Signals

Department of Electrical and Computer Engineering

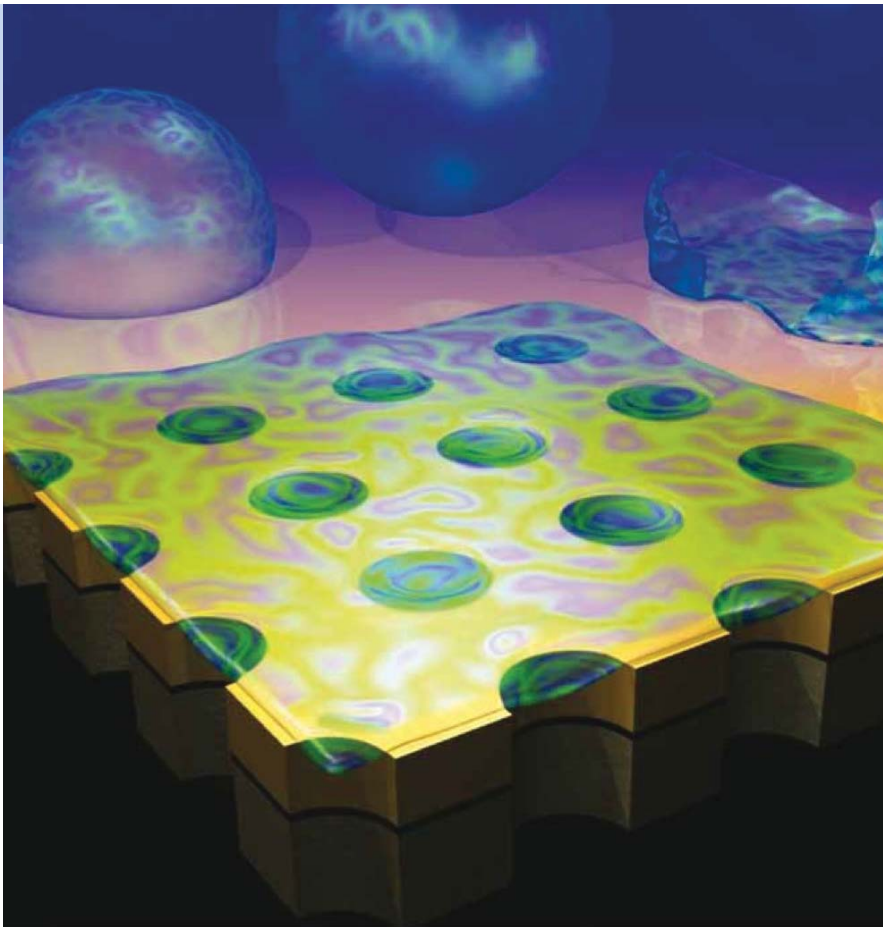
2011 Summer, Vol. XI, Issue 1

Harnessing nanostructures for new applications

Light is a versatile carrier of information but is constrained by diffraction limits. The emerging field of plasmonics—using the surface plasmon waves of metal nanostructures to manipulate optical energy at the nanometer scale—works to overcome the constraints and involves engineering metals such as gold, silver, and copper for diverse applications.

Department of Electrical and Computer Engineering Prof. Sang-Hyun Oh and his research team work to address the challenges of plasmonics and harness nanostructures for a number of applications in biosensing, spectroscopy, and solar cells.

"In 1998, researchers at NEC laboratory showed that nanoscale holes in gold and silver films provided unusually strong optical transmission," says Oh. "Building on those findings, many researchers like us began developing techniques to engineer gold and silver films and to drill tiny holes in these structures. Eventually, in the University of Minnesota Nanofabrication Center, we developed a successful recipe to turn these structures into functional biosensors." Oh's work led to collaborations with researchers both at the University and in industry.



Above is a conceptual illustration of cell-mimicking lipid membranes formed on a metallic nanopore biosensor by the rupture of spherical shaped lipid membranes, called lipid vesicles. The nanopore plasmonic biosensor can detect molecular binding to the membrane in real-time to study dynamic interactions between antibodies and lipid membranes. (Illustration by post-doctoral researcher Nathan Lindquist.)

Investigating biomolecular interactions

Oh entered into collaboration with Mayo Clinic's Dr. Moses Rodriguez to study antibody interaction with cell membranes using the nanopore sensor technology. With funding from the Minnesota Partnership for Biotechnology and Medical Genomics, the researchers hope to better understand the mechanism of new antibody molecules that potentially could treat multiple sclerosis.

In order to provide precise measurement of the antibody molecules binding with the cell surface, the device's metallic nanopore structure allows cellular membranes to adhere to the chip surface. Using a microfluidic device, antibody molecules are delivered to the membrane surface. "Reconstituting cell membrane on the metallic surfaces was a challenge, but postdoctoral researcher Nathan Wittenberg and PhD candidate Hyungsoon Im* developed the chemistry and instrumentation techniques to overcome these issues step by step," says Oh. "Now that we have new technology to study dynamic interactions between antibodies and cell membranes, this will play an important role in new drug discovery."

With preliminary results from therapeutic antibodies, Oh and Rodriguez wrote a grant proposal for nanopore biosensor research and re-

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University of Minnesota

ceived an R01 grant from the National Institutes of Health. Further studies will be made on how antibodies and other drug molecules react on cell membranes.

Solar film enhancement

It turns out that these metallic nanostructures also can benefit the performance of thin-film solar cells. Oh's team has ongoing collaborations with Department of Chemical Engineering's Prof. Russell Holmes to combine metallic nanostructures with organic solar cells for more efficient operations. Thin film solar cells can reduce materials and processing cost, but cannot absorb large amounts of light energy efficiently. Nanostructured metallic electrodes can efficiently capture light in the form of surface plasmon waves, which can lead to enhanced power conversion efficiency. ACS Petroleum Research Fund has been supporting Oh's research with a Doctoral New Investigator Award grant.

Working with Oh on this project are postdoctoral researcher Nathan Lindquist ** (Ph.D. '10) and doctoral candidate Tim Johnson.

Making smooth patterned metals

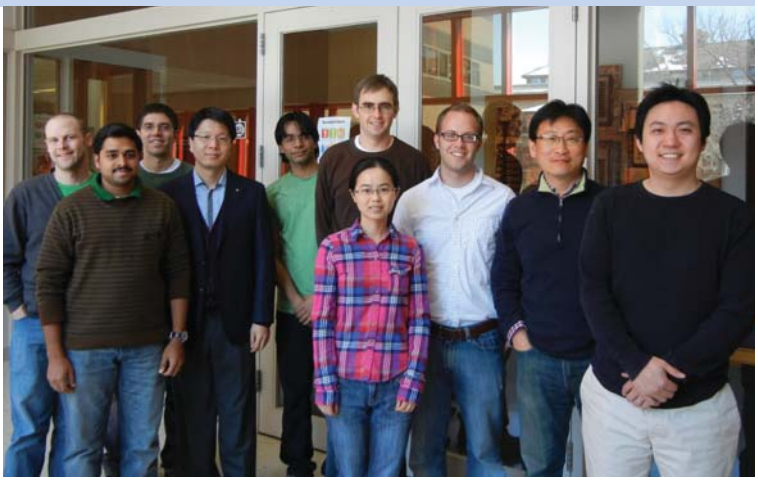
In 2009, the University's Department of Chemical Engineering Prof. David Norris's*** team and Oh's team joined efforts to develop a new nanofabrication technique called template stripping. In this process, one first creates silicon patterns, which have the desired property of smoothness (plasmon waves are very sensitive to surface roughness.) Using gold or silver, the pattern is replicated and peeled off of the silicon mold. This method can solve many challenges of reproducible plasmonic devices.

Oh notes, "I've been fortunate to work with many talented students, postdocs and collaborators over the last five years. Now we have powerful new technologies to engineer metallic nanostructures, and we look forward to demonstrating a series of devices and instruments for practical applications in drug discovery, nanoscale imaging, and photovoltaics."

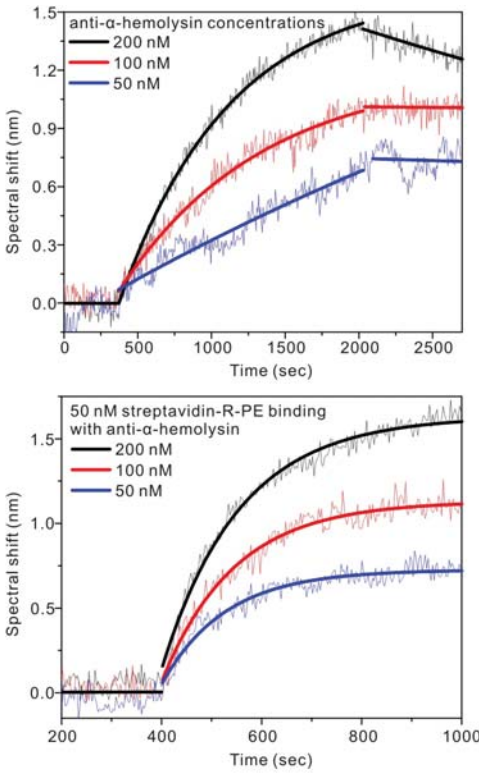
**Recently the Materials Research Society (MRS) selected Im to receive the 2011 MRS Graduate Student Award based on his biosensor research, which was presented at the MRS Spring Meeting in San Francisco in April.*

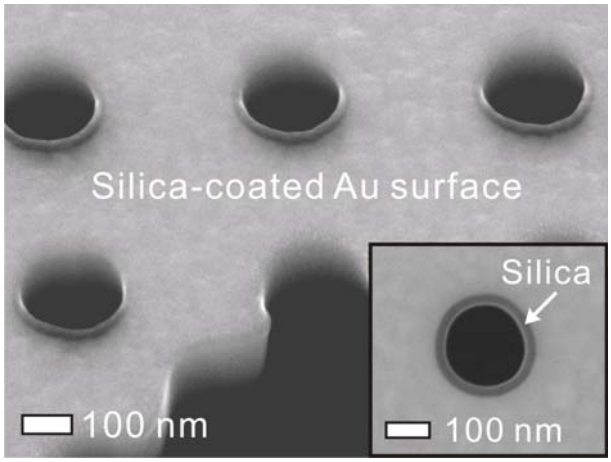
***Lindquist will join Bethel University as an Assistant Professor of Physics beginning fall 2011.*

****Dr. Norris now works at ETH Zurich in Switzerland.*



Dr. Oh's Research Team - (from left) Dr. Nathan Wittenberg, Sudhir Cherukulappurath, Luke Jordan, Prof. Sang-Hyun Oh, Shailabh Kumar, Dr. Nathan Lindquist, Xiaoshu Chen, Timothy Johnson, Si Hoon Lee, Hyungsoon Im.





(Right - graphs) The plasmonic biosensors can measure real-time binding kinetics of different concentrations of antibodies to their binding partners embedded in lipid membranes. From these curves the rate and strength of molecular binding can be determined. This information is essential to understand the behavior of antibodies and to develop new drug molecules. (Right, bottom) An image of a plasmonic nanopore sensor. A scanning electron microscope allows imaging of nanometer-scale structures.

REU: Enhancing students' research careers

The University of Minnesota's Research Experience for Undergraduates (REU) program, funded by the National Science Foundation (NSF), is a 10-week summer experience for sophomore- or junior-year undergraduate students from across the United States. The program focuses on encouraging a culturally-diverse group of individuals to pursue successful careers in science and engineering. By providing women and under-represented minority undergraduates and undergraduates from non-research universities with a challenging and rewarding introduction to research in electrical and computer engineering, our REU program seeks to motivate these students towards obtaining advanced degrees.

ECE's REU program successes

This is the 14th summer for the ECE REU program that has run every summer since 1997, except for the summer of 2010. Our current NSF grant will support the summer program through 2013.

During the past 13 summers, 156 undergraduate students drawn from more than 50 higher education institutions across the U.S. and Puerto Rico have participated in the program. Of these, 59 were women and 97 men. Ten students are participating in the summer 2011 program, two women and eight men.

"Based on a recent survey of our past program participants, nearly 90 percent have completed an advanced degree (M.S., M.A., or M.B.A.), with about 60 percent having completed or currently are completing a Ph.D. in a STEM discipline," says Prof. Douglas Ernie, director of the ECE REU program. "Sixty-six percent of past participants indicated that their REU experience in our program motivated them to continue on to graduate school. This is a good indicator of success in accomplishing our goal of persuading these students to continue to pursue advanced degrees, given that only about 50 percent of them expressed a strong interest in graduate school when they first came to our program. In recent years, three REU participants have been included as co-authors on journal publications by their faculty advisors."

Impact of one conversation

Faculty members have countless conversations with students and little means of measuring the impact. "It really reinforces the responsibility we have to be good role models and teachers," says David Lilja, ECE Department Head and Louis John Schnell Professor. "Much of the real teaching we do happens outside the classroom."

Last February, after Prof. Rhonda Franklin gave a presentation at Georgia Tech, an audience member— Tyrone Roach, a former REU participant—told her he graduated fall of 2010 with a Ph.D. from University of Illinois at Urbana-Champaign (UIUC) and now is working at Georgia Tech Research Institute (GTRI) as a research scientist. He said his chosen career path was in part due to the conversation he had with Franklin when he was an REU student in 2000.

"Tyrone was in a target group—African-American undergraduates," says Franklin. "The outcome of this particular REU effort was a success.

"I recalled our conversation in which I pointed out how important it was for him in deciding to pursue graduate school," she says. "He was interested, but did not have anyone to encourage him to take it seriously. When we talked he was considering going into industry but wanted to have some research experiences."

Franklin met Roach again in 2002 at UIUC where he was pursuing his master's degree and where eventually he would receive his Ph.D. degree.

"For me it was really comforting and reassuring to know that one conversation made such an impact on the life of a student," says Franklin. "Over the years, it is a conversation I have had with many undergraduates who I think have what it takes though to get a doctorate. For the ones I have targeted, the results are just starting to show."

2000 REU student Tyrone Roach (above) and today (below).

Tyron Roach, Research Engineer II, Georgia Tech Research Institute

"In the last year or two of my undergraduate studies, I wanted to do something different for the summer," says Roach."Why not study abroad? My advisor suggested I seek out a summer undergraduate research experience since I had expressed an interest in attending graduate school. I am glad I went down that path because, ultimately, I landed an REU opportunity with U of MN. The program brought great excitement and challenge to my life; it opened a door to possibilities for my career from that point forward."

He adds, "The REU program ran perfectly; there were all sorts of activities planned in the off-hours by the coordinators that allowed all of the participants to bond with each other—I still have fond memories of all the great times. The fellow REU members were a joy to be around; it was great to see so many students coming from different parts of the country and with unique backgrounds, share so many of the same interests."

Roach worked with a wireless communication theory research team headed by Dr. Mohamed Slim-Alouni. "I contributed to the research efforts by analyzing probability relationships for mobile channels—a technical level above my competency at the time," he says. "But that was OK, because it was just as important to learn and to understand the new topic and how to go about researching it. Often, an undergraduate researcher thinks his or her contribution is insignificant, such is not the case. I was quite surprised to hear that later on the results from my work contributed to publication."

Roach says, the experience allowed him to get a perspective of what graduate school would be like, and as a result, his interest in continuing to learn grew. "As a result, I pursued another REU-type program the following summer, went to grad school and obtained

In the Classroom - continued on page 5

Solar Vehicle Project Team Wins 2011 Formula Sun Grand Prix

The University of Minnesota Solar Vehicle Project student team placed first in the 2011 Formula Sun Grand Prix held May 4-5 at the Indianapolis Motor Speedway "Brickyard" track. The American Solar Challenge event was part of the 100th anniversary celebration of the Indianapolis Motor Speedway.

With its latest solar-powered car—Centaurus II—the team completed 569 laps on the .9-mile track (512.1 miles total) throughout the three-day, 23-hour race. This was 39 laps more than the second-place finisher Illinois State University. Northwestern University placed third. Ten solar car teams from across the country participated in the event this year.

"We knew we had a reliable car going into the race, and we were happy that we were able to stay out on the track during the entire race," said team leader Jonathan Nutzmann, a University of Minnesota junior majoring in electrical engineering. "Our team's great drivers were a big reason we won. We specifically designed our car so it could fit any team member. We take a hit on aerodynamics, but the payoff is that we can have the best driver out there, not just one that is small enough to fit in the car."

The U of MN team raced one of the fastest laps at 1 minute and 24 seconds and also was the first team to meet all the requirements of inspection receiving the pole position for the start of the race.

Team member Nick LaMoore, a first-year student in mechanical engineering, received one of the four Spirit Awards presented because of the mechanical assistance he provided to the Michigan State team to help them qualify for the race.

Centaurus II, the University of Minnesota's Solar Car Project entry to the 2011 Formula Sun Grand Prix, placed first among ten national university teams at the Indianapolis Motor Speedway.

The Solar Vehicle Project team is funded by generous private donations from corporations and individuals. Major sponsors include 3M, Altium, Cirrus Aircraft, Delta Air Lines, PaR Systems, Caterpillar, Earle M. Jorgensen Company, University of Minnesota Initiative for Renewable Energy and the Environment, and General Plastics. For more information about the Solar Vehicle Project, visit the website at www.svp.umn.edu.

Gysler Castelino
2010-2011 CSE Outstanding Teaching Assistant

Department of Electrical and Computer Engineering Ph.D. candidate Gysler Castelino (Prof. Ned Mohan, advisor) was named College of Science and Engineering Outstanding Teaching Assistant (TA) for 2010-2011. Currently, she is researching power electronic converters for harnessing renewable energy, mainly wind and solar PV.

Castelino received her Master's in Electrical Engineering (EE) in 2010 from the University of Minnesota and her undergraduate EE degree in 2007 from College of Engineering, Pune, India.

Castelino began her TA duties as have many before her—holding office hours and grading papers. She then advanced to assisting with the 4747 Power Electronics Lab and the 4703 Electric Drives Lab.

"I set up the labs, write instructions, and help the students," she says. "I also help prepare and assist at the Department of Energy (DOE) workshops for Prof. Mohan. It's fun to meet professors from around the country who have an interest in fine tuning their curricula." The grant-funded workshops conducted by Profs. Mohan, Bruce Wollenberg, William Robbins and Paul Imbertson help to revitalize power engineering education in colleges and universities nationwide and to prepare the next generation of engineers for the power grid utility and manufacturing industries.

Castelino particularly enjoys working with the students in her labs—she had 84 students in eight sections during spring semester. "They are good students with great ideas and in-depth understanding of power electronics and power systems," she says.

By serving as a TA, Castelino has learned to understand her subject in greater depth. "Teaching is the best way to learn; the students ask questions and it gets me to think, too."

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my Ph.D.," he says. "Now, I am a research engineer at a research lab working on some cool projects! I never imagined it to be this way. With the REU program, I begin to obtain the skill set and the wherewithal that would lead the way."

Dr. Kjersti Kleven, OptiComp Corporation

2002 REU student Kjersti Kleven (above) and today.

In 2002, Kjersti Kleven, an undergraduate student at Embry-Riddle Aeronautical University and a McNair Scholars Program participant, was encouraged by her advisor to attend the University of Minnesota REU program where she participated in simulation, design and testing of end-coupled microstrips.

"At the time, I was thinking about going directly into industry right after graduation," says Kleven. "I would not have gone to graduate school had it not been for my experience in REU and particularly for Prof. Franklin who encouraged me. She told me to look at all my options, and that I was in a great position to continue researching areas that interested me if I went on to graduate school."

Kleven attended the University of Washington to study MEMS and Device Physics receiving her M.S.E.E. in 2005 and her Ph.D. in electrical engineering in 2008. She now works as a Design Engineer at OptiComp Corporation, a research and development company in Nevada.

Dr. Riki Banerjee, Medtronic - Neuromodulation

2000 REU student Riki Banerjee (above) and today.

In 2000, Dr. Riki Banerjee (Ph.D.'05) participated in the REU program which exposed her to graduate school life and the pursuit of knowledge in their disciplines. "My peers in the program and I felt very excited about pursuing graduate school after participating in the REU program," says Banerjee."It helped me build a relationship with the ECE department and with Prof. Rhonda Franklin. Because of REU, Prof. Franklin offered me a research assistantship within her group upon graduation."

When Banerjee returned as a graduate student in 2001, she was able to immerse herself in the research program immediately and produce results quickly. She completed a master's degree in 2002 and Ph.D. in 2005 with Prof. Franklin as her advisor.

"I mentored other REU students as they came through Prof. Franklin's lab through the years," she says. "Subsequently, I launched my career at 3M in RF modeling. And now, I work at Medtronic Neuromodulation developing RF testing techniques."

ECE New Faculty

Prof. Nikos Sidiropolous joins the Department of Electrical and Computer Engineering at the start of the 2011 Fall Semester and will be a member of the communications/signal processing group.

Sidiropoulos (Fellow, IEEE) received a diploma in Electrical Engineering from the Aristotelian University of Thessaloniki, Greece, and M.S. and Ph.D. degrees in Electrical Engineering from the University of Maryland - College Park, in 1988, 1990 and 1992, respectively.

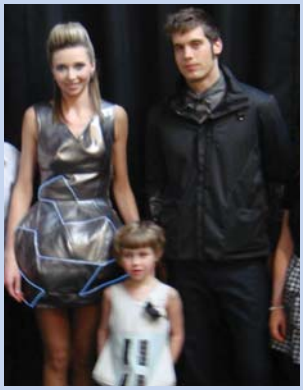
He served as Assistant Professor in the Department of Electrical Engineering at the University of Virginia (1997-1999), Associate Professor in the Department of Electrical and Computer Engineering at the University of Minnesota - Minneapolis (2000-2002), and Professor in the Department of Electronic and Computer Engineering at the Technical University of Crete, Chania - Crete, Greece (2002-2011). (Go to www.ece.umn.edu for more.)

Highlights of 2011 Spring Senior Design Show

Fifteen projects and 13 Senior Honors posters were presented at ECE's 2011 Spring Senior Design Show. From canine monitoring to fashion design with a lighting component, this year's show had a variety of interesting projects for judges to assess.

In addition, a team from National Cheng Kung University (NCHU) visited the University of Minnesota to participate in a joint senior design show project. Three students—Di-Kai Yang, Kuan-Wei Chi, Yu Hsiung Su—worked on the "FPGA Implementation of an ECG-based Attention Monitoring System". (Prof. Gerald Sobleman, Advisor)

(Right, top) Prof. Gerald Sobelman presents NCHU students with certificates of completion for their Senior Design Project.



(Right, below) "Photo Voltaic Clothing" project had EE and Fashion Design students collaborating on lighted and moving design items. The woman's dress has zigzagging blue lights; the man's jacket has zigzagging flashing lights on the jacket back; the child's dress has a whirling flower. All lights and movement are powered by photo voltaic batteries.

ECE Students

ECE Ph.D. candidate **Gysler Castelino** was named College of Science and Engineering 2010-2011 Outstanding Teaching Assistant. (Prof. Ned Mohan, advisor)

Graduate student **Neil Dhingra** received the year-long 2011 "Aeroservoelastic Control using Distributed Sensing Fellowship" at Dryden Flight Research Center from the National Aeronautics and Space Administration (NASA). (Prof. Mihailo Jovanovic, advisor)

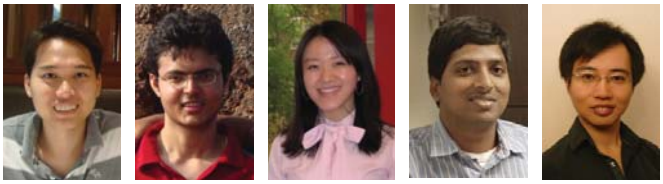
Graduate student **Jesse Gantz** was selected to participate in the National Science Foundation East Asia and Pacific Summer Institutes for U.S. Graduate Students to conduct research at the Tsinghua University in Beijing, China. (Bruce Wollenberg, advisor)

Ph.D. student **Hyungsoon Im** received the Materials Research Society's (MRS) Graduate Student Silver Award for "Plasmonic Nanopore Arrays for Label-Free Kinetic Biosensing of IgM Antibody Binding to Lipid Membranes." He conducted this research in collaboration with Mayo Clinic. (Prof. Sang-Hyun Oh, advisor)

Graduate student **Kyle Olson** received the 4-year 3M Science and Technology Doctoral Fellowship in Electrical Engineering. The award includes stipends, tuition and health insurance. Olson will have the opportunity to interact with 3M scientists (Prof. Joseph Talghader, advisor)

Doctoral student **Niranjay Ravindran** and his advisor Prof. Nihar Jindal received a 2011 IT/ ComSoc & Information Theory Society Joint PaperAward for "Multiuser MIMO Achievable Rate with Downlink Training and Channel State Feedback."

Graduate student **Eric Severson** received the National Science Foundation's Nordic Research Opportunity Award for his proposed project "Design of Outer-Rotor, Bearingless Motors for a Power Distribution-Grid Flywheel Energy Storage Module." Eric also is the recipient of the NSF Graduate Research Fellowship and the Department of Defense NDSEG Fellowship. (Prof. Ned Mohan, advisor)



Graduate students (from left) **Binh Lieu**, **Bodhisatwa Sadhu**, **Hao Zhu**, **Manohar Ayinala**, and **Wei Zhang** were awarded 2011-2012 Doctoral Dissertation Fellowships from the University of Minnesota Graduate School.

ECE Faculty

Prof. Massoud Amin was elected to the grade of Fellow of the American Society of Mechanical Engineers (ASME), an organization that promotes the art, science and practice of mechanical and multidisciplinary engineering and allied sciences to diverse communities throughout the world. He is one of 3,068 Fellows out of 121,087 ASME members and is recognized for his engineering achievements. In addition, Amin provided a keynote presentation—"Smart Grid: Enable a Stronger and Smarter Energy Infrastructure"— at the Smart Grid Conference held in Miami Beach, Feb. 2-3, 2011. He also provided the presentation to Federal Reserve Bank of Minneapolis, Minn., March 2, 2011.

Prof. Chris Kim's article titled "An Odometer for CPUs" was published in the IEEE *Spectrum*, May 2011, pp 29-33. Kim and his colleague John Keane are researching ways to measure aging transistors.

Prof. Zhi-Quan (Tom) Luo was named one of 34 academics and professionals to receive rank of Fellow of The Society for Industrial and Applied Mathematics (SIAM) 2011. Prof. Luo received this fellowship for the development of novel applied mathematics ideas and methods for signal processing and digital communication in July at the 7th International Congress on Industrial and Applied Mathematics (ICIAM 2011) in Vancouver, British Columbia. In addition, Prof. Luo received the EURASIP 2011 Best Paper Award for his article titled "Analysis of iterative waterfilling algorithm for multiuser power control in digital subscriber lines" published in the 2006 EURASIP *Journal on Applied Signal Processing*. The award will be presented at the EUSIPCO 2011 Conference in Barcelona, Spain, Aug. 29-Sept 2, 2011.

Prof. Sang-Hyun Oh received the Department of Defense, Office of Naval Research 2011 Young Investigator Program Award. The Navy selected 21 proposals from more than 270 applications received last year. Awarded for compelling research with the potential to deliver game-changing naval science and technology, recipients will receive approximately $170,000 in annual research grants for three years. A list of the 2011 YIP awardees can be found at http://go.usa.gov/2mC. In addition, Prof. Oh received the National Science Foundation Faculty Early Career Development (CAREER) award. This highly competitive five-year award, in the amount of $597,111, is the NSF's most prestigious program to support the early career development of promising young researchers. The title of Prof. Oh's project is "Ultrasmooth patterned metals for membrane biology."

Prof. Guillermo Sapiro is part of a $3 million National Science Foundation-funded, University of Minnesota seven-member research team studying the use of robots and computer vision to diagnose mental disorders in children. The research is a partnership between the College of Science and Engineering, the Medical School, and the College of Education and Human Development. For more, go to http://www1.umn.edu/news/news-releases/2011/UR_CONTENT_304914.html

Prof. Jian-Ping Wang (far left) and **Prof. Paul Imbertson** (left) received the College of Science and Engineering (CSE) 2010-11 Outstanding Professor Awards in electrical and computer engineering.

This is an unprecedented eleventh year for **Prof. Imbertson** to receive this award. Imbertson also has been named Center for Compact and Efficient Fluid Power (CCEFP) Education and Outreach Co-Director. He will share directorship with Linda Western, past executive director of the National Fluid Power Association (NFPA) and instrumental leader in obtaining the Engineering Research Center for the University of Minnesota. The CCEFP, working through its networks of strong partners, places an emphasis on developing new understandings of fluid power and related STEM topics as it reaches out to diverse audiences. More than twenty projects are included in the CCEFP's Education and Outreach Program Portfolio.

"Reforming Electrical Energy Systems Curriculum with Emphasis on Renewables/Storage, Smart Delivery and Efficient End-Use." On Feb. 4-5, (left to right) **Prof. Ned Mohan**, his colleagues **Profs. Bruce Wollenberg, William Robbins, Tom Posbergh, and Paul Imbertson,** and his students organized an ONR/NSF-sponsored workshop about Electric Energy Curriculum Reform in Napa, Calif. The objective of this workshop was to disseminate the electric energy curriculum developed at the University of Minnesota to universities nationwide. This workshop was highly successful, with nearly 150 participants attending from various industries and U.S. universities, including 52 directors, ECE department heads and engineering deans.

Faculty Promotions

Prof. Gerald Sobelman (far left) was promoted to Professor. **Prof. Mihailo Jovanovic** (near left) was promoted to Associate Professor.

ECE Alumni

Oregon State University Assistant Prof. **Ted Brekken** (Ph.D. '05), has been selected to receive the IEEE Power and Energy Society (PES) Outstanding Young Engineer Award. Brekken will receive his award at the IEEE PES General Meeting to be held in Detroit, Mich., July 26.

Former Faculty

Prof. Dennis Polla, Honeywell/WR.Sweatt Chair in Management of Technology and former ECE professor, received two awards recognizing his exceptional public service: Office of the Secretary of Defense Medal for Exceptional Public Service and the DARPA Devoted Service and Achievement Award. One of the awards stated: "America's national security is strengthened by his efforts." Prof. Polla serves as University of Minnesota Technology Leadership Institute Securities Technology (MSST) Professor and Director of Graduate Studies in Management of Technologies (MOT).

In Memoriam

Erland Persson (EE '55), passed away February 22, 2011. He was a Life Fellow of both the Institute of Electrical and Electronic Engineers (IEEE) and the Audio Engineering Society (AES) Persson worked for General Mills, the Jupiter Rocket program, Electro Craft Corporation, and eventually ran his own consulting business—Erland Persson Company, specializing in motor, tachometer, and magnetostrictive transducer design. He amassed 11 U.S. patents and three British patents. A long-time supporter of the University of Minnesota Solar Car Project, Persson helped with the design of a motor to propel the solar car.

Dr. Dennis Speliotis (PhD '61), died May 15, 2011. He was the president of Digital Measurement Systems, Inc., co-founder of Micro-Bit Corp. where he served as vice president and general manager, and founder of the International Symposium on Barium Ferrite. Early in his career, Speliotis served as an IBM advanced recording technology manager. He received a Bachelors of Science from University of Rhode Island, a Masters of Science from Massachusetts Institute of Technology, and a Doctorate in solid state physics from the University of Minnesota. He served as Associate professor at the University of Minnesota and founded and directed the Magnetics Research Lab known as MINT. Speliotis was a IEEE Fellow and distinguished lecturer who delivered more than 50 invited presentations and 300 technical papers.

Staff Promotion

Kyle Dukart has been promoted to Associate Academic Advisor.

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University of Minnesota's Economic Impact on the State of Minnesota

- U of MN creates $8.6 billion in total economic impact in Minnesota annually.
- Every dollar invested in the U of MN by the state generates $13.20 in the statewide economy.
- One out of every 43 jobs in Minnesota is attributable to the U of MN.
- Research expenditures from competitively awarded funds generate $1.5 billion in total annual economic impact in Minnesota and support 16,193 jobs, both inside and outside the U of MN.
- A total of 79,497 jobs are supported by the U of MN (42,319 on campus jobs; 37,178 employed in communities across the state through U of MN spending) 19,157 faculty and staff, 8,866 fellows and student employees, 8,017 U of MN Medical Center, Fairview and U of MN Physicians, 6,279 graduate assistants, postdoctoral students, and residents.

Additional information can be found on the Economic Impact Website at http://www1.umn.edu/twincities/impact.php

Mark Your Calendars

Fall Senior Design Show - Tuesday, Dec. 13, 2-4:30 p.m.

Spring 2011 Senior Design Show K9 Timer Group (from left) Jeffrey Hillyer, Daniel Heim, August Lentsch, and Ernie Kim with Woodbury Police Canine Officer Levi (front).

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