such junctions, employed as quantum bits, or "qubits," is an extremely promising candidate to serve as a basis for a quantum computer that could solve certain kinds of problems exponentially faster than today's best supercomputers. However, the microscopic sheets of aluminum oxide currently used in the junctions' dielectric (insulating) barriers characteristically contain tiny defects, or regions with unfortunate atomic arrangements, that prevent the qubits

from remaining for long in a quantum "superposition" of multiple states at the same time. That condition, called "coherence," is necessary during the computation time of the quantum computing algorithm.

"Under the best conditions, we can't get coherence times longer than a few microseconds, and in most cases the times



LEFT TO RIGHT: VICTOR GALITSKI, CHRIS LOBB, AND GARY RUBLOFF.

are much shorter," says Lobb, who has three decades of research experience with superconducting qubits, Josephson junctions and sub-micrometer electronics. "That's much too brief for a working computer. It's clear that the major problem is defects in the atomic configuration of the conventional barrier material. However, it may be possible to minimize structural defects in the

continues next page



chair'sm ssage



ROBERT M. BRIBER

IT'S AN EXCITING TIME AT MARYLAND. THE DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING IS MOVING FORWARD ON A BROAD RANGE OF NEW INITIATIVES IN EDUCATION AND RESEARCH.

Our faculty are winning significant new research awards. In this issue, you can read about a new initiative in quantum computing in which Professor **Gary Rubloff** is participating (see cover story) and another new research project in liquid crystals led by Professor **Luz Martinez-Miranda** (see p. 3). We also have a very interesting story about how the field of semiconductor processing is being pushed forward through the thesis research of **Bobby Bruce** (Ph.D. '10, advised by Professor **Gottlieb Oerhlein**; see p. 4). Plasma processing is a key step in semiconductor manufacturing and as new polymer photoresists

have been introduced, the plasma etching behavior has changed. The work shows how the degradation process of the polymer can play a critical role in how a smooth surface can be maintained during etching.

The Department has been reaching out to bring the exciting world of materials science to the rest of the University of Maryland campus with the Marquee Science and Technology course "Materials of Civilization." (See p. 9.) Non-engineering and non-science majors can now learn how advances in materials have lead to revolutions in technology and as a consequence of civilization.

If you enjoy *Techtracks*, you can keep up with all of our news and events as they happen. Take a moment to visit our website at **www.mse.umd.edu** and read through the news—we are posting stories all the time! You can also browse our lineup of great <u>seminars</u>, which you are welcome to attend.

Now more than ever, our talented students need your support. Even a few hundred dollars can make the difference between a student obtaining a Terp education or not. Are you looking for a way to help, but need inspiration on how to make the perfect gift within your budget? A variety of meaningful and fun ideas can be found online on our "Creative Ways to Give!" page: eng.umd.edu/giving/giving_ creative.html. Possibilities include funding new courses, buying books for a student, sending a prospective engineer to a Clark School summer camp, and supplying Engineers Without Borders with tools. For more information, you can also visit the Give to MSE link on the Department homepage at www.mse.umd.edu.

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.

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Robert M. Briber Professor and Chair, MSE

QUANTUM COMPUTING GRANT, continued from page 1

junctions that are problematic—dramatically increasing the coherence time—by going beyond the conventional thermal oxide used by today's qubit research groups. This proposal will allow us to carefully assemble the dielectric barriers one atomic layer at a time."

The team's atomic layer deposition (ALD) assembly technique uses alternating cycles of reactive gases to achieve nanoscale conformal dielectric films. ALD is widely employed by Intel and other microelectronics companies, but it has not been applied to Josephson junctions.

Rubloff, an expert in ultraclean processing and ALD nanostructures, will grow and perform surface analysis on both conventional oxide and the new ALD dielectric barriers in a system configured explicitly for this work.

"We don't know how much better ALD dielectrics will perform, but we will be able to compare both junction types from our customized deposition and analysis system to find out," he says.

Osborn, who specializes in qubits and low-temperature measurements of dielectrics, will characterize the junctions at low temperature prior to incorporating them into qubits. The defects in the junctions can appear randomly, which leads to noise as well as poor coherence. "By attempting to improve superconducting qubits...we are [also] going to bring new understanding to universally-observed noise phenomena in superconducting devices," he explains.

Candidate defect structures and mechanisms will be studied by two theory groups. Musgrave will simulate candidate defects using his expertise in atomic modeling calculations of metal-insulator interfaces. He will also be able to use input from surface data taken by Rubloff during the junction growth. Galitski, an expert in superconductivity and defect models, will produce a comprehensive theoretical analysis of how defects affect

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junctions, and will work with Musgrave to identify which simulated defects are likely to lower the coherence at low temperatures.

"This kind of interdisciplinary synergy is exactly what the superconducting qubit community needs," Lobb says. "By bringing together proven expertise in both theory and experiment, and a wide variety of perspectives from physics, engineering and chemistry, we will be able to mount a uniquely powerful research effort."

Story courtesy of & adapted from the original published by the Joint Quantum Institute.

\$360K NSF GRANT FOR LIQUID CRYSTAL STUDY

Associate Professor Luz J. Martínez-Miranda has been awarded a 3-year, \$360,000 National Science Foundation grant, funded by the American Recovery and Reinvestment Act, for a proposal titled "Effect of the Nanoparticle Surface Termination on the Nanoparticle-Smectic Liquid Crystal Interaction: Order/Disorder Effect." The research will be carried out in collaboration with Dr. Lynn Kurihara, a chemist at the Naval Research Laboratory.

While most people associate liquid crystals with televisions and other device displays, liquid crystal structures are found throughout nature, including the cell walls of the human body. Their ability to change phase (the alignment of their molecules) allows cells to perform certain tasks, including the absorption or excretion of nutrients and drugs. Martínez-Miranda has spent the past ten years examining liquid crystal behavior in cell walls for bio-applications including human healthcare.

In her current study, she and Kurihara are using the liquid crystals as a model for cell walls. By understanding the effect of certain kinds of nanoparticles on liquid crystals, they hope to build a general interaction model that could be used by other researchers to test how effectively a drug could be delivered to and taken up by different kinds of cells. "Doing these kinds of studies with cultured cells requires a complex facility that many researchers simply can't obtain," Martínez-Miranda explains. "If we can produce an accurate model, it could serve as a platform for preliminary drug testing, and speed up the process."

In drug delivery, organic molecules called terminal compounds are attached to inorganic nanoparticles. They create a coating, a disguise designed to tempt the targeted cell types to absorb the nanoparticles instead of regarding them as foreign objects. They also help identify the target inside the

body. Martínez-Miranda is interested in how the terminal compounds order or disorder cell walls as they pass through.

The liquid crystals in a cell wall can have a nematic structure (semi-ordered and not aligned) or a smectic structure (ordered and aligned). Smectic structures, which are more common in organic materials, are more difficult to "open up" to allow drugs to enter the cell. Creating terminal compounds that disorder the smectic structure, however, is not necessarily the solution. "Ordering and disordering are neither good nor bad things," Martínez-Miranda explains. "Which state is more desirable depends on what you're trying to accomplish. If you're attacking cancerous cells, disordering-which could mean rupturing-their walls may be the outcome you need. The real challenge is to have the terminal compounds change the phase of the liquid crystal to whatever configuration makes it easiest for the drug to get inside the cell. What I've observed is that we can achieve different liquid crystal configurations

[(A) AND (B)] POLARIZING MICROSCOPE PICTURE OF 2nm MIXED WITH 8CB COVERED NANOPARTICLE SHOWING THE NEMATIC-LIKE DEFECTS FORMED IN THE SMECTIC LIQUID CRYSTAL AT ROOM TEMPERATURE: (A) THE EDGE OF THE SAMPLE AND (B) THE CENTER OF THE SAMPLE, "200µm THICK. [(C) AND (D)] POLARIZING MICROSCOPE PICTURE OF 2nm MHDA COVERED NANOPARTICLES MIXED WITH 8CB SHOWING THE SMECTICLIKE STRUCTURES: (C) THE EDGE OF THE SAMPLE AND (D) THE CENTER OF THE SAMPLE "200µm THICK. FOR A-D NO MAGNETIC FIELD WAS APPLIED. J. APPL. PHYS. **105**, 084305 2009.



by varying the molecular structure of the terminal compound it interacts with. This may apply to the cell wall."

While many researchers are studying the interactions between cells and nanoparticles, Martínez-Miranda says that what sets her research apart is its particular focus on the effects different terminal compounds have on smectic ordering. She was one of the first people to publish research in that area. "When I started my liquid crystal research ten years ago," she explains, "people were concentrating mostly on liquid crystal structures with nematic ordering. The focus was on engineering-oriented applications, rather than biological ones, so the terminal compounds that were studied were chosen for their potential in engineering applications. What was learned from that research did not necessarily apply to biological applications."

"I'm really excited about the project," Martínez-Miranda adds. "Anything we learn from it is important because it is new territory."

featured RESEARCH

INFLUENCE OF POLYMER STRUCTURE ON PLASMA-POLYMER INTERACTIONS IN RESIST MATERIALS

Dr. Bobby Bruce (Ph.D. '10)

Bobby Bruce, formerly advised by Professor **Gottlieb Oehrlein**, completed his Ph.D. thesis defense in early 2010. In his dissertation, he was able to identify one of the root causes of uncontrolled microscopic roughening that takes place on polymer surfaces as they are contacted by plasma. Dr. Bruce will continue his work in nanoscience and technology at IBM Research in Yorktown Heights, NY.

The controlled patterning of polymer resists by plasma plays an essential role in the fabrication of integrated circuits and nanostructures. As the dimensions of patterned structures continue to decrease, we require an atomistic understanding underlying the morphological changes that occur during plasma-polymer interactions. In this work, we investigated how plasma surface modifications and the initial polymer structure influenced plasma etch behavior and morphological changes in polymer resists.

Using a prototypical argon discharge, we observed polymer modification by ions and vacuum ultraviolet (VUV) radiation from the plasma. A thin, highly dense modified layer was formed at the polymer surface due to ion bombardment. The ion-damaged layer acted as a barrier to further etching and significantly reduced the plasma etch rate. The thickness and physical properties of this ion-damaged layer was independent of polymer structure for the systems examined here. A relationship was observed that strongly suggests that buckling caused by ion-damaged layer formation on a polymer is the origin of roughness that develops during plasma etching. Our results indicate that with knowledge of the elastic modulus of the ion-damaged layer and the polymer being processed, plasma-induced surface roughness can be predicted and the surface morphology calculated.

In addition, we observed the absence of surface and line-edge roughness in the polymer poly(4-vinylpyridine) (P4VP) in



FIG. 1: (A) A SCHEMATIC OF THE HIGHLY STRESSED, MODIFIED LAYER FORMATION AND ROUGHENING THAT OCCURS SIMULTANEOUSLY AT THE SURFACE OF A POLYSTYRENE FILM UNDER Ar PLASMA EXPOSURE. IMPORTANTMATERIALS ANDMORPHOLOGICALPROPERTIES ARE ALSO SHOWN. BELOW THIS ARE AFM IMAGES OF THE SURFACE MORPHOLOGY IN PS AFTER ION BOMBARDMENT AT VARYING MAXIMUM ION ENERGIES. ALSO SHOWN ARE CALCULATED AND EXPERIMENTAL VALUES OF λ (B) AND A (C) VERSUS MAXIMUM ION ENERGY OF THE NANOSCALE ROUGHNESS PROCESSED AT 40°C.

plasma etching conditions that produced significant roughness in every other polymer structure tested. We found that in an Ar plasma, plasma VUV radiation caused crosslinking to occur below the iondamaged layer in P4VP. For other polymers tested, VUV radiation showed no effect or enhanced chain scissioning. Our data suggest that crosslinking of P4VP by plasma VUV radiation may prevent the buckling instability that causes plasma-induced roughness by increasing the elastic modulus of the polymer region directly below the iondamaged layer.

Overall, the present work shows that when polymers are used as resists in plasmabased pattern transfer, the effectiveness of

> the resist is due to the formation of a thin, dense layer at the resist surface that slows the rate of etching. However, this surface modified layer is the source of the plasmainduced roughening that leads to high roughness. Minimizing the difference in the mechanical properties between the surface modified layer and the polymer, as is achieved by VUV crosslinking in P4VP, is a possible solution to maintaining smooth surfaces during plasma etching.

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researchnews continued

CUMINGS, YOUN RECEIVE NRC GRANT

Assistant Professor **John Cumings** and his colleague, Assistant Professor **Byeng Dong Youn** (Mechanical Engineering, Reliability Engineering, and Nuclear Engineering), have been awarded a 2009 Nuclear Regulatory Commission (NRC) Young Faculty Development Grant to design better prognostic systems for nuclear facilities.

Youn will investigate how sensor-based prognostics modules (life, reliability and loading) for nuclear systems could enable damage prognostics and become part of a maintenance platform to proactively manage risk in nuclear reactor systems. His findings will be integrated into a reactor material damage analysis platform to be developed by Cumings. The results have the potential to establish a new paradigm of life and reliability prognostics for nuclear system maintenance.

The pair hope the outcomes of the grant will help to build signature research in damage prognostics and maintenance for nuclear and reliability programs. They also plan to develop a new graduate course on the topic, called System Health Monitoring and Prognostics.

DETECTING CORROSION IN CONCRETE FOR HIGHWAY SAFETY

Professor **Mohamad Al-Sheikhly** and Adjunct Professor **Richard Livingston** are co-PI's on a new highway safety project funded by an IDEA grant from the Transportation Research Board of the National Academies. The pair is developing a faster, non-destructive technique for detecting corrosion in concrete, particularly in roads, overpasses, and bridges.

Chlorides, or salts, are one of the leading causes of damage in roads and other highway structures, which receive repeated exposure from the salting in the winter, proximity to the ocean, or from being submerged in salt water (for example, bridge pilings).

In order to test a concrete structure for chloride exposure, and determine whether it is in need of replacement or repair, road crews must currently bore a hole in it and extract a core of material, which is then sent to a lab for analysis. Since the roads or structures are typically in use and heavy equipment is required to take the sample, workers often need to close lanes, snarling traffic. The lab results can take weeks to receive.

Al-Sheikhly and Livingston have proposed a device that would allow workers to conduct a test and receive results in the field, without having to drill for a sample, using what Al-Sheikhly describes as "a straightforward application of nuclear engineering." A device containing a neutron generator is used to "fire" neutronsradioactive atomic particles-into the concrete. The neutrons react with any chloride present, bouncing back gamma ray signals that the device can interpret as a measure of how much chloride is in the concrete, and how deeply it has penetrated. "Within 20 minutes you have results," says Al-Sheikhly. "You don't have to dig, you won't cause any more damage, and the process costs a lot less. Any problems can be addressed before they get worse."

The use of radiation poses no danger to highway crews or passing motorists. "It's such a small amount," Al-Sheikhly explains. "Much less than your dentist would use to take an X-ray."

Al-Sheikhly and Livingston's project was featured in the Fall/Winter 2009 issue of *Ignition*, the Transportation Research Board's IDEA Program magazine.

LIVINGSTON TEAM WINS NSF-EAGER GRANT

Adjunct Professor **Richard Livingston** is the co-PI on a research collaboration recently awarded a National Science Foundation Early-concept Grant for Exploratory Research (NSF-EAGER). The project, titled "Development of Synthetic Fly Ash Glass as a Model System for Investigating Fly Ash Reactivity," is funded under the American Recovery and Reinvestment Act of 2009. Livingston's co-PI is Department of Civil and Environmental Engineering professor **Amde M. Amde**. The pair will be working with **Walairat Bumrongjaroen** of the Catholic University of America's Vitreous State Laboratory. The project's goal is to demonstrate the use of synthetic glass as a simulant and model for studying the reactivity of fly ash in concrete.

Fly ash, a byproduct generated by the combustion of coal, is currently being recycled in a variety of ways-including use in road construction, soil stabilization, paint, and building materials-to help keep some of the millions of tons of it produced each year out of landfills. One of its popular uses is as a substitute for a portion of the Portland cement required in the creation of concrete. It is less expensive than Portland cement, and its glassy quality improves the flow of the concrete in its liquid state. However, concrete made with fly ash does not always perform as expected because the ash's particle size and chemical composition may vary widely depending on the coal and combustion conditions it came from. This also makes it difficult to study in our efforts to improve materials made with it.

To better understand and predict the behavior of fly ash in concrete, Livingston and his colleagues will develop a synthetic glass fly ash whose particle size and composition can be controlled in a variety of conditions, enabling a truly systematic study. The new material will be produced at Bumrongjaroen's Vitreous State Laboratory and characterized using an environmental scanning electron microscope and other instruments in the Nanoscale Imaging, Spectroscopy, and Properties Laboratory (NispLab). Its mechanical properties will be measured in the Department of Civil and Environmental Engineering's Concrete Test Laboratory.

NSF-EAGER grants are used to support potentially "high risk, high payoff" research in its early stages. EAGER projects often focus on entirely new or radically different approaches to problems, special expertise, or novel interdisciplinary collaborations.

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RUBLOFF GROUP RESEARCH SELECTED FOR *HIGHLIGHTS IN CHEMICAL TECHNOLOGY*

A paper produced by the research group of Professor **Gary Rubloff** has been selected for inclusion in *Highlights in Chemical Technology (HCT)*. The magazine, produced by the Royal Society of Chemistry (RSC), combines interviews and reviews with select papers recently published in RSC's various peer-reviewed journals. HCT is designed to highlight the best examples of the industrial applications of the latest research in a variety of chemical sciences.

The Rubloff Group paper, "In situ generation of pH gradients in microfluidic devices for biofabrication of freestanding, semi-permeable chitosan membranes," originally published in Lab on a Chip, describes the group's advances in the use of chitosan, a naturally occurring bipolymer, as a biological membrane component of bioMEMS (biological microelectromechanical systems) devices and microfluidic systems used for microdialysis, filtration, gas-liquid exchange, and biochemical, bioanalytical, biosensing, and cellular studies. The group describes a fast, simple way of manufacturing the chitosan membranes. Their biofabrication technique also addresses problems associated with current fabrication methods that are harder to control and may result in cytotoxic conditions when used in cell culture environments. Rubloff's co-authors are Xiaolong Luo (Ph.D. '08, currently a postdoctoral research associate), Dean Berlin (M.S. '09), Jordan Betz (graduate student, Fischell Department of Bioengineering), Professor Gregory Payne (University of Maryland Biotechnology Institute), and Professor William Bentley (Fischell Department of Bioengineering).

AL-SHEIKHLY DELIVERS POLYMER CONFERENCE KEYNOTE

Professor **Mohamad Al-Sheikhly** was a keynote speaker at the 11th Pacific Polymer Conference (PPC11), held in December 2009 in Cairns, Australia, and in conjunction with the 31st Australasian Polymer Symposium (31APS).

Al-Sheikhly's talk, titled "On the Mechanisms of Synthesis of Polymer Nano-Hydrogels Using Pulsed Electron Beams," discussed the use of nano-hydrogels made of biocompatible hydrophilic polymers that can be used in a variety of medical applications, including drug delivery and imaging. He described his research group's investigation of the radiation-induced synthesis of functionalized polymer nano-hydrogels that can serve as targeted nanomedicine carriers, and can be selectively guided to tumors using the enhanced permeability and retention (EPR) effect. He also described the effects of pulsed electron beam irradiation on the polymers' inter-molecular crosslinking during synthesis.



(A) POLYSACCHARIDE CHITOSAN WITH PH-RESPONSIVE SOLUBILITY; (B) A TOP VIEW AND (C) A 3D PERSPECTIVE VIEW OF THE PH GRADIENT ACROSS APERTURE OPENINGS BETWEEN THE BUFFER AND CHITOSAN FLOW STREAMS.

The combined Pacific Polymer Conference and Australasian Polymer Symposium gathered leading polymer scientists and engineers from around the world to present research on topics including polymerization methodologies, polymer architecture, nanocomposites, polymers for

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use in biological and medical applications, interfaces, polymers in energy applications, and mechanical properties of polymers.

HISPANIC PHYSICISTS ELECT MARTINEZ-MIRANDA

Associate Professor Luz J. Martínez-Miranda has been elected President of the National Society of Hispanic Physicists (NSHP). Her term will span 2010-2012. Martínez-Miranda has been a member of NSHP's board since 1998, and previously served as its president from 2002-2005.

Founded in 1995 with a grant from the Alfred P. Sloan Foundation, the NSHP promotes and recognizes the accomplishments of Hispanic physicists, and seeks to increase both the opportunities for and the number of Hispanic physicists in the scientific community, particularly through outreach and mentorship of high school and college students.

The NSHP maintains a close working relationship with the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS), of which Martínez-Miranda is also a member and former board member (2005-2008). Her activities with the organization include advising graduate and undergraduate students in physics and engineering majors and serving as a research poster judge and session organizer at events.

"Both organizations provide Hispanic role models all in one place," she says. "In other large physics or materials society events you may only find one in a session."

Martínez-Miranda is an elected Fellow of the American Physical Society (APS) and an undergraduate advisor. She is also active in mentoring-oriented programs such as the university's Materials Research Science and Engineering Center's Research Experience for Undergraduates program, and the Alfred P. Sloan Foundation's efforts to increase and support underrepresented American minority Ph.D. students in math, science and engineering.

NIST AWARDS UM \$15.5 MILLION IN FELLOWSHIPS

MSE professor and chair **Robert M. Briber** was a co-PI on a proposal that has earned the University of Maryland a \$15.5 million award from the U.S. Commerce Department's National Institute of Standards and Technology (NIST) to develop and implement a national NIST measurement science and engineering fellowship program. Briber will be working closely on the project with the program's PI, Professor **Daniel Lathrop** (director, Institute for Research in Electronics and Applied Physics [IREAP]; physics) and co-PI Professor **Ellen Williams** (physics). The new grant was funded under the American Recovery and Reinvestment Act of 2009.

The program 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.

"The program reflects and highlights the close interactions between the A. James Clark School of Engineering, the College of Chemical & Life Sciences, the College of Computer, Mathematical & Physical Sciences, and NIST," says Briber. "MSE already has strong ties to NIST and this program will help build on them by creating jobs, supporting top level students and scientists, and advancing science and technology projects that are crucial for maintaining U.S. leadership in the world economy."

According to University of Maryland Vice President for Research **Mel Bernstein** the new grant brings the amount of federal recovery act funding the university has received to date to more than \$52 million, primarily from NIST. "This funding, by helping to build the careers of young scientists and engineers, and supporting a broad range of innovative research, will significantly assist short and long term job creation," he adds. "By advancing basic understanding in areas ranging from early childhood development to quantum physics, it will lay the foundation for new treatments, new products and new technologies."

The NIST measurement science and engineering fellowship program will be administered by IREAP. Undergraduate and graduate students from the A. James Clark School of Engineering, the University of Maryland at large, and other universities are eligible and encouraged to apply. The University of Maryland will also recruit nationally to fill the senior scientist and postdoctoral research positions.

PHANEUF AT ASPEN INSTITUTE ITALIA'S TRANSATLANTIC DIALOG

Professor **Raymond Phaneuf** was invited to participate in the Aspen Institute Italia's Transatlantic Dialog, an international conference held in Rome, Italy in November 2009.

The Aspen Institute is an independent, nonpartisan, international organization dedicated to addressing the complex problems, decisions and policies countries face in contexts such as mass media, business, academia, politics, and economics, in an effort to find common ground and create informed leadership. Italy's branch, Aspen Institute Italia, is particularly dedicated to trans-Atlantic relations.

Phaneuf participated in discussions about the role of the scientists in shaping public policy, the future of innovation, the complex relationship between scientists and the media, "dual use technologies" (developed by defense, but also applicable to civilian society), and the need for political and societal reality checks to help people understand that "science" does not always have solutions to our problems.

Phaneuf was selected for the Transatlantic Dialog based on his longtime experience in both the U.S. and Italy's scientific and academic communities. Since 1984, his work in Italy has included collaborations with research groups at the Elettra Synchrotron Light Source in Trieste, serving as a visiting professor at the National Nanotechnology Institute in Lecce during his sabbatical year, spending time at the Italian Institute of Technology (ITT) in Genova, and publishing papers based upon the work carried out with his Italian colleagues during these visits. He has also given lectures at the University of Rome, the Istituto dei Materiali per l'Elettronica ed il Magnetismo (IMEM) in Parma, the ITT, and the National Nanotechnology Laboratory (NNL) in Lecce, and taught a course on nanocharacterization to Italian undergraduates at the NNL.

MSE AFFILIATE, COLLABORATOR NAMED DIRECTOR OF ISR

The Department extends its congratulations to affiliate professor **Reza Ghodssi** (electrical and computer engineering), who became the new director of the Institute for Systems Research (ISR) effective October 1, 2009. Ghodssi is actively involved in collaborations with MSE faculty members.

"Professor Ghodssi has worked closely with MSE faculty and has directed MSE graduate students in their thesis work," said MSE Professor and Chair **Robert M. Briber**. "He brings extensive skills in research and management to his new position and represents an opportunity to strengthen ties between our department and ISR."

Some of Ghodssi's notable collaborations with MSE faculty, particularly with Professor **Gary Rubloff**, include devising means to detect and disrupt bacterial communication known as quorum sensing, which could prevent coordinated behavior leading to infection or illness; the development of labon-a-chip technology for the testing of new drugs' effects on living cells; and designing nanoscale storage systems for wind and solar energy that show a dramatic improvement over currently available technology.

Established by a National Science Foundation grant in 1985, ISR works closely with industry to deliver one of the top crossdisciplinary research and education programs

invited LECTURES

A SELECTION OF INVITED LECTURES BY MSE FACULTY IN 2009-10

Sriramamurthy Ankem

"The Effect of Metastability on Room Temperature Deformation Behavior of Beta Titanium Alloys," with Z. Wyatt. ICAM 2009, Rio De Janeiro, Brazil, September 2009.

"Recent Advances in Kinetics of Deformation Twinning in Titanium Alloys," with Z. Wyatt and R. Mulholland. Keynote Presentation at the International Symposium on Plasticity 2010, St. Kitts, January 2010.

Aris Cristou

"Integrated Thin Film Power Source with Amorphous Si-SiGe MOSFETs for Flexible Electronics," 2009 WOCSDICE Meeting, Malaga, Spain, June 2009.

John Cumings

"Developments in Artificial Spin Ice and Artificial Kagome Ice," Workshop for Novel Physics on the Kagome Network, Laboratoire de Physique des Solides, Orsay, France, January 2010.

Isabel Lloyd

"High Thermal Conductivity AIN Materials," International Symposium on Dielectric Materials and Electronic Devices, MS&T 2009, Pittsburgh PA, October 2009.

Gottlieb Oehrlein

"Plasma-Polymer Interactions For Nanoscale Patterning Of Materials," 215th Meeting of the Electrochemical Society, San Francisco, CA, May 2009.

'Low-Temperature Plasma Surface Interactions with Carbon-Based Materials," Princeton Plasma Physics Laboratory, Princeton, NJ, December 2009.

Raymond Phaneuf

"Fluorescence Enhancement from Artificial Nanostructure Arrays-the Role of the Substrate," Italian Institute of Technology, Genova, Italy, June 2009.

Oded Rabin

"Directed Self-Assembly of Silver Nanocubes: A Method for Regenerable Surface-Enhanced Raman Spectroscopy (SERS) Substrates," AVS Mid-Atlantic Chapter Meeting, Gaithersburg, MD, April 2009.

"Directed Self-Assembly of Silver Nanocubes: A Method for Regenerable Surface-Enhanced Raman Spectroscopy (SERS) Substrates," SPIE NanoScience + Engineering Symposium, San Diego, CA, August 2009.

Gary Rubloff

"Surface Chemistry Controlling Technology: Multiscale Spatial Behavior in Atomic Layer Deposition," with Laurent Henn-Lecordier, Erin Cleveland, Parag Banerjee, and Israel Perez, EuroCVD-17 and CVD XVII, Vienna, Austria, October 2009.

"Chitosan to Electroaddress Biological Components in Lab-on-a-Chip Devices", with Y. Liu, X.-W. Shi, E. Kim, L. M. Robinson, C. K. Nye, R. Ghodssi, W. E. Bentley, and G. F. Payne, 11th International Conference on Chitin and Chitosan & 8th Asia-Pacific Chitin and Chitosan Symposium, Taipei, Taiwan, June 2009.

Ichiro Takeuchi

"Morphotropic Phase Boundaries in Rare-Earth Doped BiFeO₃ and Thin Film Magnetoelectric Devices," Intermag 2009, Sacramento, CA, May 2009.

- "High-throughput XRD and Analysis for Rapid Determination of Phase Distribution Across Combinatorial Libraries," Denver X-ray Conference, Colorado Springs, CO, July 2009.
- "Universal Behavior and Electric-Field Induced Transition in Rare-Earth Doped BiFeO₃," Workshop on Fundamental Physics of Ferroelectrics, Aspen, CO, February 2010.

Manfred Wuttig

"Bottom up Magnetoelectrics," Materials Science & Technology, Symposium on Multiferroics, Pittsburgh, October 2009.

5 PROFESSORS NAMED 2009 RESEARCH LEADERS

PROFESSORS **ROBERT M. BRIBER, ALEXANDER ROYTBURD, GARY RUBLOFF, ICHIRO TAKEUCHI**, AND **MANFRED WUTTIG** WERE AMONG A GROUP UNIVERSITY FACULTY RECOGNIZED AT THE 11TH ANNUAL RESEARCH LEADERS LUNCHEON FOR THEIR EFFORTS IN BRINGING SPONSORED RESEARCH DOLLARS TO CAMPUS.

THE PROFESSORS' RESEARCH INTERESTS COVER A BROAD CROSS-SECTION OF MATERIALS SCIENCE, INCLUDING POLYMER SYSTEMS AND STRUCTURAL SOLUTIONS OF NOVEL MOLECULES (BRIBER); MODULATED STRUCTURES IN EPITAXIAL LAYERS AND MULTILAYER COMPOSITES (ROYTBURD); SEMICONDUCTORS, RENEWABLE ENERGY STORAGE, AND BIOMEMS (RUBLOFF); COMBINATORIAL SYNTHESIS AND CHARACTERIZATION OF NOVEL ELECTRONIC AND SMART MATERIALS AND SCANNING PROBE MICROSCOPY (TAKEUCHI); AND PHASE TRANSFORMATIONS, MAGNETOELECTRICS, AND NANOMAGNETISM (WUTTIG).

in the nation. ISR's faculty is drawn from five University of Maryland colleges who are engaged in systems engineering research in a wide variety of fields.

OEHRLEIN, ARSENAULT HIGHLY CITED WORLDWIDE

Two MSE faculty members, Professor **Gottleib Oehrlein** (joint, Institute for Research in Electronics and Applied Physics) and Professor Emeritus **Richard J. Arsenault**, are recognized as being among the 250 most highly cited authors in their discipline over the past three decades by Thomson Reuters' ISIHighlyCited. com web site. According to the site, these authors represent the researchers "who have contributed to the progress of science through their insight and accomplishments."

Thomson Reuters provides citation indexes of top scholarly works in the sciences, arts and humanities. Its services include the Web of Science and Web of Knowledge, which are licensed to universities and corporations around the world.

Oehrlein is the director of the Laboratory for Plasma Processing of Materials. His research interests include low-temperature plasma science and technology, plasma and process diagnostics, plasma-surface interactions, physics and chemistry of micro- and nanostructure fabrication, novel materials, and surface physics and chemistry. In 2007, he spent his sabbatical at the Max-Planck Institut für Plasmaphysik, where he participated in research on plasmamaterials interactions for fusion reactor design.

Arsenault, who retired in 2000, specialized in mechanical properties of materials and metal matrix composites.

"This is an honor not only for our professors, but also for the Clark School and the University of Maryland," says MSE Professor and Chair **Robert M. Briber.** "The quantity of research our faculty publish in top journals, combined with the frequency with which they're considered the go-to experts in their fields by their peers, reflects the quality of our work and enhances our reputation."

studentnews

NON-MAJORS DELVE INTO MATERIALS SCIENCE

Undergraduates from a variety of majors gathered in the Kim Building rotunda to discuss world-changing materials as part of their final project for ENMA 150: The Materials of Civilization. The course, taught by Department of Materials Science and Engineering Professor and Chair **Robert M. Briber**, is part of Maryland's two year-old Marquee Courses in Science and Technology program. Marquee courses, which fulfill undergraduate CORE requirements, are aimed at non-science majors and examine science and technology's roles in historical and contemporary issues, such as energy, the environment, and medicine.

ENMA 150: The Materials of Civilization, 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, which includes hands-on demonstrations and guest speakers, provides students with an understanding of the basic science that controls material properties. Students also learn about the future of technology-based breakthroughs in the materials that are driving the fields of nanotechnology, nano-medicine, microelectronics and biomaterials.

For the final project, the 80-member class divided into teams that were asked to produce a research poster covering the discovery, properties, composition or structure, applications, and future of a material behind important technologies and products. Teams also discussed issues of the material's scarcity or abundance, chemistry, effect on human health, and environmental impact. Topics included Teflon®, Kevlar®, synthetic diamonds, superconductors, solar energy, light-emitting diodes (LEDs), fiber optics, medical implants, titanium, and the evolution of batteries. The resulting poster session gave students a chance to interact with and teach each other, while continuing to expand their understanding of materials.

"Teaching 'Materials of Civilization' in the University of Maryland Marquee Science and Technology program is really enjoyable," says Briber. "The students are great and working with the other faculty in the program really helps to bring the ideas of science and technology to life, and new innovations for teaching to the classroom."

BRUCE WINS 2009 AVS STUDENT MERIT AWARD

Graduate student (now alumnus, Ph.D. '10) **Bobby Bruce**, advised by Professor **Gottlieb Oehrlein**, won the 2009 American Vacuum Society (AVS) Student Merit Award for a talk he delivered at the AVS 56th International Symposium and Exhibition in San Jose, California. Award recipients are selected on the basis of technical and scientific merit and originality of research, and receive a \$500 prize. Bruce was also one of six finalists for the AVS's highly prestigious John Coburn and Harold Winters Student Award in Plasma Science and Technology.

Bruce's winning presentation, titled "On the Absence of Post-Plasma Etch Surface and Line Edge Roughness in Vinylpyridine Resists," described his research on the origin of plasma (super-heated gas)-induced surface roughness in polymer films used in the manufacturing of integrated circuits, and how both polymer structure and plasma processing parameters affect polymer roughening. *(See related story, p. 4.)* His work has provided a deeper understanding of how plasma interaction impacts the mechanical properties of polymers' surfaces, and how these changes directly lead to surface roughness.

The research is particularly important to the electronics manufacturing industry. "When you use a polymer mask as a stencil to create patterned nanostructures in something

continues next page

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:

www.mse.umd.edu/whatismse

ABOVE AND RIGHT: UNDERGRADUATES IN PROFESSOR BRIBER'S "MATERIALS OF CIVILIZATION" COURSE PRESENT THEIR FINAL PROJECTS.



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like a computer processor," Bruce explains, "the plasma used to etch the pattern is so intense that it only takes seconds before the mask starts to erode. This is what creates

the rough edges on the mask and degrades the quality of the transferred pattern. By selecting the appropriate material for the polymer mask or by tuning the plasma process to be gentler on the polymer we can improve the mask performance. What we learn from our research will help establish a framework of correct design criteria that can be applied to different manufacturing situations."

Cleaner, sharper masks with finer details could be used to create more sophisticated patterns for integrated circuits, which in turn could mean computers that are faster, have higher storage capacities, and produce less heat.

"The roughening problem currently limits the size and performance of the nanostructures we want to manufacture," says Bruce. "Understanding and controlling plasma-induced polymer surface roughness would be highly beneficial for nanofabrication and nanotechnology in general."

LANE NAMED SENIOR MARSHAL FOR COMMENCEMENT



HILARY LANE

The Department of Materials Science and Engineering and the A. James Clark School of Engineering extend their congratulations to **Hilary Lane**, who was selected to be one of the Senior Marshals for the Winter 2009 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.

In addition to her studies, Lane was a member of Unbound, the University of Maryland's competitive dance team, and a Resident Assistant. She also served as the treasurer of the undergraduate Materials Science and Engineering Society, and was active in outreach activities for the department.

WOLK WINS WOMEN MOVING FORWARD AWARD

Graduate student **Jennifer Wolk**, advised by Professor **Lourdes Salamanca-Riba**, won the 2009 Naval Sea Systems Command's Women Moving Forward Award for her work in friction stir welding, an alternative to traditional gas-metal arc welding. Her research focused on using friction stir processing to modify the microstructure and strength of alloys used in propellers. Wolk, a materials engineer at the Naval Surface Warfare Center (NSWC), Carderock Division, is currently pursuing her Ph.D. on friction stir welding of near-alpha titanium at the University of Maryland.

Wolk has also been very active in Navy, nonprofit, and community engineering outreach efforts, including the NSWC's National Student Leadership Conference, the FIRST Robotics program, the Federal Asian Pacific American Council Conference, and the Fairfax County Science Fair. She also led a team of students from Burning Tree Elementary School in Bethesda, Md., to win seven trophies at the LEGO[®] League Robotics Challenge.

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ENGELMANN PUBLISHES BOOK ON PLASMA ETCHING

Sebastian Engelmann (Ph.D. '08), formerly advised by Professor Gottlieb Oehrlein, has published his first book, *Plasma-Surface Interactions of Advanced Photoresist Systems.* The work, based on his research at the Laboratory for Plasma Processing of Materials at the A. James Clark School Engineering, discusses improved methods of nanostructure manufacturing using plasma etching technology. Engelmann was approached to publish the book by VDM Verlag, which specializes in making dissertations available to a wider audience.

Plasma-Surface Interactions of Advanced Photoresist Systems addresses manufacturing problems that may occur when plasma is used to etch patterns onto materials that will subsequently become semiconductor or other devices. The pattern is set into a photoresist, a sort of template or stencil that sits above the surface of the device material, and determines where the plasma is allowed through to interact with it. During the course of his research, Engelmann studied breakdowns in the photoresist layers that roughened the lines and edges of semiconductor patterns, resulting in defective products. The book explains how the properties of very complex interactions of plasmas and photoresist materials can be adjusted to ensure a successful transfer process.

"Depending on the material that you want to transfer your features onto, the plasma needs to be fine-tuned for the desired outcome," Engelmann explains. "For nanoscale manufacturing, increased attention also has to be given to how the chemically reactive photoresists change their behavior and material properties during processing, depending on the plasma condition."

Engelmann hopes his book will inspire advances in nanoscale manufacturing, both in established areas such as semiconducting devices, and in new areas to which the technology can be applied, such as biosensors. "I guess the best and the worst thing about writing a book are the same as writing a dissertation," Engelmann said of his first experience as a book author, "—you have to do it on your own! You can write things your own way, but on the other hand you don't have the help your professor would give you. And instead of getting feedback [from readers] about your work from the committee right after the defense, you'll have to wait until someone buys the book or leaves a comment on Amazon."

Engelmann is currently working in the Reactive Ion Etching Group in the Department of Advanced Materials and Process Science in the IBM Research Division at the T.J. Watson Research Center in Yorktown Heights, N.Y. Although he has no immediate plans to write a second book, he's not ruling out the possibility: "We are working on really exciting projects here [at IBM] and I think we are close to something spectacular. In my job I discover a lot of new things on a daily basis, so you never know what will come out of it!"

Plasma-Surface Interactions of Advanced Photoresist Systems can be ordered from Amazon.com.

LEI DEVELOPS NEW ALD MEMORY MANUFACTURING PROCESS

Wei Lei (Ph.D. '06) works at Novellus Systems, a leading supplier of semiconductor manufacturing equipment. He has developed and transferred to manufacturing a new atomic layer deposition process for WN layers to replace Ti/TiN in advanced processing, including high volume manufacturing for 45nm DRAM/flash devices. The work was published in the proceedings of the Advanced Metallization Conference 2008.

CAULEY NAMED PRESIDENT, CEO OF NERC

Gerry Cauley (M.S. '80, nuclear engineering) was named President and Chief Executive Officer of the North American Electric Reliability Corporation (NERC),

which works to ensure the reliability of the continent's bulk power system through monitoring, assessment, education of industry personnel, and the creation and enforcement of standards. His tenure began on January 1, 2010. "I am looking forward to working with NERC's stakeholders in industry and government to continue the progress that's already been made toward our mutual goal of building a lasting and successful self-regulatory model," Cauley is quoted as saying in a recent NERC press release, "We have many opportunities ahead of us, notably including continued focus on cyber security and other emerging reliability issues....I'm eager to dive in and get down to work."

PEREZ JOINS COLLINS GROUP AT UC IRVINE

Israel "Izzy" Perez (Ph.D. '09), formerly advised by Professor Gary Rubloff, has joined Professor Phil Collins' research group at the University of California Irvine as a postdoctoral research associate. The Collins Group focuses on the electronic properties of devices and circuits made with novel, nanometer-scale objects, including carbon nanotubes, metal and semiconductor nanowires, clusters, and biological molecules. The group also addresses the challenges associated with unexpected nanocircuit behaviors and nanoscale fabrication and optimization.



SEBASTIAN ENGELMANN (PH.D. '08) WITH HIS BOOK, "PLASMA-SURFACE INTERACTIONS OF ADVANCED PHOTORESIST SYSTEMS."

RECENT GRADUATES

2009 M.S. GRADUATES

DECEMBER

Zoila Forgione Brendan Hanrahan Brian Watson

2009 PH.D. GRADUATES

AUGUST

Michael Kasser: "The Photochemistry of Polyenyl Radicals and Its Application to UHMWPE for Use in Artificial Cartilage." Advisor: Mohamad Al-Sheikhly

DECEMBER

Susan Beatty Buckhout-White:

"Characterization of Electrodeposited Chitosan: an Interfacial Layer for Bioassembly and Sensing." Advisor: Gary Rubloff

Laurent Lecordier: "Wafer-scale Process and Materials Optimization in Cross-Flow Atomic Layer Deposition." Advisor: Gary Rubloff

Wonjoo Lee: "Nanostructure Investigation of Polymer Solutions, Polymer Gels, and Polymer Thin Films." Advisor: Robert M. Briber

Israel Perez: "Nanoporous AAO: A Platform for Regular Heterogeneous Nanostructures and Energy Storage Devices." Advisor: Gary Rubloff

Shenqiang Ren: "Bottom-Up Multiferroic Nanostructures." Advisor: Manfred Wuttig





A. JAMES CLARK SCHOOL OF ENGINEERING

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ABOUT THE COVER IMAGE

THE RED IMAGE USED ON THE COVERS, FROM THE LAB OF ASSOCIATE PROFESSOR LUZ J. MARTÍNEZ-MIRANDA, SHOWS NEMATIC-LIKE DEFECTS FORMED IN A SMECTIC LIQUID CRYSTAL AT ROOM TEMPERATURE. MARTÍNEZ-MIRANDA IS STUDYING THE EFFECT OF CERTAIN KINDS OF NANOPARTICLES ON LIQUID CRYSTALS IN ORDER TO BUILD A GENERAL INTERACTION MODEL THAT COULD BE USED TO TEST HOW EFFECTIVELY A DRUG COULD BE DELIVERED TO AND TAKEN UP BY DIFFERENT KINDS OF CELLS. FOR MORE INFORMATION ABOUT THIS RESEARCH, PLEASE SEE THE RELATED STORY ON PAGE 3. 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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Department Chair: Dr. Robert M. Briber Editor: Faye Levine

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

We are hosting open house events this spring 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

SEE IF WE'RE ONLINE! AOL IM: mseatumd

WE'RE ALSO ON FACEBOOK AND YOUTUBE!

