

ENGINEERING @ Northeastern

2011

MAGNET magnates

NIAN SUN, LAURA LEWIS, VINCENT HARRIS

RESEARCH IN PURSUIT OF FASTER,
CHEAPER, AND BETTER MAGNETS

Northeastern University
College of Engineering



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Dear Friends,

Our “magnetic” cover story provides an apt metaphor for this column: People and organizations are being drawn to Northeastern like never before.

The university’s appeal among prospective undergraduate students led to a record 43,000 applications for 2,800 seats across our seven colleges this fall. In engineering, 5,200 students—double the number of just five years ago—applied for this fall’s 500 first-year slots, with academic credentials surpassing those of any previous class. Meanwhile, at the Graduate School of Engineering, applications increased by 40 percent, continuing a significant growth trend over the past several years. New doctoral programs in bioengineering and information assurance are particular draws.

We have expanded the ranks of our engineering faculty by 25 percent over the past four years. Our eight national research centers; multifaceted partnerships with academia, government, and industry; and stunningly transformed campus at the doorstep of Boston’s technology, medical, and cultural corridors are attracting established and rising stars across all engineering disciplines (see page 14). In June of this year, we completed construction of the 70,000-square-foot George J. Kostas Research Institute for Homeland Security, in which faculty and partners will conduct groundbreaking research in the security domain.

Northeastern’s century-old and signature program—cooperative education—continues to thrive, with a 100 percent placement rate for engineering undergraduates, and 250 graduate students now engaged in co-op positions through a program launched just a few years ago. The attraction of co-op among students and employers clearly is mutual.

While our global reach does not yet extend to both poles, we continue to expand our international focus. Notable pursuits include our research program with the Technion–Israel Institute of Technology to develop new ways to fight terrorism; a novel capstone design project for Tyco International that brought together a team of undergraduate engineering students at Northeastern and China’s Shanghai Jiao Tong University; and our “NU in” program, through which 60 engineering freshmen will study at international partner institutions during the fall semester.

As you read about our use-inspired research and the achievements of our faculty and students, I encourage you to consider ways that you and your organization can connect and engage with Northeastern University. Your comments, ideas, and suggestions are most welcome and much appreciated.

Best regards,

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CURRENT FACULTY MEMBERS 135



faculty

BS DEGREES conferred 2008–2011 **1,097***

MS DEGREES conferred 2008–2011 **1,255***

PHD DEGREES conferred 2008–2011 **137***

*Academic Year Totals



degrees

BS DEGREE PROGRAMS offered **9**

MS DEGREE PROGRAMS offered **12**

PHD DEGREE PROGRAMS offered **8**



programs

**COMPANIES EMPLOYING
COE CO-OP STUDENTS: 600
IN 33 STATES AND AROUND THE GLOBE**



co-op

RESEARCH AWARDS Fiscal Year 2010–2011
AWARDS RECEIVED 131

**MORE THAN \$30.5 MILLION
IN ANNUAL FEDERAL FUNDING**



research

FEDERALLY FUNDED MULTI-UNIVERSITY RESEARCH CENTERS: 8

Awareness & Localization of Explosives-Related Threats (ALERT), a Department of Homeland Security Center of Excellence www.northeastern.edu/alert

The Bernard M. Gordon Center for Subsurface Sensing & Imaging Systems (Gordon-CenSSIS), an NSF Engineering Research Center www.censsis.neu.edu

New England Healthcare Engineering Partnership, a Department of Veterans Affairs Engineering Resource Center www.coe.neu.edu/healthcare

NIST Center for Versatile Onboard Traffic Embedded Roaming Sensors (VOTERS) www.northeastern.edu/voters

NSF Center for Health Organization Transformation (Industry-University Collaborative Research Center) www.coe.neu.edu/healthcare

NSF Center for High-rate Nanomanufacturing www.northeastern.edu/chn

NSF-Department of Energy Center for Ultra-wide-area Resilient Electric Energy Transmission Networks (CURENT) <http://curent.utk.edu>

Puerto Rico Testsite for Exploring Contamination Threats (PROTECT), a National Institute of Environmental Health Sciences' Center www.northeastern.edu/protect



FASTER, SMALLER, CHEAPER, LIGHTER, AND BETTER

The Future of Electromagnetic Research

As time-tested as the art of *feng shui* in Chinese civilization and as cutting edge as the latest cancer-remediation therapies, magnets are indispensable to a wide range of applications in power generation, conversion, and conditioning in the electric and electronic industries, including radar, communications, and information technologies. And with emerging markets, demand is growing for their use in economically and environmentally efficient systems such as hybrid-energy vehicles and wind-turbine power systems.

Whether the solutions lie in alternative advanced materials or new ways to maximize energy efficiency, Northeastern College of Engineering faculty members are in the vanguard of next-generation magnet research, with significant grants in support of their work. Highlighted here are some examples of their current research.

Vincent Harris

Promising Solutions for Tomorrow's Energy Sources

From cell phones to radar, next-generation electromagnetic materials and components play the important role of managing energy and power flow through systems.

They provide the most promising pathways toward realizing tomorrow's smaller, cheaper, and better technologies. Among the leaders in this area of research is Northeastern's Vincent Harris, the William Lincoln Smith Distinguished Professor of Electrical and Computer Engineering and internationally recognized authority in the field of microwave materials and technologies. The laboratory that houses this research was established in 1985 by Professor Carmine Vittoria and is now headed by Harris and Vittoria. Known as the Center for Microwave Magnetic Materials and Integrated Circuits, or CM3IC, the laboratory develops next-generation microwave magnetic materials and device solutions for radar and a range of wireless communication technologies for U.S. defense and commercial industries. Specifically, the research focuses on advances in antennas and supporting electronics that send, receive, and manipulate electromagnetic signals.

SPECIFICALLY, THE RESEARCH FOCUSES ON ADVANCES IN ANTENNAS AND SUPPORTING ELECTRONICS THAT SEND, RECEIVE, AND MANIPULATE ELECTROMAGNETIC SIGNALS.

Harris and his colleagues are exploring a number of pathways for designing and refining microwave magnetic materials and devices, many of which have military applications. For example, the ferrite microstrip phase shifter technology being developed at the center could play an integral part in surveillance and reconnaissance platforms in next-generation unmanned aerial vehicles (UAVs), such as weight-sensitive drones. "How long the drones can loiter on-site is a function, in part, of how light the sensing systems are," says Harris. Drone loitering time proved significant in the May 1, 2011, apprehension of Osama bin Laden. Among the potential commercial applications for these patented next-generation microwave devices are anticollision radar systems for automobiles, which Harris notes may someday be as common as the airbag is today.

Another area of Harris's research, in collaboration with Laura Lewis of the Department of Chemical Engineering, focuses on developing advanced materials with properties that are superior to the world's strongest magnets, which must rely on a family of chemical elements known as rare-earth minerals for their manufacture. Although there are plans under way to revive long-dormant U.S. commercial mining, the source for much of the planet's rare-earth minerals is China, leaving the United States without a secure supply chain for the production of high-powered permanent magnets. Among the alternative materials Harris is exploring are cobalt carbides, a technology that allows lighter and cheaper energy sources without potentially sacrificing performance. Last year, Harris and his colleagues at CM3IC created the fourth most powerful magnet in the world, one that does not rely on rare-earth metals for raw materials.

Says Harris about the work he and his colleagues in the College of Engineering are pursuing, "Everyone is sitting up and taking notice and watching us to see what will happen next. Our ultimate goal is to make smaller, lighter, cheaper, and better magnets capable of integrating with other technologies, leading to enhanced performance." ■

From left, Northeastern faculty researchers Laura Lewis, Vincent Harris, Nian Sun, and Hossein Mosallaei in a microwave magnetic materials and integrated circuits laboratory in the Egan Research Center.

Nian Sun

Electric Field Control of Magnetism

Increased energy efficiency to control magnetic properties is among the areas of research currently being conducted by associate professor Nian Sun and his team in the Department of Electrical and Computer Engineering.

Applications for their research range from motors, generators, inductors, and transformers in cars to computers, cell phones, and a variety of electronic devices.

According to Sun, tuning of magnetization, or the ability to adjust the frequency performance of the output of a device, is of great fundamental and technological importance and has typically been achieved by magnetic bias fields generated from electromagnets, which are slow, bulky, and noisy; consume excessive energy; and put severe limits on the applications of the magnetic materials and devices.

Sun notes that electrostatically tunable RF/microwave multiferroic fields, if realized, will lead to new magnetic devices that are fast, compact, and energy efficient, and can prevail in a wide variety of applications, including sensors and RF/microwave systems. Applications of electric control of magnetism with significantly reduced power consumption and longer battery life include magnetic random-access memory devices and devices for information storage, among other uses.

The study of electric field control of magnetism by Sun and his colleagues was named one of the top 10 papers of the last decade by the prestigious journal *Advanced Functional Materials*. Sun says, “This area of inquiry may have the potential to change the way we live.”

Besides their research on multiferroics and tunable RF/microwave magnetic devices, Sun and members of his laboratory have been actively involved in research on power and energy areas, including high-power-density/low-loss RF magnetic materials, integrated magnetic inductors and transformers, new electric field tunable inductors, and energy harvesting technologies. In particular, these next-generation tunable conductors are compact and energy efficient, with a giant tunable inductance range of 10 to 1, which can be widely used in RF circuits such as cell phones and power electronics. ■

Laura Lewis

Reducing Dependence on the Rare Earths

In Northeastern’s Department of Chemical Engineering, under the direction of Cabot Professor and Chair Laura Lewis, fundamental work is being done to produce magnets that are not reliant upon rare-earth elements, or REEs, for the fabrication of ultra-strong “supermagnets.”

Rare-earth elements are a family of 17 chemical elements in the periodic table with a unique arrangement of electrons that lends special properties to materials containing them.

Supermagnets are much more powerful than conventional oxide magnets and deliver much more strength per gram, which makes them well suited to a variety of uses. Today, these rare earth-containing supermagnets are being utilized in everything from computers, automobiles, and other vehicles (including hybrids) to consumer electronic products and military technologies, and serve as integral parts of alternative energy systems, such as those that harvest wind, wave, and tidal power.

Despite their name, rare earths are not particularly rare in the earth’s crust, but they are widely scattered. The global distribution of rare earths is uneven, with 43 percent of the proven reserves in China and 13 percent in the United States. Most of the global REE production is in China, and while there is current activity to revitalize domestic sources of REEs, it will take years before there is a reliable supply. Recent economic and geopolitical trends suggest that the supply of REEs will not keep up with global demand.

In response, the United States (in particular, the departments of Defense and Energy) and the European Union have begun to fund basic research on reduced-REE-content magnets, in attempts to come up with alternatives that are competitive with supermagnets. Both Lewis and Vincent Harris in the Department of Electrical and Computer Engineering are undertaking important research in this area. Lewis is currently a principal investigator on an Office of Naval Research project, “Rare Earth-Free Permanent Magnets for Advanced Applications.”

According to Lewis, one potential solution to the challenge of creating ultra-strong, ultra-efficient magnets that do not contain REEs is for scientists to “revisit the fundamental magnetic properties and interactions in metals and alloys and attempt to recover the magnetic strength from other mechanisms in the materials, a very significant challenge.”

Lewis notes that the shortage of rare-earth metals will most certainly spur “new creativity and new strategies to engineer and optimize rare earth-free compounds and alloys that can provide the same functionality as those that contain REEs.” ■

MAGNETS ARE INTEGRAL PARTS OF ALTERNATIVE ENERGY SYSTEMS,
SUCH AS THOSE THAT HARVEST WIND, WAVE, AND TIDAL POWER. — Laura Lewis

HOSSEIN MOSALLAEI Research in Magnetic Metamaterial Technology

Addressing the need for antenna technology that can keep pace with trends in wireless communications devices through metamaterials—manufactured materials not found in nature—is the goal of Hossein Mosallaei, associate professor in the Department of Electrical and Computer Engineering. With research on the micro- and nanoscales, Mosallaei and his colleagues are working to engineer and assemble antennas with metamaterials that are integrated with active circuits, fostering for the first time wide-band and tunable artificial magnetic materials at high frequency spectrum, and leading the way toward devices with greater energy efficiency, faster speed, smaller components, and enhanced performance.

Applications for the active magnetic metamaterial antenna technology range from medical diagnostics to airport security screen-

ing devices. For example, smaller antennas that transmit information quickly and use less power can support the development of tiny medical biosensors that transmit diagnostic data faster and provide doctors with more accurate, focused information about a patient's condition.




"The technological capabilities of these tiny antennas, integrated with active circuit-based metamaterials and magnetic materials, will bring about a new era in improved wireless communications," says Mosallaei. His current research includes creating novel active metamaterial antennas having miniaturized size and with the potential for transmitting information at high speed while maintaining optimal functionality. ■

Faculty Researchers Lead the Way

MEMBERS OF THE NORTHEASTERN COLLEGE OF ENGINEERING FACULTY

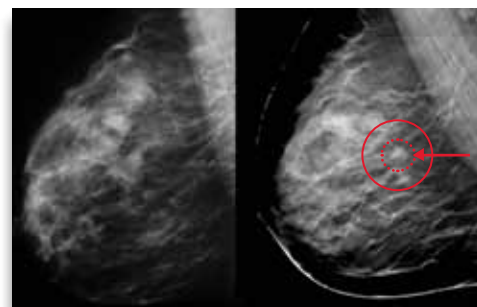
pursue a broad range of basic and applied interdisciplinary research, with particular exploration of three of the major challenges of the 21st century: healthcare, sustainability, and security. Whether it is discovering new knowledge or revising accepted theories or seeking practical applications to solve real-life problems, Northeastern researchers are leading the way. Here are some highlights of their current work.

A photograph of Professor Dagmar Sternad, a woman with red hair and glasses, wearing a green cardigan over a white top. She is smiling and looking at a large, white, cylindrical robotic arm. The arm has the word "MASTER" printed on it. A hand is visible in the foreground, interacting with the arm. In the background, a man with a beard is partially visible, looking towards the arm. The setting appears to be a laboratory or research facility.

Professor Dagmar Sternad, with postdoctoral student C. J. Hasson, was awarded a \$1.6 million grant from the National Institutes of Health to investigate how humans acquire and control sensorimotor skills.

Partnering with MGH: Breast cancer imaging gains FDA approval, reduces false alarms

Professors and students in the Northeastern Department of Electrical and Computer Engineering have made vital contributions to new imaging technology developed by researchers at Massachusetts General Hospital. The new 3-D mammography technique, known as digital breast tomosynthesis (DBT), makes it possible to see single inner layers of the breast without the superimposition of the other layers. Providing detailed and clear images, DBT allows physicians to identify tumors that may go undetected through 2-D conventional mammography (CM), while reducing false alarms by 40 percent. By combining data from 11 low-dose projection images, DBT creates a single 3-D volume, without additional examination time or X-ray dose. MGH researchers began work on DBT nearly two decades ago, and although they were able to collect the data, processing took a day, which is where the Northeastern students came in. According to Rick Moore, MGH director of Breast Imaging Research, the undergraduate co-ops and graduate students brought “new thinking” and a “don’t know they can’t do it” enthusiasm. Using a high-speed cluster and technology originally developed for video game cards, the students have made DBT practical: The processing time dropped from 48 hours to 5 hours to 20 minutes to 3.5 seconds! DBT has recently been approved by the FDA for clinical use and is expected to avoid false alarms and detect more cancers than 2-D CM. Members of the Northeastern team included professors David Kaeli, Miriam Leeser, and Waleed Meleis, and students Benjamin Brown, Fernando Quivira, Diego Rivera, Micha Moffie, Dana Schaa, and Juemin Zhang. ■



Conventional 2-D mammography view with obscure lesion (left) and 3-D digital breast tomosynthesis (DBT) with clearer image of lesion.

Grants support fundamental research in nanocomposites

Marilyn Minus, assistant professor of mechanical and industrial engineering, has recently won two grants in support of her fundamental research in nanocomposites. Her work focuses on the development of nanocomposites that are stronger, lighter, and cheaper than conventional composite materials available today, with adaptability to a variety of uses. In June she was awarded a Defense University Research Instrumentation grant of \$750,000 to extend her laboratory research capabilities in the area of X-ray diffraction of nanostructured materials. She has also been awarded a \$525,000 grant from the Air Force Office of Scientific Research to develop new approaches to preserve the structure of carbon nanotubes. The main objective of this research is to minimize harsh processing conditions for carbon nanotubes in the composite by developing new approaches, along with optimizing current methods in order to preserve the nanotubes' structure. Preserving carbon nanotube length and tube structure has been increasingly recognized as an important component for improving the tensile strength properties in polymer single-wall carbon nanotube-based composite fibers. ■

Remote acoustic sensing of oceans

Purnima Ratilal, associate professor of electrical and computer engineering, has received a \$1 million grant from the National Science Foundation (NSF) to develop a Lightweight Towed

Area Receiver (LTAR) to remotely monitor and image large areas of the ocean with acoustics. The LTAR will serve as a general-purpose mobile ocean remote-sensing tool to study marine life, oceanography, geologic and geophysical properties, and anthropogenic noise in the ocean and its effect on marine life. The system design is intended to be portable, user-friendly, economical, and efficient, and to significantly reduce the cost of at-sea research as well as make it available to a broader range of researchers. She also was awarded a \$150,000 grant from the NSF to use existing data from a previous ocean acoustic waveguide remote-sensing experiment to develop passive and active methods for tracking marine mammals in near-real time, which can lead to the development of methods for minimizing the impact of man-made activities on these populations and to differentiate underwater objects. ■

NIH grant to study how the brain controls the body

Carrying a virtual cup of coffee can provide insights into how the central nervous system works and may open new avenues for intervention for neurologically impaired people, according to research conducted by Dagmar Sternad, professor of electrical and computer engineering and physics and professor of biology. Sternad was recently awarded a five-year \$1.6 million grant from the National Institutes of Health to investigate how humans acquire and control sensorimotor skills—the ability to coordinate sensory experiences—with physical actions.

Such coordination is fundamental to all human existence, but scientists know little about how the brain controls the body. As a result, when people suffer from an injury to the brain that impairs their ability to perform common sensorimotor tasks, scientists are still largely in the dark about how to provide targeted therapy. Using a systems approach to understanding coordination and control in the complex human system and mathematical models based on physical principles to model the workings of the neuromotor system, Sternad has designed several “toy tasks” to conduct her research. One experimental setup simulates the task of carrying a cup of coffee using a virtual environment with an interface that is affected by a user’s sense of touch. The subject is asked to grasp a robotic arm and move a virtual cup across the screen without having the ball (coffee) inside the cup fall out. Recording and analyzing the movements provides insight into how humans interact with objects via visual and other sensory information. ■

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STEM success reaps new reward

Christos Zahopoulos, executive director of the Center for STEM (Science, Technology, Engineering, and Mathematics) Education, has won a second-stage grant from the National Science Foundation for his work improving teaching and learning in Boston public schools. The \$2.1 million Phase II Math/Science Partnership award will expand his work with Boston science teachers to help them understand fundamentals about energy in an interdisciplinary fashion. The grant for the Boston Energy in Science Teaching (BEST) project (a partnership among Northeastern; University of Massachusetts, Boston; Roxbury Community College; the Boston Public Schools; and the Education Development Center) builds on the success of the \$14.1 million Phase I Boston Science Partnership grant. It will apply the Collaborative Coaching and Learning in Science educational model to the university setting to support faculty discussions on interdisciplinary research and teaching at both graduate and undergraduate levels. Researchers will look at content-based and concept-based professional development for teachers, and evaluate the impact each has on student achievement and engagement. *Science* magazine recently highlighted Northeastern’s program for math and science partnerships as one of the nation’s best. ■

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A step forward in arthritis prevention

Osteoarthritis (OA), caused by the breakdown of joint cartilage, leaves more than 20 million people in the United States suffering from recurring pain and frustrated over their limitations in movement. Researchers have broken new ground with an interdisciplinary study of factors that cause and exacerbate OA. Nicholas Yang, a recent PhD in mechanical engineering, along with professor Hamid Nayeib-Hashemi and assistant professor

Ashkan Vaziri in the Department of Mechanical and Industrial Engineering and assistant professor of physical therapy Paul Canavan, found that individualized assessments from 3-D imaging, along with earlier diagnosis based on a patient’s knee alignment, are critical factors in improving treatment and prevention. Northeastern student volunteers walked on a platform that measured applied force to the knee while high-speed motion analysis cameras captured their movements. This data was fed into software to build 3-D models of each student’s knee joints, allowing researchers to measure individualized stress levels on the knee cartilage and to more accurately gauge strain and stress distribution. The new research can lead to preventive measures such as customized shoe inserts. ■

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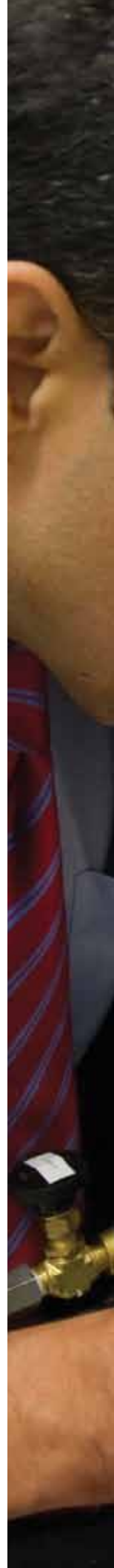
Replicating a sticky situation in nature

Inspired by the ease with which gecko lizards can move on almost any surface, researchers at Northeastern, the Korea Institute of Science and Technology, and Seoul National University hope to reproduce properties found in the gecko’s footpad for applications ranging from adhesives to robotic movement and navigation. The team, led by Northeastern’s Ashkan Vaziri, assistant professor of mechanical and industrial engineering, and Myoung-Woon Moon of the Korea Institute of Science and Technology, created nanoscale and microscale patterned surfaces with adhesion and friction properties similar to that of the gecko footpad. These unique properties were replicated through a series of micropillars, which were tilted through exposure to ion beam radiation so that they resembled the setae or hairlike structures on gecko toes. If equipped with micropillars, small high-tech robots might be able to climb with speed, precision, and accuracy on uneven, slippery surfaces. The technology also could lead to a new generation of smart adhesives that strongly bond with any surface. ■

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Staying ahead in cybersecurity

When Engin Kirda, the Sy and Laurie Sternberg Interdisciplinary Associate Professor for Information Assurance, started focusing on cybersecurity research 10 years ago, those primarily responsible for launching Internet attacks were teenagers out for kicks. But the scope of threats has changed dramatically since then. Now security breaches are often financially motivated and highly organized. Kirda studies Internet security issues and how to discover vulnerabilities in websites and Internet applications. He is also working on creating better virus-detection techniques, and plans to take a closer look at why some users’ computers get infected with malware, a software designed to harm or secretly access a computer system, and how well those people are able to identify cyber attacks. He hopes to explore interdisciplinary collaboration to develop more robust systems and better solutions. ■



A man with dark hair, wearing a dark lab coat, is looking through the eyepiece of a large, white and black industrial microscope. The microscope is positioned over a metallic, circular workpiece. A flexible, braided metal hose is connected to the side of the workpiece. The background is slightly blurred, showing other laboratory equipment.

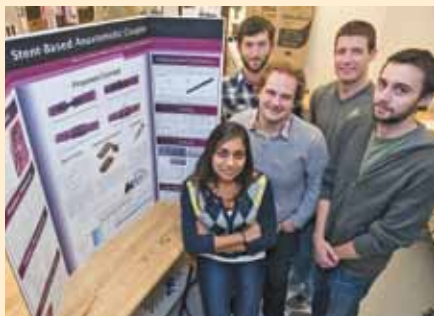
Bringing nanotechnology to market and advancing occupational safety

With government and private partners, the National Science Foundation-funded Center for High-rate Nanomanufacturing (CHN) is collaborating to bring nanotechnology to the marketplace and to ensure the safety of those in the field. CHN has received a \$2 million grant to help commercialize nanotechnology and put smaller, more energy-efficient electronic devices into the marketplace. Funded by the John Adams Innovation Institute—a division of the Massachusetts Technology Collaborative—the grant will support the center's cutting-edge research and help it commercialize its nanomanufacturing technologies, such as those related to cancer-detecting biosensors, high-powered batteries, and flexible, lightweight electronics. The grant will also enable CHN to collaborate with small to midsize companies on commercialization. Along with its partner institutions, the University of Massachusetts Lowell and the University of New Hampshire, CHN has also signed an agreement with the National Institute for Occupational Safety and Health to advance workplace health and safety standards and practices, and act as a global resource for research, education, and information dissemination in nanotechnology safety and health. Research will focus on worker and consumer protection from exposures as well as on the toxicity of nanomaterials and their life cycle and environmental impacts. ■

Ahmed Busnaina, William Lincoln Smith Professor of Mechanical and Industrial Engineering, heads Northeastern's Center for High-rate Nanomanufacturing. A leader in cutting-edge research, Busnaina also focuses on the societal impacts as nanomanufacturing scales to commercial production.

Student Innovation

From developing a new device that utilizes solar power to preserve food at low cost, to improving microsurgery techniques by binding tiny blood vessels, Northeastern students are creating innovative engineering solutions to some of the planet's most challenging problems.



Device to tie tiny blood vessels

Northeastern engineering students recently worked with Dr. Lifei Guo, an inventor and reconstructive microsurgeon at Boston's Brigham and Women's Hospital, to design an "anastomotic coupler" to bind tiny blood vessels only millimeters in diameter. Microsurgery requires doctors to carefully hand-sew with sutures thinner than hair follicles; each vessel can take more than an hour to reconnect, a process that is tedious, technically demanding, and error prone. In the students' chosen theoretical design, the procedure could be performed in minutes rather than hours. Dr. Guo said this work could open up new frontiers not only for future research, but also for a paradigm change in reconstructive microsurgery. · *Jeff Ruberti, Faculty Advisor*



Enhancing the lives of the physically impaired

Through their senior capstone projects, students in the Department of Electrical and Computer Engineering have designed devices to improve the lives of those with physical impairments. One new system allows a user to look at different parts of a computer screen to control a robot named DARWiN—Disability Assistant Robot With i (Eye) Navigation—which can move from room to room and pick up items such as mail, keys, and medicine. The team developed a computer interface that tracks where on the screen a person is looking, a skill that takes only about an



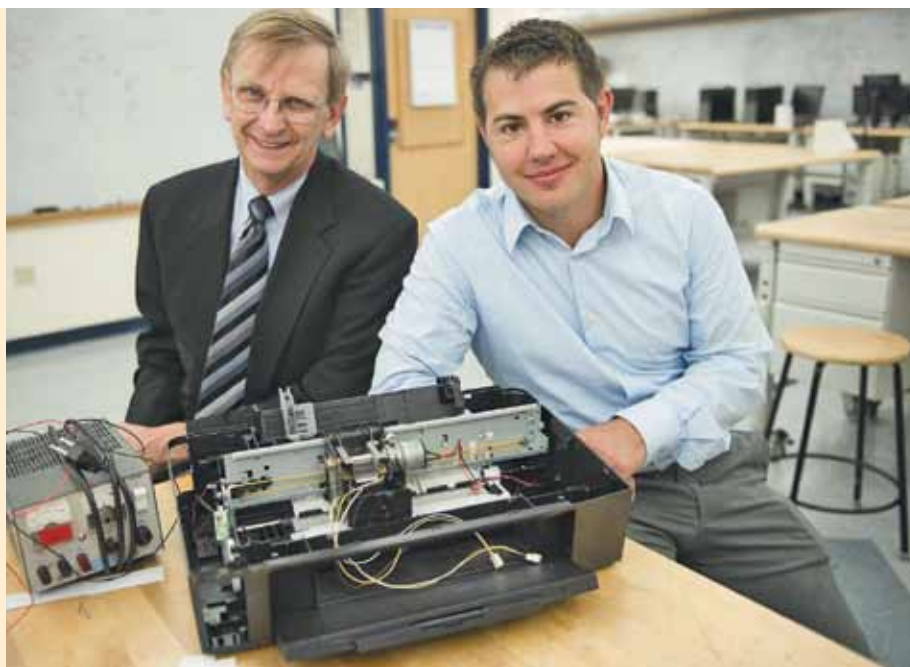
hour for an individual to learn. A camera mounted on the robot's arm sends a video signal of what DARWiN sees to a special application on the user's computer. From this application, a user can completely control DARWiN simply by looking at different areas on the screen. DARWiN will also respond to voice commands. Another senior team developed a voice-operated wheelchair that can navigate through a cluttered room, move alongside walls, and detect stairwells. The user memorizes a short list of basic voice commands to move the wheelchair as desired. An integrated network of ultrasonic distance sensors detects obstacles ahead and to the side, and can also determine whether the wheelchair

is approaching a significant drop. For safety, the system could override user commands, to avoid obstacles such as stairs. Beneath the seat is a universal control unit that communicates with the sensor array and processes and sends commands to the motor controller. A display panel extending from the right armrest shows users the current direction they are going in and whether they are approaching any barriers. The universal design makes the wheelchair adaptable with other command technologies. *Waleed Meleis (DARWiN), and Bahram Shafai (Voice-Operated Wheelchair) Faculty Advisors*

Engineering a response to world hunger

A team of mechanical and industrial engineering students has come up with a low-cost way to help the world's poor preserve food, utilizing the power of the sun to remove moisture from fruits and vegetables in order to extend their storage lives. The design uses a 360-degree solar collection surface that dissipates the water content of the fruits and vegetables by creating a continuous flow of air, without bringing the foodstuffs to cooking temperature. The design is a collapsible, lightweight solution that is portable so that the product can be taken wherever it is needed. The assembly is similar to that of a small tent and features a removable food-drying component. · *Mohammad Taslim, Faculty Advisor*





\$20,000 Touch of Genius Prize for Innovation

Student researchers have won the \$20,000 Touch of Genius Prize for Innovation from the National Braille Press for designing a low-cost, retrofitted Braille embosser. The new embosser would cost about \$200 to produce (rather than the \$2,000–\$6,000 price tag of existing technology) and can print one character per second. Using an inkjet printer, the students replaced the ink cartridge with two independently motor-operated embossing wheels that print half a character each. When the embossing wheels apply force to a series of pins, the pins puncture the paper in the formation of the correct Braille character.

Gregory Kowalski, Faculty Advisor



high-tech unit that impressed their Joule engineering colleagues. · *Jeff Ruberti, Faculty Advisor*

A brainy innovation takes flight

A team of students has developed a system that allows a pilot to fly a simulated airplane relying on nothing more than brainwaves. Using equipment that allows a user to control computers or robots with signals from different parts of the body rather than a joystick and throttle, the students were able to identify the essential controls and write an interface that lets a pilot control a simulated airplane by looking at specific points on an array of LEDs mounted on Plexiglas in front of a television screen.

Waleed Meleis and Deniz Erdogmus, Faculty Advisors



Clean, green heating machine

As calls to curb the world's dependence on fossil fuels grow louder, scientists continue to push for breakthroughs in green technology. Five Northeastern engineering students found themselves helping to look for ways to curb global dependence on fossil fuels through breakthroughs in green technology. In collaboration with Joule Unlimited, a firm in Cambridge, Massachusetts, whose technology involves collecting sunlight and waste carbon dioxide and converting it into clean, renewable energy using specially designed microbes, the students designed a low-cost bio-reactor in which engineered organisms synthesize and secrete liquid biofuels in large volumes. The results of months of hard work and collaboration resulted in the group devising an elaborate,



Eye-tracking device for video gaming

Mechanical and industrial engineering graduate student Jeffrey Breugelmans is developing a new interface system that uses an eye-tracking device and a data-gathering glove to replace the inputs ordinarily used with PCs to enable people with limited use of their hands to enjoy the pleasures of gaming. The system uses the eye-tracking device to perform the on-screen pointing and clicking a player would do with a mouse. The data glove replaces keyboard inputs for navigating and interacting with virtual worlds and games. Testing the eye gaze-controlled systems with gamers with disabilities will begin soon.



Even in an uncertain job market, Northeastern co-op students stand out from the crowd in their search for permanent employment. For many, the transition from college co-op to full-time engineer is seamless.

student co-op STANDOUTS



A Valued Team Member **Ann Polaneczky**

PARTNERS IN HEALTH

In a small office in Beverly, Massachusetts, Ann Polaneczky works with her team, designing and planning a new 320-bed hospital under construction 1,650 miles away in Mirebalais, Haiti. This is the biggest construction project yet for her employer, Partners in Health (PIH), the international nonprofit that has been working nonstop to help rebuild Haiti since the devastating January 2010 earthquake.

A civil and environmental engineering major, Polaneczky has already managed water projects in Honduras and Uganda with the Northeastern chapter of Engineers Without Borders (EWB), a national student organization that cited her as an Emerging Leader, one of only nine collegiate and professional engineers to earn the distinction in 2011.

Polaneczky applied for a summer internship at PIH with the hope that it would turn into a senior co-op. She landed the internship and was placed on the Mirebalais team, where she quickly developed a role for herself within the project group and demonstrated her commitment to the work, which she says was critical to continuing as a co-op and then a full-time hire. In the months between the end of co-op and graduation in May 2011, she continued to work for PIH as time allowed, before beginning her new job.

Designing the hospital's wastewater system is her largest contribution to the project. Her other responsibilities include helping design the potable water, IT, solar, and electrical systems, and selecting and coordinating specialized equipment for endoscopies and other medical procedures. While her EWB experience in Honduras and Uganda was invaluable to her new job, she notes, "The technology may be replicable, but each application is unique."

Polaneczky says that co-op teaches you how to be a valuable employee and how to deal with real-world deadlines and pressures. She hopes to be on the ground in Haiti by year's end.

Making Smartphones Smarter

Vinay Rao

CISCO SYSTEMS

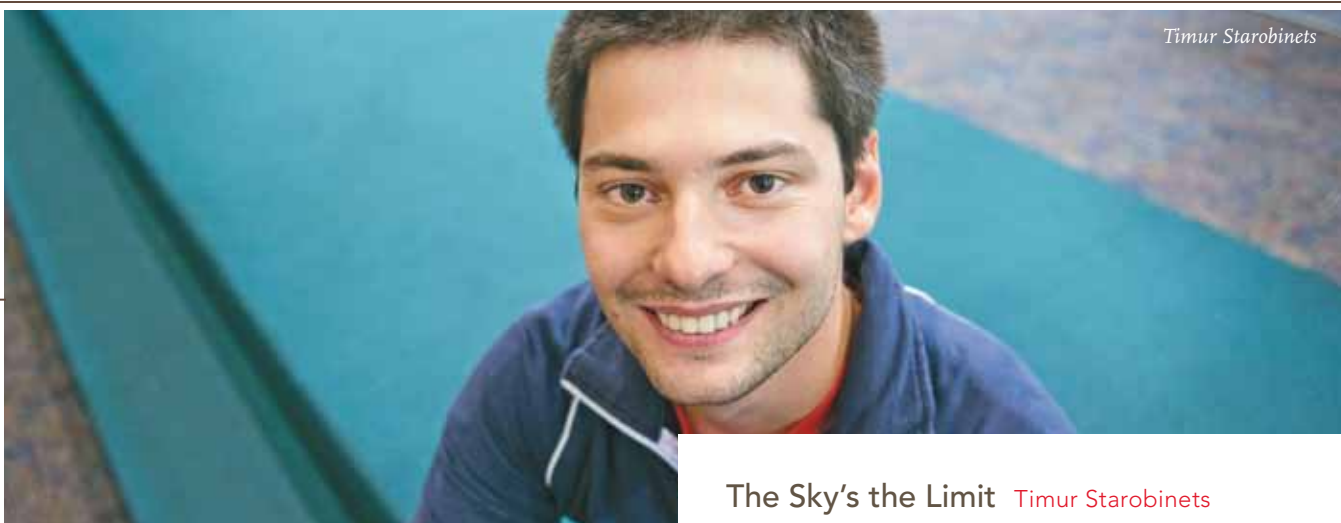
As advances in technology continue to offer us an ever-changing world of options on our smartphones and other mobile devices, Vinay Rao is making sure that we can take advantage of the wide range of Internet experiences. At Cisco Systems in Tewksbury, Massachusetts, Rao is now a full-time member of a team that does test engineering for next-generation wireless systems. It was during his Northeastern graduate student co-op at Starent Networks (now a Cisco company) that he learned the entire quality assurance cycle from beginning to end.

Rao credits both classroom instruction and co-op with preparing him for this role. "The Northeastern curriculum gave me the theoretical background I needed while the co-op experience at Starent added the real-world dimension to my skills," says Rao, who earned his master's degree in telecommunications management in 2011.



According to Rao, the theoretical would have been incomplete without the practical. "My co-op assignment helped me gain insight and understand how to apply my academic expertise to real-time industrial functional tasks. And returning to the team that I joined as a co-op made the transition seamless for both me and my employer."

Timur Starobinets



The Sky's the Limit **Timur Starobinets**

SPACEX

As a child growing up in Russia, Timur Starobinets dreamed of becoming an astronaut.

But his self-described “obsession” with intergalactic travel really took off when he landed a co-op with a space-transport company in California called SpaceX, which was working on a rocket called the Falcon 9, hoping to become the first private company to successfully launch a mid- to heavy-lift rocket into space. So when the electrical and computer engineering major got the co-op, he says, he couldn't wait to dig into a lot of “high-tech design challenges and achieve something that's never been done before.”

As it turned out, he did just that.

Starobinets designed avionics for spacecrafts and rockets, including engine controllers and solar panels, and performed destructive tests on circuit boards with an eye toward building next-generation technology using very durable materials.

By the end of the co-op, the Falcon 9 had lifted off from Cape Canaveral with Starobinets's fingerprints all over the successful launch. “Things I was working on were on the first launch or will be on the second.”

SpaceX has offered Starobinets a full-time position, but he has decided to pursue graduate study at Stanford for now. “One of the best things about Northeastern is the co-op,” says Starobinets, who chose engineering at Northeastern over aerospace programs at other universities so he could get practical, hands-on experience under his belt.

The Journey from Idea to Reality **Brian Racca**

THE WEIR GROUP PLC

While on co-op at a global engineering firm, Brian Racca was confronted with a vexing challenge of redesigning a small but critical component of a nuclear reactor valve.

“There were so many design configurations I went through,” says Racca, who ultimately produced a design that suited the needs of the U.K.-based Weir Group PLC. The task forced him to think about why the part needed to be replaced—the type of question engineers face every day in the real world.

“There is always more than one way to look at an engineering problem,” Racca says. “Whenever I approached someone with a question, they'd always answer it with another question, which definitely helped me learn.”

A mechanical engineering major, Racca tackled many engineering design projects, often under pressure of tight deadlines. The branch where he worked produces valves for power plants, nuclear plants, and a variety of other commercial facilities.

One assignment involved studying a nuclear power plant valve that carries river water but was collecting too much dirt and sediment. He simulated tests to reduce the amount of friction inside the valve, and solved the problem.

“I wanted to take the design experience from this co-op, how you go about designing a part and making it a reality,” he says.



Brian Racca

Faculty Appointments

PROMISE AND EXPERIENCE

New Faculty Members



Srinath Chakravarthy, Assistant Professor of Mechanical and Industrial Engineering, researches size effects in plasticity, multiscale modeling of fracture, modeling of micro- and nanomanufacturing, and damage initiation and evolution in next-generation Li-ion batteries. He holds a PhD in mechanical engineering from the University of Connecticut and has conducted postdoctoral work at Brown University.

Sunho Choi, Assistant Professor of Chemical Engineering, focuses on the fundamentals and application of nanostructure interfacial engineering that entails molecular design and synthesis of nanostructured materials and hybrids for clean-energy applications. He has research expertise in chemical engineering and materials science, and practical experience in the semiconductor industry. He holds a PhD in materials science and engineering from the University of Minnesota and was a Dreyfus Foundation Postdoctoral Fellow at the Georgia Institute of Technology.



Matthew Eckelman will join the Department of Civil and Environmental Engineering in January 2012 as an assistant professor. An environmental engineer with training in

energy and material resource analysis and the urban environment, his research uses systems modeling tools to evaluate the life-cycle effects of novel materials, technologies, and policies on the environment and human health. He holds a PhD in environmental engineering from Yale University.

Yunsi Fei, Associate Professor of Electrical and Computer Engineering, researches hardware-oriented security, mobile computing, underwater sensor networks,



adaptable and efficient computer architecture, and integrated circuit and embedded system design automation. She received an NSF CAREER award and holds a PhD in electrical engineering from Princeton University.



Auroop R. Ganguly, Associate Professor of Civil and Environmental Engineering, researches climate extremes and uncertainty, surface water hydrology, and interdisciplinary data sciences. He comes to Northeastern from the Oak Ridge National Laboratory and the University of Tennessee, Knoxville. He holds a PhD from MIT.

Carol Livermore, Associate Professor of Mechanical and Industrial Engineering, is engaged in research that encompasses energy storage in carbon nanotube nanomechanical springs, energy harvesting, power MEMS, and techniques and applications for assembly and self-assembly in micro- and nanoscale systems. The recipient of an NSF CAREER award, she was previously at MIT and holds a PhD in physics from Harvard.



Andrew Myers, Assistant Professor of Civil and Environmental Engineering, focuses his research on multiscale experimental testing, computational simulation, and probabilistic modeling of physical systems, with applications to structural and earthquake engineering. He is a licensed Professional Engineer and earned his PhD at Stanford.

Marvin Onabajo, Assistant Professor of Electrical and Computer Engineering, studies the design of analog and mixed-signal circuits with on-chip measurement and self-calibration circuitry, focusing on reliability improvements for portable wireless devices and thermal sensing. He holds a PhD in electrical engineering from Texas A&M University.



Matteo Rinaldi, Assistant Professor of Electrical and Computer Engineering, researches micro/nano electro mechanical systems (MEMS/NEMS) devices, with particular emphasis on aluminum nitride (AlN) piezoelectric NEMS sensors for chemical and biological detection, AlN radio frequency MEMS/NEMS devices, and micro/nano fabrication techniques. He holds a PhD in electrical and systems engineering from the University of Pennsylvania.

William Robertson, Assistant Professor of Electrical and Computer Engineering, has researched several areas of systems security, focusing on detecting and preventing attacks against legacy software as well as new software architecture and development frameworks to facilitate the construction of software that is secure by design. He holds a PhD in computer science from the University of California, Santa Barbara.



Richard West, Assistant Professor of Chemical Engineering, focuses on using computational methods to build predictive models of chemical reaction systems, with applications in catalysis and energy conversion. He earned his PhD in chemical engineering from the University of Cambridge (U.K.) and conducted postdoctoral research at MIT into automatic generation of detailed kinetic models.

Edmund Yeh, Associate Professor of Electrical Engineering, focuses on wireless network cybersecurity, future Internet architecture, network information theory and coding, smart power grids, network economics, and cross-layer optimization of wireless networks. He holds a PhD in electrical engineering and computer science from MIT. He received an Army Research Office Young Investigator Award.



"As is the case at all great academic institutions, the heart and soul is the faculty. We have a strong group of men and women who are passionately dedicated to teaching students and advancing knowledge." **DEAN DAVID E. LUZZI**

University Promotions



Sinan Muftu, Professor of Mechanical and Industrial Engineering, leads research in applied mechanics. His work focuses on mechanics of flexible foils, particle-based manufacturing methods, and bioengineering. His research team introduced rigorous mechanics-based analysis of the biomechanical factors that affect the long-term success of dental implant treatments. He is a Fellow of the American Society of Mechanical Engineers and earned a PhD in mechanical engineering from the University of Rochester.

Elizabeth Podlaha-Murphy,

Professor of Chemical Engineering, focuses her research on electrochemical engineering and nanomaterials. Her recent study of electrodeposited materials includes: molybdenum and tungsten catalyst for clean hydrogen generation and surface finishing applications; nanocomposites useful for photoelectrochemical reactions; nanostructured, multilayered metallic alloys for enhanced magnetic and catalytic properties; and modeling of the electrodeposition process. She holds a PhD in chemical engineering from Columbia University.



Milica Stojanovic, Professor of Electrical and Computer Engineering, conducts research in digital communications, signal processing, and communication networks. She is interested in

communication system design and performance analysis for time-varying channels, with related applications to mobile wireless environments in general and underwater acoustic communication channels in particular. She is a member of IEEE and the Acoustical Society of America. She earned a PhD in electrical engineering from Northeastern.

Ali Touran, Professor of Civil and Environmental Engineering, conducts research in construction cost/schedule uncertainty, project delivery methods, simulation, risk assessment, and construction productivity. He is a Fellow of the American Society



of Civil Engineers and received the President's Award from the Boston Society of Civil Engineers in 2009. He earned his PhD in civil engineering from Stanford University.

Awarded Tenure



Anand Asthagiri, Associate Professor of Chemical Engineering, focuses on elucidating design principles for engineering living cells and tissues, providing a foundation for tissue engineer-

ing and regenerative medicine. His lab received an R01 award from the National Cancer Institute to investigate multicellular dynamics during cancer progressions; the lab is a member of the USC Physical Sciences of Oncology Center. He holds a PhD in chemical engineering from MIT.

Luca Caracaglia,

Associate Professor of Civil and Environmental Engineering, focuses his research on structural engineering, structural dynamics, wind engineering, wind-induced vibration, cable dynamics, and wind-based energy-harvesting systems. He received an NSF CAREER award, and he holds a PhD in civil engineering from the University of Trieste (Italy).



Rebecca Carrier,

Associate Professor of Chemical Engineering, heads the Advanced Drug Delivery Research Lab, which is currently studying computational modeling of the intestinal drug

delivery environment, modeling and experimental studies of drug transport through intestinal mucus, and tissue engineering of the intestine. She earned her PhD in chemical engineering at MIT.

Yung Joon Jung, Associate Professor of Mechanical and Industrial Engineering, researches controlled synthesis, assembly, and integration of low-dimensional carbon nanostructured materials for diverse multifunctional devices and systems. He holds a PhD in materials science and engineering from Rensselaer Polytechnic Institute.



Yingzi Lin, Associate Professor of Mechanical and Industrial Engineering, directs the Intelligent Human-Machine Systems Lab and co-directs the Virtual Environments Lab. Her

areas of expertise include intelligent human-machine systems, smart sensors and sensing systems, and applications in transportation safety and healthcare telemedicine. She is the recipient of an NSF CAREER award. She earned her PhD in mechanical engineering at the University of Saskatchewan in Canada.

Lee Makowski,

Professor of Electrical and Computer Engineering, focuses his research on image and signal processing as applied to biophysical data to answer fundamental questions about the molecular basis of living systems. Previously, he was at Argonne National Laboratory as director of the biosciences division and then as senior scientist. He holds a PhD in electrical engineering from MIT and did postdoctoral research in structural biology at Brandeis University.



Hossein Mosallaei, Associate Professor of Electrical and Computer Engineering, specializes in computational electromagnetics and photonics. He is the director of the

Computational EM and Photonics Lab and leads research activities in physics and modeling of metamaterials, hybridized materials, microwave and photonic systems, nanoscale plasmonics, bioinspired structures, and quantum/molecular phenomena. He holds a PhD from the University of California at Los Angeles.

Shashi Murthy,

Associate Professor of Chemical Engineering, heads the Biological Surface Engineering and Microfluidics Laboratory. The primary focus of the lab's research is the design of microfluidic devices for applications in clinical diagnostics and regenerative medicine. He was the recipient of an NSF CAREER award and earned his PhD in materials science and engineering at MIT.



NOTABLES

ECM Stiffness Regulates Growth

Anand Asthagiri, Department of Chemical Engineering, was featured in the March 2011 issue of the *Journal of Cell Science* describing how physical changes in the cellular microenvironment could play a role in cancer progression.

Awards for Service and Best Paper

James Benneyan, Department of Mechanical and Industrial Engineering, was given the President's Service Award from the Society for Health Systems for his service to the healthcare IE profession. He also gave the keynote address at the 2011 American Society for Healthcare Engineers' PDC Annual Conference. Benneyan and coauthor Jordan Peck won the best paper award at the 2011 Technology Management and Policy Graduate Consortium for "Using Prediction to Improve Patient Flow in a Healthcare Delivery Chain."

ASME Award

John Cipolla, Department of Mechanical and Industrial Engineering, received the ASME Dedicated Service Award for his 20 years of involvement and leadership in the Center of Education at ASME.

Second Patent Granted

Charles DiMarzio, Department of Electrical and Computer Engineering, has been awarded a patent for "Opto-acoustic signal detection with coherent confocal microscopy." This is his second patent to be registered this year.

Impact of TiO₂ Nanoparticles

The research of **April Gu**, Department of Civil and Environmental Engineering, was featured in a recent issue of *Chemical & Engineering News*, describing how TiO₂ nanomaterials are affecting the carbon and nitrogen cycles of aquatic ecosystems.

ASME Potter Gold Medal

Hameed Metghalchi, Department of Mechanical and Industrial Engineering, is the recipient of the ASME James H. Potter Gold Medal, which recognizes eminent achievement or distinguished service in the science of thermodynamics.

Top Emerging Investigator

Shashi Murthy, Department of Chemical Engineering, was selected for inclusion in a

special edition of *Lab on a Chip*, which features the top 22 Emerging Investigators of 2010 in the field of microsystems and microfluidics.

Cover of Orthopaedic Research

An article by **Hamid Nayeib-Hashemi** and **Ashkan Vaziri**, Department of Mechanical and Industrial Engineering, titled "Effect of frontal plane tibiofemoral angle on the stress and strain at the knee cartilage during the stance phase of gait," is featured on the cover of the December 2010 issue of the *Journal of Orthopaedic Research*.

Cover of IEEE

Control Systems Magazine

An article by **Rifat Sipahi**, Department of Mechanical and Industrial Engineering, titled "Stability and stabilization of systems with time delay, limitations and opportunities," is featured on the cover of the February 2011 issue of *IEEE Control Systems Magazine*.

Top 10 Article of Decade

A paper by **Nian Sun**, Department of Electrical and Computer Engineering, on "Giant electric field tuning of magnetic properties in multiferroic heterostructures," has been selected as one of the 10 most outstanding full papers and featured articles in the past 10 years by *Advanced Functional Materials*.

Cover of Soft Matter Journal

An article by **Ashkan Vaziri**, Department of Mechanical and Industrial Engineering, on "High aspect ratio wrinkles on a soft polymer," is featured on the cover of Issue 22, 2010, of the journal *Soft Matter*.

STEM Center Director Honored

Christos Zahopoulos, who leads Northeastern's effort to boost math- and science-based education in the public schools, has been elected a 2011 Fellow of the Massachusetts Academy of the Sciences. The honor is based on professional achievement in scientific research or education.

AIChE Board Election

Katherine Ziemer, Department of Chemical Engineering, has been elected to serve as a member of the AIChE Board of Directors for the next three years.

2010–2011 EVENTS



Dean David E. Luzzi and Professors Ming L. Wang, Dionisio P. Bernal, and Jerome F. Hajjar at the 2011 ASCE conference

2011 ASCE Engineering Mechanics Institute Conference June 2011

Co-chairs: Jerome F. Hajjar, Ming L. Wang, and Dionisio P. Bernal, Department of Civil and Environmental Engineering

The conference explored advanced engineering mechanics at the intersection of academic research in engineering mechanics and real-world applications. Keynote speakers addressed such issues as the use of intelligent wireless technologies to monitor the structural health of infrastructure as well as the lessons learned from the massive earthquake and tsunami that struck Japan.



Gordon Engineering Leadership Conference April 2011

Gordon Engineering Leadership Program at Northeastern and Gordon-MIT Engineering Leadership Program

Co-chairs: Simon Pitts, Director of Gordon Engineering Leadership Program, and Ed Crawley, Ford Professor of Engineering, MIT

The program is part of a nationally organized effort to align institutions committed to the burgeoning field of engineering leadership education. Participating institutions: Northeastern, MIT, Tufts, Penn State, Rice, SMU, University of Toronto, UCSD, University of Florida, and Iowa State.



ADVANCE for Engineering and Science Women Faculty June 2011

Northeastern ADVANCE hosted senior graduate students and postdoctoral research associates from around the country in Future Faculty Workshops in conjunction with interdisciplinary conferences on campus.

Test "boot camps" helped participants understand different viewpoints in faculty hiring, key aspects of the interview, and tips for negotiation. Attendee Abigail Engelberth, PhD, said, "With my confidence from the workshop, I was able to navigate through the [university] offers that I received. I hope that the other participants have similar success."



Research & Industrial Collaboration Conference

October 2010

The Bernard M. Gordon Center for Subsurface Sensing & Imaging Systems, an NSF Engineering Research Center, and ALERT (Awareness & Localization of Explosives-Related Threats), a DHS Center of Excellence

Transitioning university research to the field was the main topic of keynote addresses delivered by officials at the departments of Defense and Homeland Security and the National Science Foundation. More than 400 representatives of academia, industry, and government attended the annual event.



Former astronaut Dr. Bernard Harris joins middle-school students from Greater Boston as they prepare a rocket launch experiment during the ExxonMobil Bernard Harris Summer Science Camp at Northeastern.

Fifth ExxonMobil Bernard Harris Summer Science Camp July 2011

For middle-school mathematicians and scientists, the camp encourages education in STEM (Science, Technology, Engineering, and Mathematics); inspires students to pursue careers in STEM fields; and fosters teamwork, leadership, and citizenship. The program, founded and guided by former astronaut Dr. Bernard Harris, engages students in the practical aspects of STEM through hands-on, minds-on activities and field excursions.



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More than 1,500 people from academe, government, and industry are expected at the conference, which is sponsored by the NSF Division of Civil, Mechanical and Manufacturing Innovation (CMMI).

Learn more at: www.neu.edu/cmmi2012

Northeastern University is proud to host the NSF CMMI Conference, July 9-12, 2012, in the heart of Boston.