SIGNALS

Department of Electrical and Computer Engineering
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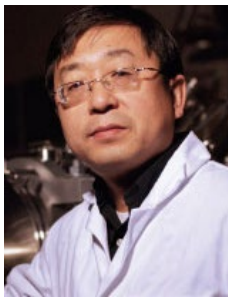
College of Science & Engineering
University of Minnesota

C-SPIN collaborators discuss research themes and objectives on $28 million project

The University of Minnesota's Center for Spintronic Materials, Interfaces, and Novel Architectures (C-SPIN) held its kickoff meeting on March 26 with researchers from the 14 participating universities, and industry representatives and sponsors in attendance.



To facilitate collaborations within and across the research groups, **C-SPIN Director Jian-Ping Wang** (left) invited research team leaders to share current efforts and to establish research themes and goals. In addition, the group outlined ways to enhance and to streamline collaborations. The five research areas include:

C-SPIN Objectives

• Perpendicular Magnetic Materials. Research to develop magnetic materials that will improve the power consumption, scalability, and stability of magnetic device structures

• Spin Channel Materials. Research investigating a wide range of spin channel materials, including topological insulators, monolayer MoS2, and graphene

• Spintronic Interface Engineering. Research focused on understanding, designing, modeling, making and optimizing the interfaces between magnetic materials and spin channels

• Spin Devices and Interconnects. Research to develop novel memory, logic, and communication device solutions necessary to realize a complete spintronic computational system

• Spintronic Circuits and Architectures. Research to develop novel architectural solutions that take advantage of the unique functionality that can be achieved using a spin-based technology

C-SPIN was established with a $28 million grant from MARCO and the Semiconductor Research Corporation (SRC) to develop technologies for spin-based computing and memory systems. Unlike today's computers, which function on the basis of electrical charges moving across wires, the emerging spin-based computing systems will process and store information through spin, a fundamental property of electrons.

The fourteen participating universities include:

- University of Minnesota-Twin Cities, Lead Institution
- Carnegie Mellon University
- Cornell University
- Johns Hopkins University
- Massachusetts Institute of Technology
- Pennsylvania State University
- Purdue University
- University of Alabama
- University of California, Riverside
- University of California, Santa Barbara
- University of Iowa
- University of Michigan
- University of Nebraska
- University of Wisconsin-Madison

Since C-SPIN's inception, more than 70 postdoctoral and student researchers have been added to the 31 faculty researchers.

C-SPIN hosts International Conference on Non-Volatile Memory

From Aug. 12-14, C-SPIN hosts the 13th Non-Volatile Memory Technology Symposium (NVMTS) at the University of Minnesota along with sponsors IEEE and IEEE's Electron Devices Society. This is the world's pre-eminent forum for researchers and engineers from both academia and industry to exchange information about technology advances on non-volatile memory. Keynote speakers include: William J. Gallagher, IBM Watson Research Center, USA; Hongsik Jeong, Samsung, Korea; and Gurtej Sandhu, Micron, USA.

Visit the C-SPIN website at http://cspin.umn.edu.

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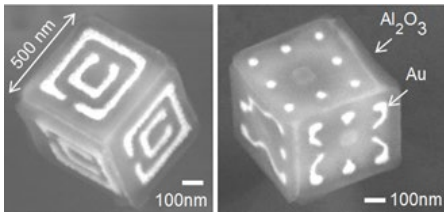
ECE welcomes five new faculty members to its Driven to Discover Team

Prof. Jeong-Hyun Cho—Micro and Nano Structures

Prof. Jeong-Hyun Cho (left) received his Ph.D. in Engineering Science in 2007 at Washington State University, Pullman, Wash. He completed two postdoctoral fellowships: 2008-2010 at The Johns Hopkins University and 2010-2013 at The Center for Integrated Nanotechnologies, Los Alamos National Laboratory.

Cho is working on two areas of research: silicon nanowire-based lithium ion battery anodes and surface patterning on 3D micro- and nano-structures.

Even with the improvements of recent years, the current power source of choice—lithium ion batteries—must be recharged frequently. In a continuation of the research he began at Los Alamos, Cho is working to enhance the life and energy density of a lithium ion battery by creating a 3D structure.



Scanning electron microscopy (SEM) images of 500 nm sized cubic structures with specific surface patterning on each face.

Cho's second area of research involves surface patterning on micro-and nano-structures. "If we can realize surface patterning on 3D nanostructures, we can alter physical and chemical properties of the structures," Cho says. "There is no doubt that utilizing the new physical and chemical properties will reveal many applications in diverse fields. For example, we can achieve superior resolution with metamaterials (artificial materials) which can capture images of objects smaller than one wavelength of light." In order to realize patterning on the surface of 3D nanostructures, he has developed origami-inspired and self-assembly approaches (see illustration above).

During his first semester at the University of Minnesota (he began in January 2013), Cho has been building his research team which now comprises one post-doctoral researcher, three graduate students, and five undergraduate students. Cho has been working frequently with them in the Nanofabrication Center (NFC) to teach them skills that they cannot learn from textbooks.

Cho also has been fulfilling invitations for presentations, most recently from Honeywell, 3M, and the University's Nanofabrications Lab. He already is scheduled for two more invited talks—one in the United Kingdom and the other at MIT. He plans to teach "Microelectronic Fabrication" during the upcoming fall semester.

Prof. Sairaj Dhople—Sustainable Energy Systems, Power Electronics, and Drives

Prof. Sairaj Dhople (left) received his Ph.D. in Electrical and Computer Engineering in 2012 from the University of Illinois, Urbana-Champaign.

Dhople's research focus is modeling, analysis, and control of power and energy systems, specifically to efficiently integrate renewables into power distribution systems. "Power engineers typically worked in either power electronic circuits or in large power systems," says Dhople. "I'm trying to bridge the gaps between circuits and systems to address the growing challenge of renewable integration in distribution networks."

A particular research focus area relates to increasing the use of renewable resources in microgrids, which are small footprint power systems that can ensure power is available locally should natural or man-made disasters disrupt the main grid. Citing a recent example, Dhople says, "Thanks to the Princeton University microgrid, its campus continued operating in the aftermath of Hurricane Sandy despite the widespread power outages throughout the area."

Benefits abound from using microgrids, some of which include: potential for increasing renewable integration, ensuring the availability of supply in case the main utility grid power is unavailable, as well as the potential for reducing transmission losses to load centers. To increase deployment of microgrids, Dhople is focusing on modeling and control challenges to improve cost effectiveness, reliability, and performance.

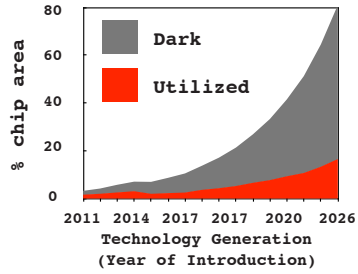
In the process of building his research team, Dhople currently has one graduate student. He hopes to add two more graduate students in the fall.

Prof. Dhople's research seeks to increase the integration of PV systems in distribution systems. An example of such a system are the homes that competed in the 2009 U. S. Department of Energy's Solar Decathlon competition. The University of Minnesota's solar home is the second one from the top in the left column. (Credit: Stefano Paltera/U.S. Department of Energy Solar Decathlon)

Prof. Ulya Karpuzcu—Computer Engineering, VLSI, and Circuits

Prof. Ulya Karpuzcu (left) received her Ph.D. in Electrical and Computer Engineering in 2012 from the University of Illinois, Urbana-Champaign.

Karpuzcu's research addresses technology-induced barriers to energy-efficient computing. "In each technology generation, more and more functionality can be crammed onto the unit chip area, yet not all can be utilized simultaneously due to the resulting excessive demand for energy," says Karpuzcu. "We are not far away from hitting the utilization wall. A progressively growing fraction of silicon area has to remain unused—'dark'—without improving energy efficiency across all levels of the system stack."



To illuminate dark silicon, computer architecture researchers delve into unconventional regimes of operation, such as near threshold voltage computing (NTC). Unfortunately, NTC's promise of improved energy efficiency comes with substantial degradation in system reliability.

"Overcoming NTC's practical limitations can help push back the utilization wall," says Karpuzcu. She continues an Illinois-led DARPA project on the trade-off between energy efficiency and reliability of NTC. She developed the first public architectural model to characterize NTC's higher susceptibility to errors. Karpuzcu also belongs to the team of researchers who started and chaired the first NTC workshop with an architectural focus.

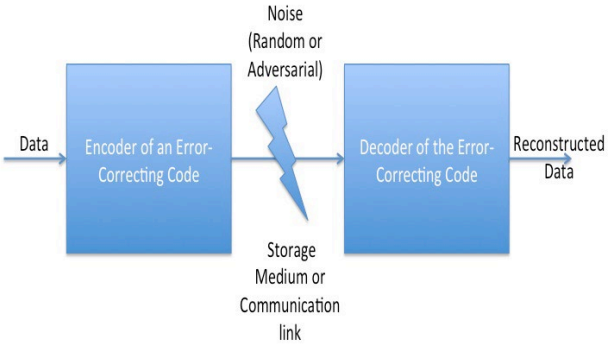
Karpuzcu recently began investigating how computing with beyond-CMOS devices will transform the architecture landscape. "Since fundamental shortcomings of CMOS render the utilization wall, only beyond-CMOS devices relying on different physical phenomena to represent and process information can lead us behind the wall," she says.

Karpuzcu has begun to build her research team and will have three Ph.D. students by fall semester. During last fall, Karpuzcu presented ECE's "Advanced Computer Architecture" to a class of 90+ students. "It was a steep learning curve, but I have been thoroughly vaccinated," she says. Next year, she plans to teach "Physics of Computing" inspired by Feynman's lectures on computation.

Prof. Arya Mazumdar—Communications, Signal Processing, and Networking

Prof. Arya Mazumdar (left) received his Ph.D. in 2011 from the University of Maryland-College Park. He also completed a 1.5 year post-doctorate experience at MIT's Research Laboratory of Electronics.

Mazumdar's research focuses on error correcting codes to clarify and to enhance communication. As he explains it, "When you and I are talking, the information we share passes through a noisy medium of air currents and background noise. If we begin to back away from each other, the further away we get, the communication must travel through more and more interference. My research involves how to correct for the noise as the energy is transferred and to ensure clear communication."



The methods of reliable communication and storage

"Currently, the error-correcting coding implemented in most databases consists of simple repetition schemes; however, this huge overhead is not optimal," says Mazumdar. "If we are accustomed to English, and I drop a word out of a spoken sentence or drop a letter from a common written word, we still communicate. You can understand because the redundancy of the language fights the error. That is the magic of language. Even if we have a scratched CD, the information on the CD still can be decoded over the noise of the scratch using an error-correcting code. My fundamental motivation is to develop a technique using the required mathematics."

The application of Mazumdar's work will be useful to security, testing, signal processing, algorithm designs, and database management systems. Error-correcting codes are vital in distributed storage systems such as the information clouds used by businesses like Amazon and Google.

To accomplish objectives of this research, Mazumdar is looking forward to collaborating with University of Minnesota electrical engineering and math colleagues including Digital Technology Center (DTC) professors Georgios Giannakis, Nikos Sidiropoulos, and Zhi Quan (Tom) Luo, as well as Mathematics professor Andrew Odlyzko, and ECE professor Marc Riedel.

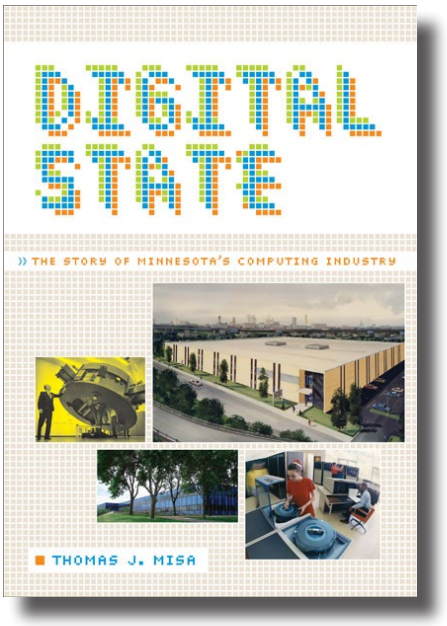
This past spring, Mazumdar taught a "Data Compression" class. During the summer, as a special project, ECE undergraduates joined Mazumdar in his research and starting this fall, he hopes to begin collaborating with his own Ph.D. students.

Faculty, continued on page 7

CBI New Book

Prof. Tom Misa to publish *Digital State: The Story of Minnesota's Computing Industry*

This fall, Charles Babbage Institute (CBI) Director Tom Misa is publishing the first book-length treatment of Minnesota's remarkable role in the history of computing. His book, *Digital State: The Story of Minnesota's Computing Industry* (University of Minnesota Press, 2013) is described by Margaret Anderson Kelliher, president and CEO of the Minnesota High Tech Association and former Speaker of the Minnesota House of Representatives, as "thoroughly researched and engagingly written . . . a much needed look at the roots of Minnesota's high-tech economy."



Minnesota has played a prominent role in the computing industry, beginning with Engineering Research Associates (ERA). During 1952-1955, ERA was reorganized into a division of Sperry Rand Univac. In 1957, well-known Control Data was a spin-off from Univac. Seymour Cray's (EE'49, MSApplied Math'51) famous supercomputing ventures were a further spin-off from CDC. Minneapolis Honeywell had distinction in the minicomputer market, and made the hardware nodes for the Arpanet, a forerunner to the Internet. IBM Rochester added design, development, and manufacturing muscle.

Because of this history, the CBI, founded in the late 1970s in Palo Alto, Calif., by University of Minnesota alumnus Erwin Tomash (EE'43), was moved to the University of Minnesota in 1980 after a nationwide search for a permanent home. Among the University's advantages, as seen by the CBI site search team, were its well-established history of science and technology graduate program and its built-in proximity to the science and engineering departments of the College of Science and Engineering, formerly the Institute of Technology.

Today, CBI's internationally recognized archive and research center contains oral histories, rare documents, unique photographs, and the finding guides to archival collections. Many resources can be accessed online at <www.cbi.umn.edu>.

To obtain a copy of the new book, go to http://www.upress.umn.edu/book-division/books/digital-state.

In Memoriam

Alumnus Dr. David L. Carlson (EE'58), inventor of the infant respiratory augmentor, died Mar. 11, 2013.

Carlson received his Bachelor of Electrical Engineering in 1958 from the University of Minnesota where he worked at the University radio station as a student. He received his Masters Degree in 1961 and his Ph.D. in 1964, both from Iowa State University (ISU).

With four ISU colleagues—Dr. William McCormack (pediatrician), Dr. Leon Arp (assistant professor of engineering graphics), J. Ben Buck (dental technologist), and James M. Varnum—Carlson developed one of the first successful infant respiratory augmentors capable of keeping premature babies (weighing only 1-2 pounds) alive. He received a patent for the device in 1967.

He also developed an ultrasound device that could detect pregnancy in livestock. Renco, a Minneapolis-based company, manufactured the device that would continue to be used worldwide for more than 35 years.

During his 30 years as an Iowa State University professor, Carlson taught undergraduate and graduate biomedical engineering courses.

With his extensive electrical engineering background, he advised many organizations including Los Alamos National Lab, NASA, and the World Health Organization, as well as serving as an expert witness regarding electrical device failures.

During his lifetime, Carlson was awarded eight patents. He received the Iowa Patent Law Association Inventor of the Year Award as well and the Iowa State University Alumni Association Faculty Citation award.

Students

2013-2014 Doctoral Dissertation Fellowship recipients

Mohammad Elbadry
Prof. Ramesh Harjani, advisor

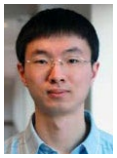
Omar Mehanna
Prof. Nikos Sidiropoulos, advisor

Tim Johnson
Prof. Sang-Hyun Oh, advisor

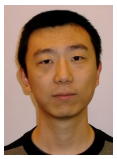
Meisam Razaviyayn
Prof. Zhi Quan Luo, advisor

Todd Klein
Prof. Jian-Ping Wang, advisor

Subhrajit Roychowdhury
Prof. Murti Salapaka, advisor



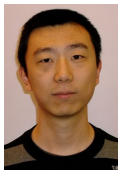
Huan Li
Prof. Mo Li, advisor



Feilong Liu
Prof. Paul Ruden, advisor

The University of Minnesota Doctoral Dissertation Fellowships are intended to enable Ph.D. candidates of particular promise to devote full-time effort to the research and writing of the dissertation during the length of one academic year.

Ph.D. candidate Vivek Bhandhari received first place in a recent social entrepreneurship challenge organized by Fulbright and the U.S. Dept. of State. The competition was based on topics of Energy, Water, and Maternal Health. There were nearly 130 participants from 60 countries participating in eight groups. (Prof. Ned Mohan, advisor)



Ph.D. student Feilong Liu won the University of Minnesota 2013 Supercomputing Grand Prize for "Numerical modeling of organic semiconductor heterostructure devices." (Prof. P. Paul Ruden, advisor)

Ph.D. candidate Lauren Otto received an NSF Graduate Research Fellowship. She also was awarded the University of Minnesota College of Science and Engineering Fellowship. (Prof. Sang-Hyun Oh, advisor)

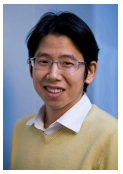
Graduating Master of Electrical Engineering student Mudita Suri won first prize in the 2013 Texas Energy Research Challenge hosted by University of Texas at Austin, along with U of MN student, Clark Koenigs (MS HHH) (Prof. Elizabeth Wilson, advisor). They presented "Evolving Context of Smart Grid: Technology and Policy across states and utilities." (Prof. Ned Mohan, advisor)

Undergraduate student Taylor Trimble received a President's Student Leadership and Service Award for 2013. The award is presented to approximately one-half of one percent of the student body for their exceptional leadership and service to the University of Minnesota and the surrounding community.

Graduate student Bo Yuan was selected to be one of the 12 student finalists in the 2013 Broadcom Foundation University Research Competition, June 5-6 during the 2013 Broadcom Technical Conference in Newport Beach, Calif. (Prof. Keshab Parhi, advisor)

Faculty

Prof. Massoud Amin has been named Government Technology's "Top 25 Doers, Dreamers and Drivers for 2013" as one who sets the standard for using innovative technology to solve public sector challenges and improve the performance of critical government programs. Amin was interviewed by "The Daily Circuit" – MPR and *Electricity Today* magazine about the U.S. Power Grid. He also served on the Environmental Congress – "Energy & Air," MNEC Panel in March 2013.



Prof. Chris H. Kim, and University of Minnesota researchers Wei Zhang and Ki Chul Chun, have developed a bit cell based on the gain cell embedded DRAM (eDRAM) concept. Fabricated in a standard 65nm logic process, the gain cell shows great promise according to KiloPass Technology, Inc.

Prof. Keshab Parhi was selected as one of the recipients for the University of Minnesota Award for Outstanding Contributions to Postbaccalaureate, Graduate, and Professional Education 2012-13. Recipients are chosen for excellence in instruction; involvement in students' research, scholarship, and professional development; development of instructional programs; and advising and mentoring of students.

Prof. Ned Mohan was selected for the 2013 Electrical and Computer Engineering Department Heads Association (ECEDHA) Innovative Program Award for his pioneering work in reforming the Electric Energy System Curriculum. He received the award in March at the annual conference awards banquet in Orlando, Fla. In addition, the Office of Naval Research (ONR) sent a news release titled "Navy Develops Power Engineering Curriculum with Universities Across U.S." in which Prof. Mohan is cited as the leader of the Consortium of Universities for Sustainable Power and the creator of the videos, textbooks, tests, assignments, and lab demonstrations that will help bring the nation's electric energy studies in line with current industry standards and practices.

News Briefs, continued on page 6

News Briefs, continued from page 5

Prof. Nikos Sidiropoulos received the 2013 Distinguished ECE Alumni Award from the University of Maryland-College Park where he earned his Ph.D. in 1992. In addition, Prof. Sidiropoulos was invited by the Office of Science and Technology Policy and the NITRD Big Data Senior Steering Group to participate in a White House Big Data Workshop held in May 2013. His NSF research projects that include work to develop theory and algorithms to tackle the complexity of language processing and methods to approximate how the human brain works in processing language were cited in congressional testimony by Dr. Farnam Jahanian, Assistant Director of CISE Directorate of NSF, on Apr. 24, 2013.

Prof. Gerald Sobelman was awarded the 2013 Charles E. Bowers Faculty Teaching Award. This award recognizes a University of Minnesota professor who has demonstrated exceptional interest and commitment to teaching. Established in 2000 by alumnus John Bowers (Physics '76) in honor of his father, Professor Emeritus Charles E. Bowers, this award recognizes an outstanding CSE professor who has demonstrated exceptional interest and commitment to teaching.

Prof. Beth Stadler was voted Top Instructor by students attending the 2012 IEEE Magnetics Society Summer School in Chennai, India. She taught for the IEEE program again this summer in Assisi, Italy, June 9-14. In addition, Prof. Stadler received the University of Minnesota Outstanding Mentor Award from the President's Distinguished Faculty Mentor Program. The program, established in 1986, pairs high-ability, underserved students with distinguished faculty members as mentors. This is the second time Stadler has received this award.

Visiting Researcher

Dr. Islam Shehata, a visiting researcher from Cairo University, Egypt, presented "Feasibility of high intensity focused ultrasound (HIFU) for treatment of polycystic ovarian syndrome using dual-mode ultrasound arrays: Tuning the exposure parameters" (authors Islam Shehata, John Ballard, Andrew Casper, Erik Cressman, Emad Ebbini) at the Society of Interventional Radiology (SIR) meeting in New Orleans, Louisiana (April 13-18). The research work features a new application of high intensity focused ultrasound (HIFU) for a potential non-invasive surgical treatment of polycystic ovarian syndrome (PCOS), a common cause of infertility among females. This potential application is conducted using advanced transducers, dual mode ultrasound arrays (DMUAs), that were developed by Dr. Ebbini's group.

Alumni

Suneel Arora (BEE'90), Schwegman Lundberg & Woessner, P.A., was chosen as a 2013 Client Choice award winner. In the United States, 222 attorneys were recognized and only 19 of those were patent lawyers. Suneel is one of five attorneys from Minnesota selected, and he is the only patent attorney in that group.

Dr. Hao Zhu (Ph.D.) accepted a position at University of Illinois, Urbana/Champaign as a tenure track assistant professor. (Prof. Georgios Giannakis, former advisor)

Dr. Shengli Zhou (Ph.D. '03), a faculty member at the University of Connecticut, recently was promoted to the rank of Professor with tenure. Prof. Zhou also received the Outstanding Faculty Advisor Award at the University of Connecticut. (Prof. G. B. Giannakis, former advisor)

Dr. Yannis Tsividis (BEE'72) receives University of Minnesota Outstanding Achievement Award

Columbia University professor Dr. Yannis Tsividis (BEE'72) (left) received the University of Minnesota Outstanding Achievement Award from Regent Thomas Devine (center) and ECE Department Head David Lilja (right).

Prof. Yannis Tsividis (BEE'72), Columbia University, developed a fully integrated MOS operational amplifier and demonstrated its use in PCM codecs at ISSCC'76. His work promptly was adopted by the industry and resulted in the first large-volume MOS mixed-signal product. Since then, he has completed pioneering work in areas ranging from fully-integrated analog filters to MOS transistor modeling, with wide industrial impact.

Tsividis is the Charles Batchelor Professor of Electrical Engineering at Columbia University, and has held positions at Motorola, AT&T Bell Laboratories, and the National Technical University of Athens, Greece. He is a Fellow of the IEEE and has received numerous awards, including the IEEE W.R.G. Baker Award, the IEEE CAS Society's Darlington and Guillemin-Cauer Awards, the 2003 IEEE International Solid-State Circuits Conference Outstanding Paper Award, and the 2007 IEEE Gustav Robert Kirchhoff Award. His latest book is the updated edition of his classic *Operation and Modeling of the MOS Transistor* (Oxford University Press, 1999).

Among his teaching awards are the Columbia University Distinguished Faculty Teaching Award, Columbia Engineering School Alumni Association (2010), the IEEE Undergraduate Teaching Award (2005), and the Columbia University Presidential Award for Outstanding Teaching (2003).

He holds a dozen patents in ten countries. He received his Bachelor's degree from the University of Minnesota in 1972, and the M.S. and Ph.D. degrees from the University of California, Berkeley in 1973 and 1976, respectively.

Making an Impact —

Establish a new scholarship fund through **Fast Start 4 Impact**

The Department of Electrical and Computer Engineering is excited to be participating in a new University-wide effort to build endowments for student support. At the center of this effort is a new program called Fast Start 4 Impact, available for a limited time, with a special benefit to donors making gifts for new endowed funds.

Fast Start 4 Impact provides the best of two worlds. It creates an endowed fund that grows each year for long-term use, and it also provides four years' worth of *immediate* funding to students. For each new endowment gift or four-year pledge of $50,000 or greater, Fast Start 4 Impact pays four years of annual scholarship or fellowship awards to students, while the earnings on the new endowment fund are re-invested for growth. It's a great way for donors to see more financial help going to students now, while also creating a permanent source of support for years to come.

Mary Leppala recently created the Robert A. and Mary C. Leppala Electrical Engineering Scholarship using Fast Start 4 Impact. Robert (Bob) Leppala earned his undergraduate degree in electrical engineering in 1964. He spent his career at IBM, retiring in 1994 at age 53. Bob passed away in February 2009, a few days before his sixty-eighth birthday.

Mary earned both a Bachelor's and a Master's Degree in Elementary Education from Winona State University in 1965 and 1977, respectively. She spent her career teaching and retired in 2005.

Mary writes, "One may ask why we are making this gift of scholarships to the University of Minnesota. To me, this gift combines a philosophy of life and a philosophy about the value of education. Every day holds something new to learn or to apply something that has been learned. One's education cannot be taken away; its value is in how it is used for the benefit of self and society, now and in the future. In honor of Bob's work and our belief in the value of education, we have established this scholarship in our names. "

For more information about Fast Star 4 Impact, go to:
http://www.giving.umn.edu/faststart/benefits.html.

FastStart 4 Impact

Faculty, continued from page 3

Prof. John Sartori—Computer Engineering, VLSI, and Circuits

Prof. John Sartori (left) received his Ph.D. in Electrical and Computer Engineering in 2012 from the University of Illinois, Urbana-Champaign.

Sartori's primary research thrust involves significantly improving the energy efficiency of computing systems. Currently, his work spans three main areas.

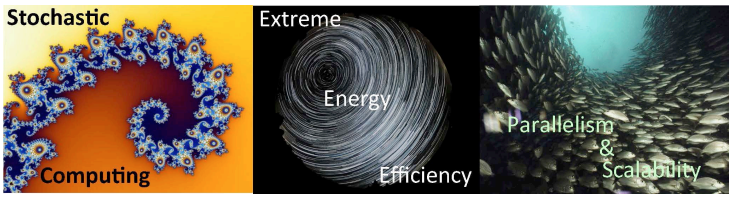
One branch of work, called stochastic computing, explores approaches for dramatically improving energy efficiency by re-designing processors and applications from the ground up to exploit software- or hardware-based noise tolerance. Sartori explains his research through an example of exploiting noise tolerance in visual perception systems. "Imagine watching a video on your cellphone," he says. "If a few pixels here or there have the wrong values, you probably won't notice. But, when I design a processor that is allowed to make these few errors, as opposed to the traditional processor that is not allowed to make any errors, the new processor can be much more energy efficient. The result is that your cellphone's battery can last twice as long." Sartori's current projects in this area include developing tools that will automate the design process for stochastic processors and applications.

Sartori also is exploring other unconventional approaches for achieving extreme energy efficiency. With support of an NSF/SRC grant, he is studying novel approaches for tolerating the increasing amount of variability in semiconductor chips. "A considerable fraction of the energy expended by processors just goes to make sure that they operate correctly all the time, under all possible conditions." Sartori is exploring energy-efficient approaches for adapting to variations rather than conservatively guarding against worst case conditions.

Another branch of Sartori's research involves exploiting parallelism and scalability, especially in the context of exascale systems. While new processors offer unprecedented levels of parallelism, utilizing that parallelism efficiently requires intelligently designed algorithms and data structures that are tailored for extreme parallelism. Sartori also notes the energy efficiency challenges in extreme parallel systems. "If we scale up one of today's most energy-efficient systems to the level of performance that we are targeting in next generation systems, we'll need a nuclear reactor just to power the system. Realistically, we will need to reduce the energy consumed by processors and applications by orders of magnitude in order to reach such ambitious performance targets."

Sartori is collaborating with other ECE faculty on research that will improve energy efficiency by obviating communication bottlenecks in large-scale parallel systems. He also is collaborating with Mechanical Engineering faculty to enable novel sensor networks by exploiting the computing capabilities of massively-parallel processors.

Currently, Sartori is working with five graduate students and will be adding two more to his team this fall. He also will be participating in the Research Experiences for Undergraduates (REU) program this summer, providing research experiences for students who have not worked in a research lab.



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Calendar of Events

Tues., Sept. 17
Fall 2013 Science and Engineering Career Fair
10 a.m. - 4 p.m., Mariucci Arena, TC Campus, University of Minnesota
For more information, go to: **ccse.umn.edu/fallcareerfair**

Mon. & Tues., Oct. 22 & 23
Cyber Security Summit 2013
7 a.m. - 5 p.m., Minneapolis Convention Center, Minneapolis, Minn.
For more information, go to: **www.cybersecuritysummit.org**

Tues. & Wed., Nov. 12 &13
2013 Robotics Alley Conference & Expo-Global Robotics and Automation
St. Paul River Center, Saint Paul, Minn.
For more information, go to: **roboticsalley.org**

Sat., Nov. 16
Math & Science Family Fun Fair
10 a.m. - 4 p.m., Coffman Memorial Union, TC Campus, University of Minnesota
For more information, go to: **cse.umn.edu/k12/CSE_CONTENT_254378**

Thurs., Dec. 5
ECE Senior Design Show
2-4:30 p.m., Coffman Union - Great Hall, TC Campus, University of Minnesota
For more information, go to: **www.ece.umn.edu**

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