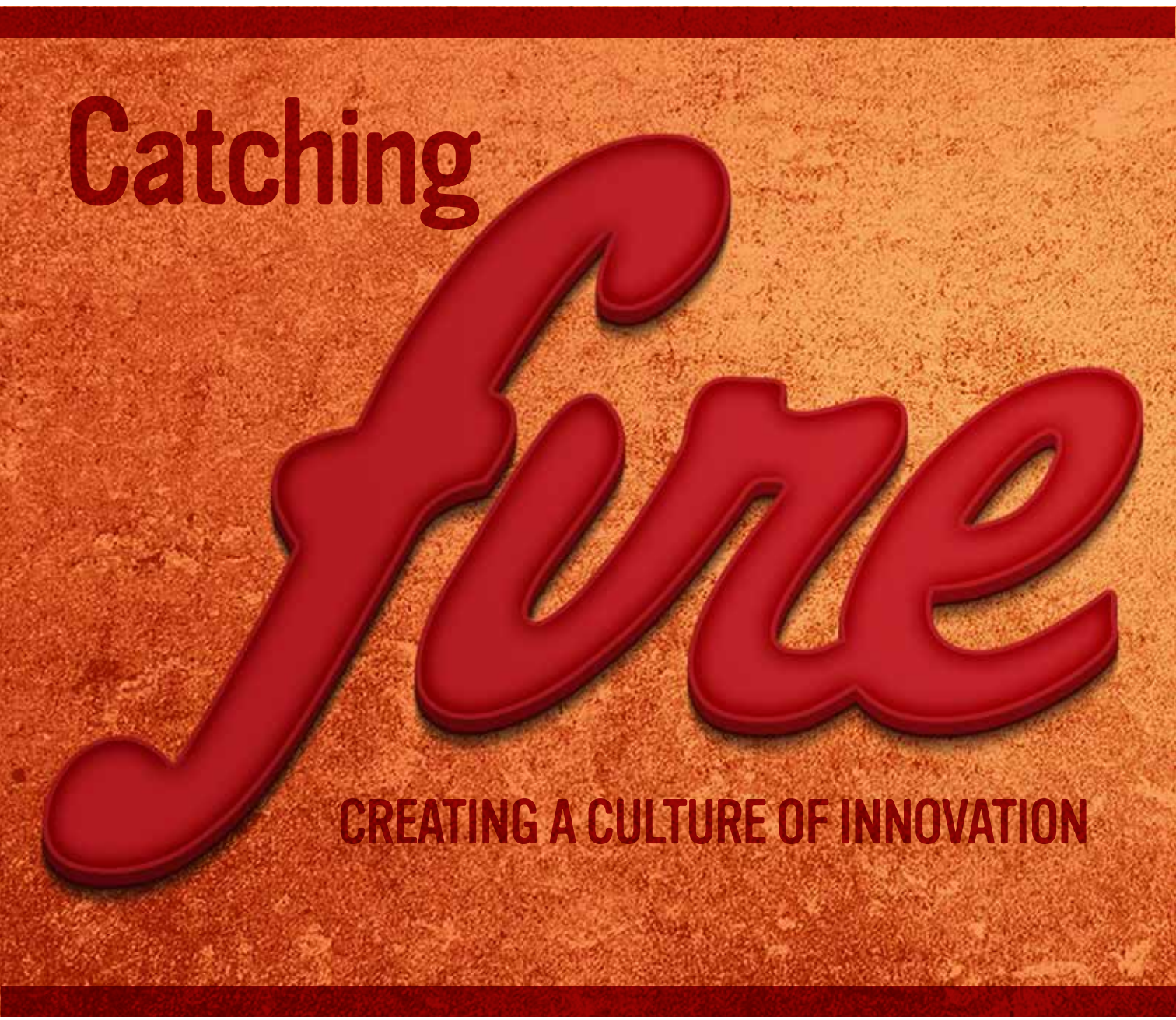
ALUMNI CHANGE THE WORLD TALKING TROLLS ECE TACKLES NANOFABRICATION POPESCU'S FIRST MICROSCOPE MOBILE PHONES IDENTIFY US FIELD REPORT WITH HILLERY HUNTER

RESONANCE

THE MAGAZINE OF ECE ILLINOIS

FALL 2014



ILLINOIS

TOP OF MIND

Great academic programs succeed because of myriad factors. World-renowned faculty members with carefully constructed, well-funded research programs are critical, but not enough. Success also takes highly creative, hardworking, talented students who approach their studies and research with enthusiasm and passion. In addition, a carefully crafted, continuously evolving curriculum ensures that the right amount of foundational knowledge is mixed with the latest developments to position students to be future leaders. Top-notch support services and extra-curricular opportunities make sure no interest and no need is left unattended. Finally, modern facilities that provide necessary tools and perhaps a bit of inspiration seal the deal.

While ECE ILLINOIS students have always benefited from world-class facilities spread across our engineering quads, ECE students began their semester Aug. 25 in a newly constructed, state-of-the-art home building. For the first time since 1949, ECE is based in the newest structure on campus. It's an important investment in our future, and not just because it's new. The building provides added opportunities, more hands-on learning, innovative course content, a benchmark-setting approach to energy efficiency, and proximity to other faculty and students. It's a game-changer for ECE.

This new building is the result of the hard work of many, including our ECE New Building Committee, which has been led tirelessly by Professor Phil Krein. Faculty and staff across the department, and many at the college and campus level too, have made this a reality. Leaders like former ECE department heads Richard Blahut and Andreas Cangellaris drove us forward. The State of Illinois made an important investment in the building, and we're grateful to Governor Pat Quinn for that. Finally, ECE's incredible and generous alumni believed in and helped fund this project.

We will celebrate the building and the future it will enable at our dedication ceremony and Alumni Board Homecoming Open House, both scheduled for October (more details on the back cover). It's an exciting time to be part of ECE ILLINOIS. I hope all ECE alumni will join us as we build on our legacy as a great academic program and launch a new era of excellence.

William H. Sanders
ECE Department Head
Donald Biggar Willett Professor of Engineering

RESONANCE

Fall 2014

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CONTENTS

_FEATURES

_DEPARTMENTS

"It's really ambitious, but that's the Illinois way. We take ideas and implement them in ingenious ways, and cost-effective ways."

Teaching Lab Specialist Dane Sievers,
on ECE ILLINOIS' new nanofabrication lab for undergraduates, the first of its kind he's aware of.
page 16

ACROSS THE SPECTRUM

JUMP TRADING GIFT

A $25-million gift from the financial technology firm Jump Trading launched a new partnership between Engineering at Illinois and the Jump Trading Simulation and Education Center at OSF HealthCare in Peoria. Known as Jump ARCHES, this $50-million-plus project will create new tools and technologies to simulate how patients respond to various treatments and operations. By combining these state-of-the-art simulation approaches with current medical equipment, the project aims to improve patient outcomes and quality of care, while simultaneously reducing health care costs.

ABET ACCREDITED

ECE ILLINOIS recently completed the evaluation process for continued ABET accreditation, which must be repeated every six years. This value-affirming designation requires rigorous reports on both electrical and computer engineering, which ABET reviews.

"We passed with flying colors," said Associate Head for Undergraduate Affairs Erhan Kudeki, who coordinated the process. "This is serious and, in various ways, something that requires a lot of hard work on the part of many people, but once again, we did very well."

JIN'S THIRD EDITION

The third edition of Professor Jianming Jin's well-known textbook, *The Finite Element Method in Electromagnetics* (Wiley), was released earlier this year. This edition contains 30 percent more material than the second edition, published in 2002, which, in turn, has almost 40 percent more material than the original 1993 edition.

The rapid growth mirrors the pace of innovation. Additional chapters cover domain decomposition, time-domain modeling, and the electromagnetic analysis of periodic structures and new devices.

ECE 398BD

BIG DATA CLASS

Some ECE ILLINOIS students have a new favorite class: Making Sense of Big Data, ECE 398BD. This team-taught course was initially offered last spring and is the first in the department's undergraduate sequence to focus specifically on Big Data. Seven ECE ILLINOIS faculty members led the students through a project-based curriculum, exploring topics that ranged from audio and video analysis to wave propagation and earthquakes, from bioinformatics to rumor transmission on social media. The course fits into a college-wide initiative to boost Big Data-related instruction and research.

WILLIAMS GIVES $1M

Alumnus Richard K. Williams (BSEE '80) provided a $1 million gift to ECE ILLINOIS. Half will go toward the new Electrical and Computer Engineering Building, in which he is sponsoring a classroom adjacent to the power electronics laboratories on the fourth floor. It will be named the Richard K. Williams Classroom. The other half of the gift will create an endowed professorship.

"[The classroom] will help bring students together to study energy, information, and process integration for future applications as diverse as electric transportation, interactive pad computers, personal medical devices, and renewable energy," said Professor Philip Krein, an expert in the area of power electronics and the chairman of the department's new building committee.

Williams invented the first trench power MOSFET in 1990. He subsequently founded Advanced Analogic Technologies, which became a leading producer of power-management components for mobile devices. Williams' connection with the department began in 1975 when Professor John Bardeen, the two-time Nobel Prize recipient, advised him on a high-school science-fair project.

GEORGE WELCOMED

Steven A. George has joined ECE ILLINOIS as the senior director of advancement and will work broadly to foster relationships with alumni and corporations, promoting the continued excellence of research and instruction in this department. He was most recently a senior major gift officer at the Illinois Institute of Technology, where he developed his interest in electrical and computer engineering.

"Steve has a proven history of successful development in higher education, particularly in the fields of science and technology," said ECE Department Head William H. Sanders. "His work will ensure alumni gifts of time, talent, advocacy, and financial resources will strengthen the department as a whole."

THREE JOIN ECE FACULTY

Three new faculty members joined ECE before the spring semester.

Associate Professor Kiruba Sivasubramaniam Haran is an expert on electric machines and power and energy systems, with 13 years of industry experience at GE's Global Research Center in upstate New York. Among his interests are superconducting machines that might be used in electric airplanes and other forms of transportation. This work requires an interdisciplinary approach, with concurrent innovations in other engineering disciplines. He was appointed an IEEE Fellow in 2014.

Assistant Professor Lav R. Varshney conducts research on the science and engineering of information systems that involve humans and machines. One recent project, begun during his three years at IBM's T.J. Watson Research Center in New York, focuses on computational creativity by demonstrating a computer system that can create novel flavorful recipes. The topic has garnered international media attention.

Assistant Professor Hao Zhu researches power systems monitoring, operations, and control, with specific applications for the smart grid. She recently collaborated with MechSE Assistant Professor Leonardo Chamorro, applying filtering ideas from traditional signal processing to predict how the wind turbines react to turbulence. Zhu joined Illinois as a postdoctoral research associate at the Information Trust Institute in August 2012.

DID YOU KNOW?

MORE THAN A THIRD OF ECE ILLINOIS UNDERGRADS PARTICIPATE IN RESEARCH WHILE EARNING THEIR DEGREES.

THANK YOU

DAN MAST

After 26 years of service in ECE, and almost 30 at the university, Manager of Systems and Services Dan Mast retired April 30.

His involvement in the department started when he was young, when he'd accompany his father, Professor Emeritus Edward Mast, and spent time in labs at Everitt. Dan is also an alumnus of the department (BSEE '84).

Mast said he's proud of all the Electronics Shop has accomplished during his tenure, including many updates to lab equipment the department provides for students and its implementation of electronic door locks to allow students more access. He's also proud of the way ECE supports students as they learn about their passions in the fields of electrical and computer engineering.

Mast is also proud of his work to help the department create long-term goals for equipment. "I've tried to provide the resources for the students to investigate whatever it is they want to learn and the opportunities to go in any direction they want to go," Mast said.

TANGÜL BAŞAR

ECE ILLINOIS' Chief Adviser Tangül Başar retired at the end of May. Başar was also a senior lecturer within the department.

Başar started her work in ECE ILLINOIS in January 1981. Between 1986 and 1989, she worked as an associate professor at the Illinois Institute of Technology, but returned to Illinois in 1989.

Başar said she's appreciated the quality of students and other faculty members within ECE. She's observed students going beyond the scope of material in their courses because they're so passionate. They're also doing quality research, and are prepared to make presentations at workshops and conferences. "It makes you proud, that you're a part of it," she said.

Başar is looking forward to staying involved with the department, and will continue to teach this fall. "I love teaching, so coming and giving lectures, that will be very comfortable for me," she said.

THOMAS STARR

ECE Distinguished Alumnus Thomas Starr (BS CompE '75, MS Computer Science '76) signs copies of his new science fiction novel, *Virtual Vengeance*, for graduate students. The novel is set at the Coordinated Science Laboratory on campus.

Photo courtesy of Miguel Moscoso

CONGRESSIONAL VISITS DAY

Seven Illinois students — including six from ECE ILLINOIS — spoke with legislators about the importance of research funding during the Congressional Visits Day in Washington, D.C.

Pictured from left to right: Braven Leung (Aerospace), Anthony Shvets, Gloria See, Lucas Hendren, and Miguel Moscoso. Not pictured: Alexander Hsu and Abhinav Chevula.

$320M DIGITAL LAB FOR MANUFACTURING

Last spring, President Barack Obama announced the inauguration of the Digital Lab for Manufacturing, a Chicago-based hub for innovation in digital manufacturing. Engineering at Illinois Dean Andreas C. Cangellaris was on hand at the White House for the announcement. The launch comes with $70 million from the Department of Defense and more than $250 million from public and private partners. Engineering at Illinois and the university's National Center for Supercomputing Applications are central members. William King, professor of mechanical science and engineering, is the lab's chief technical officer.

I-CORPS PROGRAM AT ILLINOIS

Illinois was chosen to be one of three locations for the National Science Foundation's new I-Corps Sites program. This program — short for Innovation Corps — aims to prepare university entrepreneurs for the transition into the commercial marketplace. The teams participate in an eight-week training session, consisting of four workshops where they learn about start-up methodology ranging from market evaluations to cold calls. The program is based at Illinois' Technology Entrepreneur Center. Participating teams are encouraged to apply for NSF's national I-Corps program.

I-CORPS
NSF Innovation Corps

PROFESSOR WILLIAM H. SANDERS NAMED DEPARTMENT HEAD OF ECE ILLINOIS

PROFESSOR WILLIAM H. SANDERS HAS BEEN NAMED DEPARTMENT HEAD OF ECE ILLINOIS.

Sanders served as interim head since July 2013, when former Department Head Andreas Cangellaris became dean of Engineering at Illinois. Sanders, a Donald Biggar Willett Professor of Engineering, previously served as the director of the university's Coordinated Science Laboratory (CSL), a premier, multidisciplinary research lab focused on information technology at the crossroads of computing, control, and communications. Sanders came to Illinois in 1994 as an associate professor of electrical and computer engineering and researcher in CSL. He earned the title of professor in 1998. His research is focused on dependability and security metrics and evaluation, architecting reliable and secure systems, and computer system modeling and analysis.

THE HENRY MAGNUSKI PROFESSOR OF ELECTRICAL AND COMPUTER ENGINEERING

BLAHUT RETIRES

RICHARD E. BLAHUT, FORMER ECE DEPARTMENT HEAD AND THE HENRY MAGNUSKI PROFESSOR OF ELECTRICAL AND COMPUTER ENGINEERING, RETIRED IN MAY AFTER 20 YEARS AT ILLINOIS.

Blahut joined the ECE faculty in 1994 after a successful 30-year career at IBM. His work made him a pioneer in the areas of error-control codes, passive emitter location, surveillance theory, signal processing, and digital communications systems. He's published 12 textbooks

Blahut taught at Cornell from 1973 to 1994, and also at the Swiss Federal Institute of Technology, the NATO Advanced Study Institute, and the South China University of Technology, where he was a consulting professor. He spent several months teaching in China in 1981, then one of the earliest Westerners in China after the cultural revolution ended.

Next year, he'll be a quarter-century member of the National Academy of Engineering. Blahut was named an IBM Fellow in 1980 and worked in the Federal Systems Division of that company. He's also a winner of the Alexander Graham Bell Medal and Claude Shannon Award.

He said he's proud of securing the key gift that brought the vision of a new ECE building back to life, and of his time in the department as a whole.

"I am proud to have served the faculty of the finest and strongest ECE Department in the world," he said, as he was department head for eight years. "I always believed that I worked for faculty, the students, and the alumni. It was also a privilege to have met and interacted with so many of my personal heroes, the leaders and founders of American and international corporations, many of them our alumni."

Left to right: Peter and Kim Fox and Professor Andrew C. Singer

ANDREW C.SINGER

In May, Professor Andrew C. Singer was invested as a Fox Family Professor in Electrical and Computer Engineering, recognizing his accomplishments as a technology innovator and entrepreneur.

Singer is the director of Illinois' Technology Entrepreneur Center, where he oversees a program that supports faculty and students as they make the transition from the research lab to the business table.

J. GARY EDEN

ECE Professor J. Gary Eden (MSEE '73 PhD '76) has been elected to membership in the National Academy of Engineering, in recognition of his development and commercialization of micro-plasma and excimer laser technologies.

His work has led to advances in multiple areas. Excimer lasers, for instance, are used industrially in semiconductor manufacturing and clinically for eye surgeries. His work has advanced ultrafast spectroscopy, which uses laser pulses to study the interactions between atoms and molecules, and photochemical vapor deposition, which uses lasers to deposit thin films on a surface.

›PROFESSORS ›BELABBAS›BOPPART›DO›EDEN›GODDARD ›HWU›JIN›KUMAR›PILAWA-PODGURSKI ›POPESCU›SCHUTT-AINE›SINGER›VASUDEVAN ›FACULTY AWARDS

MOHAMED ALI BELABBAS

Assistant Professor Mohamed Ali Belabbas received a CAREER Award from the National Science Foundation.

STEPHEN ALLEN BOPPART

Professor Stephen Allen Boppart was awarded the 2014 Innovation Transfer Award at Champaign County's Innovation Celebration.

MINH N. DO

Professor Minh N. Do has been named a Fellow of IEEE.

LYNFORD GODDARD

Associate Professor Lynford Goddard received the Engineering Council Outstanding Advising Award.

WEN-MEI W. HWU

Professor Wen-mei W. Hwu received the Collins Award for Innovative Teaching from the College of Engineering.

JIANMING JIN

Professor Jianming Jin was recognized with the 2014 ACES Technical Achievement Award from the Applied Computational Electromagnetics Society.

RAKESH KUMAR

Associate Professor Rakesh Kumar received the Engineering Council Outstanding Advising Award.

ROBERT PILAWA-PODGURSKI

Assistant Professor Robert Pilawa-Podgurski received the Engineering Council Outstanding Advising Award.

GABRIEL POPESCU

Associate Professor Gabriel Popescu has been named a Fellow of the International Society for Optics and Photonics (SPIE).

JOSE E. SCHUTT-AINE

Professor Jose E. Schutt-Aine received the Best Paper Award at 2013 IEEE Electrical Design of Advanced Packaging and Systems Symposium. He was also recognized with the Engineering Council Outstanding Advising Award.

ANDREW C. SINGER

Professor Andrew C. Singer has been named a distinguished lecturer of the IEEE Signal Processing Society.

SHOBHA VASUDEVAN

Assistant Professor Shobha Vasudevan received the best paper award at Very-Large-Scale-Integration (VLSI) Design 2014, and received the Dean's Award for Excellence in Research.

Catching fire

CREATING A CULTURE OF INNOVATION

BY DOUG PETERSON

JOSHUA SCHULTHEISS SAYS HE ALWAYS HEARS THE SAME QUESTION — WHY DID HE NAME HIS STARTUP COMPANY FLAMING CACTUS?

Schultheiss, an ECE student, says the name of his company was inspired by a percussion concert in which performers actually played music by plucking the needles of a real-life cactus.

"It was amazing how they could do something so innovative with a cactus," he says. "They took something that was dry and practically lifeless and breathed life into it."

In the same spirit, Schultheiss and many other students are breathing life into startup companies and tackling major problems with innovative solutions. Schultheiss co-founded Flaming Cactus with fellow students Anirudh Kosaraju and Soham Waychal — when they were all freshmen — to tackle the issue of home energy use.

The trio created an app that uses Bluetooth technology to automatically turn off lights in the house when they are not in use, potentially cutting energy costs by 10 percent. The system can cut another 10 percent in energy costs by shutting down outlets when they are not being used, because considerable power is drained through outlets, even when appliances are turned off.

ENTREPRENEURIAL ECOSYSTEM

To make such companies possible, ECE ILLINOIS has developed an efficient and elaborate "entrepreneurial ecosystem," in the words of ECE Professor Andrew Singer.

"An entrepreneur is someone who will pursue great ideas regardless of available resources," adds Singer, director of the Technology Entrepreneur Center, or TEC.

The center exists to help students find the resources to develop their ideas, offering 12 classes in entrepreneurship and engineering and reaching more than 4,000 Engineering at Illinois students each year through various programs.

Entrepreneurial programs for ECE students stretch from freshman to senior year and into graduate school. For instance, in 2010, TEC formed the Innovation Living-Learning Community, where 140 freshmen live and cultivate ideas together in the Illinois Street Residence (ISR) Hall. These students have access to special classes and programs, as well as "The Garage"—a lab in the basement that provides, tools, software, and computers "for students to gather around innovation."

In fact, Schultheiss credits ECE and the Innovation Living-Learning Community with giving him the confidence to take the plunge.

"THE MIND IS NOT A VESSEL TO BE FILLED, BUT A FIRE TO BE KINDLED."
-PLUTARCH

"Even though my father is an entrepreneur and I had this budding entrepreneur inside of me, I wasn't confident enough to let it grow," he says. "But as soon as I got on campus and met like-minded engineers, I really exploded with my ideas and my passion."

Forty years ago, the very notion of freshmen forming their own companies would have been unheard of, says ECE Professor Peter Sauer. Innovation has been an ECE hallmark from the very beginning, but until the last few decades it was not common for professors, let alone undergrads, to form companies around their research.

Take, for instance, legendary ECE Professor John Bardeen, the two-time Nobel Prize winner and inventor of the transistor in the late 1940s. Bardeen and his first PhD student, Nick Holonyak Jr., inventor of the LED, saw their work turn into products for Bell Laboratories and General Electric respectively, rather than start their own companies. That's generally the way it was done.

Sauer co-founded his own company, PowerWorld, in the late 1990s, and it was part of the university's incubator system, which at that time was modest compared with today's extensive Research Park on the south end of campus.

"Our company started in a World War II-era hut on the South Farms," Sauer recalls. "But all we needed was a room with a computer."

Today's incubator system at Research Park includes EnterpriseWorks, which is housed in a state-of-the-art building and provides an elaborate support system for new companies. EnterpriseWorks is a school of sorts, where fledgling companies get their start, "graduate," and then move out on their own.

However, a prerequisite for any startup is inspiration and motivation. One of Sauer's favorite sayings is a paraphrase of the words of Plutarch, a Greek philosopher: "Students are candles to be lighted, not bottles to be filled."

As he explains, "You don't just stuff students with lectures and turn them loose. You get them excited, you motivate them, you light them on fire. Then they take off."

This philosophy fostered the creation of ECE Pulse, a two-weekend event that started in 2012. The first weekend features a crash-course competition in which roughly 200 students compete to find solutions to problems in five different ECE areas. The catch is that teams must complete their designs in one day, says Ankit Jain, an ECE graduate student who directed the 2014 event as a senior.

The second weekend of ECE Pulse features tech talks and plenty of time to socialize and make the kind of informal connections that inspire innovation. Last year, for the first time, the conference also included a startup panel, where entrepreneurs shared the ups and downs of forming their own companies.

"A lot of students said they never thought of themselves as startup people, but after hearing stories at ECE Pulse, some are thinking they could do something entrepreneurial," Jain says.

Of course, some ideas can take years, even decades to develop, as ECE lecturer Lippold Haken stresses to his students.

"That is why the thing I want from them in my lab is constant effort," says Haken, who has been teaching ECE 395 since 2006. "Our course is about nurturing the joy of building things, the joy of making things work."

"THE THING I WANT FROM THEM IN MY LAB IS CONSTANT EFFORT. OUR COURSE IS ABOUT NURTURING THE JOY OF BUILDING THINGS, THE JOY OF MAKING THINGS WORK."
-LIPPOLD HAKEN

The course, long taught in the Advanced Digital Projects Laboratory, provides both the tools and a creative environment to tinker with ideas. The laboratory was packed with gadgets, including a robot that can play a piano and an old video game console that students used in the 1980s to create a primitive forerunner to Microsoft's first Flight Simulator.

In that space, an enormous potato launcher hung on a wall, and tucked out of sight, almost lost amidst the tangle of wires, was a steel platform with wheels—a primitive electric-powered car. Place a wooden office chair on the platform, and this car could zip you down the halls of Everitt Lab, where the lab was established.

This electric car also happens to be a piece of history. It was the design project of Martin Eberhard, an ECE alum who went on to found Tesla Motors and produce the first highway-ready electric vehicle in mass production in the United States. Eberhard's project, which he built in ECE 395, does not bear any resemblance to the famous Tesla Roadster; nevertheless, this early vehicle and the lab it sprang from are prime examples of the environment for innovation and entrepreneurship that ECE has created.

"This project was only the beginning of his dream," Haken says.

According to Sauer, ECE's atmosphere of collegiality and cooperation, coupled with Midwestern hard work, also makes it fertile ground for innovation, as ideas get tossed around over coffee.

In fact, he says the new ECE Building, which opened this fall, has been designed with this in mind, providing many open spaces where people can come together and talk.

In addition, students can pitch their ideas in formal venues, such as TEC's Social Fuse, an activity for student entrepreneurs every other month. Entrepreneurship and innovation are also honored annually through the Cozad New Venture Competition and the Illinois Innovation Prize. The Cozad Competition honors the top team venture each year, while the Illinois Innovation Prize celebrates the most innovative Illinois student in engineering.

Then there is the capstone experience for ECE majors—the senior design class, where about 300 students each year form teams and design innovative products of their own.

ONE THIRD

OF CURRENT TENURE-TRACK FACULTY HAVE STARTED THEIR OWN COMPANIES.

OF INVENTION DISCLOSURES ON CAMPUS IN 2012-13 WERE ASSOCIATED WITH ECE FACULTY MEMBERS.

OF ECE ILLINOIS UNDERGRADS PARTICIPATE IN RESEARCH WHILE EARNING THEIR DEGREES.

ECE FACULTY MEMBERS ARE A FORCE IN LICENSING INTELLECTUAL PROPERTY AT THE UNIVERSITY OF ILLINOIS. THEIR TECHNOLOGY HAS FUELED MORE THAN A QUARTER OF START-UPS ON CAMPUS SINCE 2008.

25%
INTELLECTUAL PROPERTY

20%
ACTIVE PATENT DISCLOSURES
ON CAMPUS WERE ASSOCIATED WITH ECE FACULTY MEMBERS.

224
ACTIVE PATENTS
ASSOCIATED WITH THEIR WORK AT ILLINOIS.

"YOU DON'T JUST STUFF STUDENTS WITH LECTURES AND TURN THEM LOOSE. YOU GET THEM EXCITED, YOU MOTIVATE THEM, YOU LIGHT THEM ON FIRE."
-PETER SAUER

"The students own and drive their own projects," says Professor Scott Carney, the course director for senior design. "We tell them, 'This is your class and you own it and you have to rise to the occasion.'"

Students can generate their own ideas, but the course also brings in external mentors from industry, who pitch problems that need to be solved.

"We turn the usual model on its head," Carney says. "Rather than the students going to them, it's the mentor who says, 'Here's a really cool thing to work on.' The mentor has to sell the students.

"We try to instill in them the idea that interesting problems are a lot harder to come by than interesting solutions."

Senior design projects run the gamut, from thermal monitors for firefighters to an alarm that detects when a driver is getting drowsy. Several recent projects are even helping Illinois researchers monitor American river otters, which are making a comeback in Illinois. For example, one group developed a device that can be buried in the ground and take images of paw prints as the otters pass over it. The paw prints act like fingerprints, identifying individual otters and helping researchers keep tabs on the population.

Carney says one of the simplest, most elegant ideas to come out of last year's senior design is the Cube Clock, a cube-shaped clock with the current time on one face and the alarm time on another face. To arm the alarm, simply place the alarm time face down. To turn off the alarm, turn it back up. No more fumbling for alarm switches in the dark.

Another 2014 senior design project, this one with international implications, is an HIV diagnostic device more portable than current lab diagnosis equipment, making it particularly valuable in less developed countries.

"The technology from Illinois is really far reaching. It's out there," Singer says. "So stay tuned. There's a lot more to come."

WANT TO HELP? HERE'S HOW.

SUPPORT FROM ALUMNI AND FRIENDS IS CRUCIAL AS WE PROVIDE OUR STUDENTS THE EDUCATION AND RESOURCES THEY NEED TO BE INNOVATIVE CITIZENS. TO GET INVOLVED, YOU CAN MENTOR STUDENTS TAKING SENIOR DESIGN, GIVE A TALK ON CAMPUS, OR MAKE A DONATION IN SUPPORT OF STUDENT PROJECTS OR SCHOLARSHIPS.

ECE.ILLINOIS.EDU/ALUMNI/GIVEBACK

FIRED UP

FOUR ECE ALUMNI STARTUPS THAT HAVE CHANGED THE WORLD

BY ROB LAMMLE

ECE ILLINOIS has a reputation for helping great minds reach their full potential. Many ECE graduates work successfully in their chosen fields. Here are just four of the many startups founded by ECE alumni that have helped change the world we live in today.

When **Martin Eberhard (BS CompE '82, MSEE '84)** and Marc Tarpenning founded **Tesla Motors** in 2003, their mission was to change old notions of what an electric automobile could be. By introducing the Roadster, a flashy, electric sports car, they quickly changed the public's perception. However, it's been their technological innovations that have made the auto industry take notice. When Tesla engineers experimented with lithium-ion batteries as a car power source, rival companies insisted the technology was at least a decade away. But Tesla was able to achieve more than 200 miles per charge, spurring other manufacturers to think outside the boxy, boring grocery-getter, to create more exciting, more efficient electric automobiles. Eberhard has moved on from Tesla, but continues entrepreneurial pursuits.

Jeremy Stoppelman (BS CompE '99) was searching for something more. He left his job at PayPal to attend Harvard Business School, and then left Harvard a year later in 2004 to co-found **Yelp**. More than just an online Yellow Pages, Yelp boasts more than 57 million business reviews by over 130 million unique visitors every month from 24 countries across the globe. Users search for anything from a good autobody shop to the best zucchini at the farmer's market with their smartphones, generating nearly 60 percent of the site's traffic. And with convenient features like current location awareness and restaurant reservations at the tap of a touchscreen, Yelp has become one of the most popular apps in the world.

Not many can say they're the fathers of an industry, but **Jerry Sanders (BSEE '58)** can. In 1969, Sanders co-founded **Advanced Micro Devices (AMD)** in Silicon Valley, long before the California region had earned its famous nickname. The company originally made logic chips, but later moved into microprocessors, often playing second fiddle to industry leader Intel. AMD had a breakthrough in 1997, though, with the K6, a chip that rivaled the performance of Intel's popular Pentium II at a fraction of the cost. Sanders retired in 2001, and since then, AMD has shifted focus to computer graphics. Today, AMD chips power every major home video game system.

Quantum Electro Opto Systems (QEOS) specializes in Light Emitting Diode (LED) optical communication solutions using their own Tilted Charge Dynamics technology to deliver information at speeds of up to 10 Gbps while consuming less than 1 mW/Gbps. The technology may not be as easily relatable to consumers as an electric sports car, but QEOS innovations have the potential to speed up internet connectivity, make high-definition televisions look even better, and help nearly all of our digital devices run faster, using a fraction of the power needed today. Under the guidance of founders and ECE alumni **Gabriel Walter (BSEE '98, MSEE '00, PhD '03), Nick Holonyak Jr. (BSEE '50, MSEE '51, PhD '54),** who invented the LED, **and Milton Feng (MSEE '76, PhD '79)**, QEOS is currently focusing its efforts on the Q-Link line of high-definition video surveillance systems. They stream uncompressed images at full frame rates while consuming 75 percent less power than current high-definition cameras. **Ray Chin (PhD '80)** is chairman of the board.

NANO LAB

INTEL DONATION PROVIDES UNDERGRADS THE CHANCE TO WORK IN THE ECE ILLINOIS GROUNDBREAKING NANOFABRICATION LAB

BY MEG DICKINSON

Nanofabrication is an important technnology in the tech industry right now, but the typical undergraduate student doesn't have a chance to try it.

That's about to change at ECE ILLINOIS.

Intel donated three pieces of equipment that form the basis of a lab space that will allow undergraduates to learn about nanofabrication. It is located in the new Electrical and Computer Engineering Building's nanofabrication laboratory.

"For students, using this equipment will expose them to research-level processes that most students never have the opportunity to explore until graduate school," said Dane Sievers, an engineering teaching lab specialist at ECE. The lab is expected to open this spring.

Not only will students be using the equipment to learn techniques at the forefront of technology right now, but they'll also get a sense of what kind of technology is out there. They'll be exposed to new ideas early in their academic careers, Sievers said.

"It's really ambitious, but that's the Illinois way," Sievers said, adding that ECE's existing clean room technology for students has given the department a proven record of allowing students such opportunities. "We take ideas and implement them in ingenious ways, and cost-effective ways."

Seventeen years ago, a donation from Intel helped Illinois continue to find the best way to teach students about fabricating integrated circuits in its clean room in the basement of Everitt Lab.

ECE ILLINOIS pioneered that concept, starting in the mid-1960s, Sievers said, and the donated equipment from Intel will allow it to do the same with nanofabrication.

The lab and its equipment will expand graduating students' knowledge, and expose them to new and emerging processes and technologies that, until now, haven't been available in any undergraduate lab Sievers knows about.

Intel Senior Fellow and ECE alumnus Mark Bohr (MSEE '78) said Illinois has been a leader among academic institutions as it offers a microfabrication laboratory course for its undergraduates.

"This course gives students hands-on training and experience in some of the fabrication techniques used by integrated circuit companies like Intel to make microprocessor chips," he said.

"With an eye to the future, this new laboratory course for undergraduate students teaches nanofabrication techniques using dimensions about 1,000 times smaller than in the previous course."

It will also allow students to work with new materials and devices beyond traditional silicon transistors, he said.

"Intel is a strong supporter of engineering education and believes that this new nanofabrication course will both prepare and interest students in some of the engineering challenges we'll face over the next 40 years," Bohr said. "I'm very pleased that Intel had the opportunity to play a part in setting up this new nanofabrication class."

Many current Intel employees spent time learning in ECE's Fab Lab, said Michael Hattendorf (BSEE '97, MSEE '00, PhD '02), a process integration engineer at Intel who also serves on the ECE Alumni Board.

Laura Bain, an Intel recruiter and campus engagement manager, said Illinois alums who end up working at Intel have a history of being successful within the company. In the last five years, the company has hired almost 100 students who have earned their PhDs at ECE ILLINOIS.

"We recognize that pipeline, that something's working," she said, and Intel wants to grow and strengthen that connection. "This is a demonstration of us continuing to foster that relationship, and making it the best it can be."

ECE Professor Joseph W. Lyding said the lab will be "one of the most advanced teaching facilities ever devoted to undergraduate education."

"The nanofabrication teaching laboratory will give our students a unique immersive perspective on how nanotechnology is changing our modern world," he said.

While the equipment donation from Intel will provide the basis for ECE ILLINOIS' nanofabrication laboratory, the department envisions the lab as a space that trains students on additional cutting-edge equipment. Donated research equipment should be functional and less than 10 years old. To see a complete wish-list for the lab, please visit go.ece.illinois.edu/wishlist (opens as a PDF).

Anyone interested in donating equipment or providing financial support for the lab or other spaces in the ECE Building should contact Steve George, ECE's senior director of advancement, at steveg@illinois.edu or (217) 244-8023.

FOCAL POINT

THE OUKAÏMEDEN OBSERVATORY

IN THE ATLAS MOUNTAINS OF MOROCCO IS THE SITE OF AN ILLINOIS RESEARCH TEAM'S SYSTEM THAT OBSERVES THE THERMOSPHERIC AND IONOSPHERIC LAYERS OF THE EARTH'S OUTER ATMOSPHERE. PROFESSOR JONATHAN MAKELA LEADS THE TEAM.

GO.ECE.ILLINOIS.EDU/MOROCCO.

ECE ILLINOIS
Department of Electrical and Computer Engineering

PHOTO BY BRIAN HARDING

SCROLL + CLICK WITH YOUR EYES

BY JONATHAN DAMERY

These days, we touch computers and they respond. We talk to them, motion at them. Supermarket self-checkout kiosks have no physical keyboard. Neither do smartphones or tablets. You can query the web with spoken commands, or you can request directions. Next you might simply look — glance at an application icon, perhaps blink your eyes, and the application would launch. The text could scroll automatically as you reach the bottom of the screen.

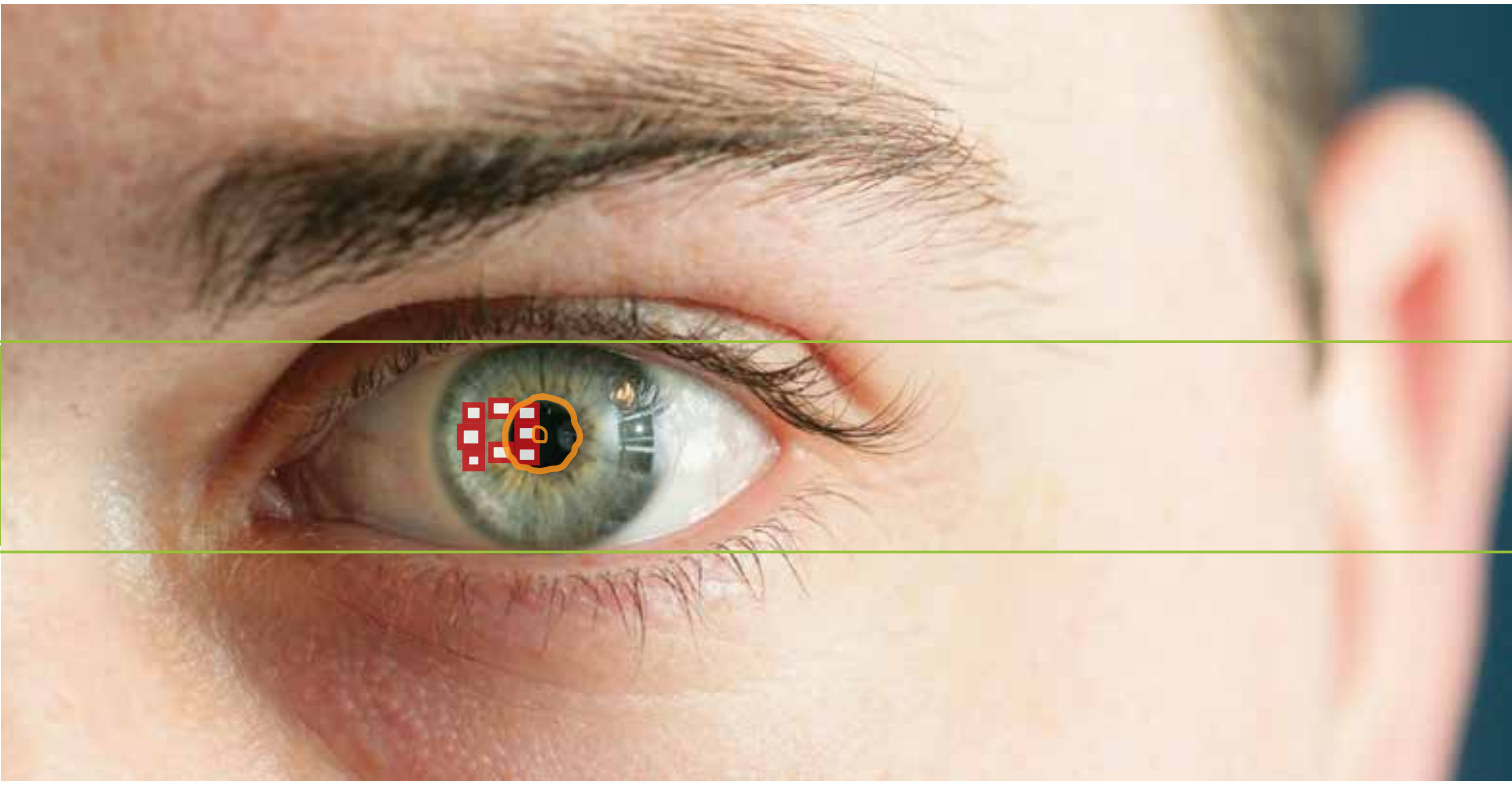
"Gaze is faster than touch," said Jia-Bin Huang, a graduate student working in Professor Narendra Ahuja's research group. "You need to look at something before you can even touch it."

While there have been considerable developments in eye-tracking research over the past several decades, practical systems for out-of-the-box computers or smartphones have been slow coming. Some of the most accurate systems, at this point, require a chinrest to keep the head stable before the screen — a limitation that deters widespread consumer appeal.

Huang, Ahuja, and collaborators at Microsoft, however, have demonstrated an innovative solution to this problem, which garnered the best paper award at the 2014 Symposium on Eye Tracking Research and Applications (ETRA), held at the end of March near Tampa, Florida. It could be a breakthrough. Recent eye-tracking research has emphasized two competing needs: accuracy, of course, and also flexibility (known as "robustness" in technical parlance). Oftentimes, the more accurate the tracking, the more limited the overall device. In psychological studies, for example, researchers use eye-tracking systems to observe how the eye moves across advertisements and other images. These systems are accurate, but the head must remain fixed. The chinrest is needed. There is little flexibility.

Huang's research, which began during an internship at Microsoft Research Redmond and continued with the support of researchers there — Qin Cai, Zicheng Liu, and Zhengyou Zhang — accounts for both of those needs. The goal is to create a more natural experience. If you're using a laptop, you should be able to lean toward the screen without losing accuracy. You should be able to walk away from the screen, come back, and sit down, without needing to resume the exact same position.

"HOW DO YOU INTEGRATE EYE GAZE AND GESTURE AND THE SPEECH, AND ALL OF THIS SENSORY [INFORMATION] TOGETHER TO BETTER COMMUNICATE WITH THE COMPUTER?"
-JIA-BIN HUANG



This color illustration shows how Huang's eye-tracking technology uses the reflection of eight infrared LEDs to monitor eye movement relative to the cornea and pupil center. Note that a color image cannot show infrared light.

Most eye-tracking systems are based on the same overall design. At least two lights — generally infrared LEDs — are positioned around the margin of the screen. The reflections of the lights on the eye are monitored, relative to the cornea and pupil, with a forward-facing camera. The system is calibrated by having the user look at a several points on the screen, thus recording the appearance of the reflections as the eyes gaze in various directions.

Huang and his collaborators take this same approach, but they devised virtual eyes for training the system. The virtual eyes are simulated at 125 locations within a cubed space, which, measuring 40 centimeters in each direction, replicates the size of a hypothetical workspace. This simulation helped the investigators understand how various factors, including eye parameters and noise levels, affect the accuracy and flexibility of the eye tracking. The simulations allowed Huang to design tracking algorithms — a type of adaptive homography mapping — with many more data points than could have been acquired using lab participants.

"This type of research would remind me of, for example, how Google is successful," Huang said. "If you type something in Google and it can correct what you type, it's not because Google is smart and it knows this typo. It's because it has so much data. It lets the data speak."

Their system initially ran through simulations with 50 virtual pairs of eyes, each with different eye characteristics, representing natural variations within a population. Then, the researchers did physical experiments, asking test subjects to gaze at a series of points from various positions.

The results show that the new system was significantly more flexible, compared to existing methods, when the subjects moved within the workspace. If the system was calibrated with the eyes 60 centimeters away from the screen, for example, and the subject then moved 10 centimeters closer, Huang's method was 40 percent more accurate in predicting the eye gaze.

A patent has been filed for the technology, and other teams at Microsoft are considering potential applications.

"It would be convenient," Huang said of a system like this, someday incorporated into widespread, commercial devices. "It will be a very big question of, how do you integrate eye gaze and gesture and the speech, and all of this sensory [information] together to better communicate with the computer?"

OPINION:
THE INNOVATION ACT

IN 2011, THE AMERICA INVENTS ACT SIGNIFICANTLY OVERHAULED THE U.S. PATENT SYSTEM. FOLLOWING CLOSELY ON ITS HEELS, LEGISLATION IN THE HOUSE AND SENATE HAVE FUELED THE DEBATE ABOUT FURTHER REFORMS THAT WILL AFFECT PATENT OWNERS AND LICENSEES.

Specifically, proposed legislation — which passed in the House but was tabled in the Senate this spring — sought to curb the influence of patent assertion entities (PAEs, also known as "patent trolls").

The House's bill, known as HR 3309 or the Innovation Act, raised the concern of many universities that its sweeping provisions will weaken their ability to protect their intellectual property, thereby making it more difficult to bring research breakthroughs into public use.

On the other side, many major technology companies support the legislation because of the high cost involved with fighting lawsuits brought by patent trolls. According to the White House, lawsuits brought by patent assertion entities have tripled in the last two years, and now represent 62 percent of all patent infringement suits. Estimates from the White House report suggest that these patent trolls have used aggressive litigation to threaten more than 100,000 companies with patent infringement in the last year alone.

CROSS TALK is a forum for individual opinions, not necessarily shared by ECE ILLINOIS. There's much more to say on the topic of patent legislation. Please share your opinion with us.

SHARE YOUR OPINION AT ECE.ILLINOIS.EDU/LINKEDIN

INNOVATION ACT

LESLEY MILLAR-NICHOLSON: Director of Illinois' Office of Technology Management

While the Innovation Act aims to protect companies from the abusive practices of patent trolls, passage of the act — in its current form — would also have damaging implications for university technology transfer.

The problem for universities stems from the Innovation Act's goal of targeting "non-practicing entities." Non-practicing entities are organizations that hold patents and enforce patent rights, but they do not manufacture or supply the services they represent. Broadly speaking, both universities and patent trolls can be classified as non-practicing entities. However, the motivations of patent trolls and universities are completely different.

University technology transfer moves the innovations that result from academic research into the public use often via startup companies, thereby creating value through economic growth and impact in society. Patent trolls aggregate patents from a variety of sources, then find users of the patents and sue them. Universities are not patent trolls. But under the proposed legislation, universities will be penalized as though they are.

Provisions within the Act expose universities and their licensees to massive financial risks. Fee-shifting provisions will mean that universities seeking to appropriately enforce their patent rights against infringers will be liable for the opposing parties' legal costs if the case is lost. In addition, joinder provisions mean that universities will be liable for these same legal costs if their licensees initiate and lose an infringement case. These penalties would make it difficult for universities to uphold their patent rights. Without that ability, what is the value of our patents?

Even worse, this risk will be a deterrent to potential investors whose funding is so critical to the success of early-stage businesses. Further, it will be a deterrent to potential licensees who are already undertaking a risky venture by committing the time, money, and resources needed to develop early-stage research into a finished product, process, or service. Increasingly, these are risks that large businesses are unwilling to take, hence the keen focus on universities as critical source of economic growth for the nation.

According to a joint statement made by six higher education associations, "more than half of U.S. economic growth since World War II is a result of technological innovation, much of which has resulted from federally funded scientific research." Universities are the stewards of federally funded research. In fact, it was the federal government through the Bayh-Dole Act of 1980 that gave universities title to the federally funded research performed on their campuses. In 2002, *The Economist* said of the Bayh-Dole Act, "more than anything, this single policy measure helped reverse America's precipitous slide into industrial irrelevance."

Universities have spun out more than 4,000 start-up companies since Bayh-Dole was enacted, according to the Association of University Technology Managers. At Illinois, we've licensed more than 30 start-up companies in the last five years alone. Those start-up companies that have incubated in our research park have raised more than $575 million in venture capital and angel funding. The University of Illinois has medical devices and therapeutics, software, electronics, environmental, and energy technologies (and much, much more) all in use today, benefiting society because of university technology transfer.

As a nation, we can't afford to jeopardize these gains by rushing to pass legislation that will have such broad and sweeping unintended negative consequences.

Lesley Millar-Nicholson is the director of the Office of Technology Management (OTM) at Illinois. She leads a team responsible for engaging with faculty, staff, corporations, and venture groups to commercialize the intellectual property arising from the more than $500 million in research conducted on campus.

"PATENT TROLLS AGGREGATE PATENTS FROM A VARIETY OF SOURCES THEN FIND USERS OF THE PATENTS AND SUE THEM."
-LESLEY MILLAR-NICHOLSON

THE PROBLEM WITH PATENT TROLLS

Christopher N. George: Partner in the Chicago office of Hanley, Flight & Zimmerman, LLC

A U.S. patent right is rooted in the Constitution, which gives Congress the power "to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

Thus, the Constitution itself provides for a limited monopoly right to be granted to inventors for their discoveries. This right isn't limited by type of inventor, and the patent laws which codify certain aspects of this right allow assignment of that patent right to someone else. The owner of a patent, as with other property, is entitled to use that property right within the bounds of the law.

Throughout U.S. history, patents have undergone a healthy scrutiny that results from the checks and balances provided by our American government—Congress passes the patent laws; the courts (including a specialized patent appeals court in the U.S. Court of Appeals for the Federal Circuit) interpret those laws; and the U.S. Patent and Trademark Office (an agency of the executive branch) develops rules to enforce those laws and the courts' interpretation of them. This interplay among the branches of government has evolved with technology, business, and society, and has served to maintain the patent right as an innovation incentive.

In recent years, a spotlight has shone on abusive litigation (or threat of litigation) tactics used by certain patent holders. These patent holders are known by various names, and whether they're called patent trolls, non-practicing entities (NPEs), or patent assertion entities (PAEs), they have stirred much debate over their definition and treatment.

For example, the International Trade Commission defines an NPE as "a company that does not manufacture or market a product that practices the specific patent(s) asserted by the NPE." The problem with such a definition is that it can encompass universities, governmental research labs, and many individual inventors, who should, in fact, be encouraged to innovate and protect their innovations. To hold otherwise would be to discount the important innovations made (and patents obtained) by Bell Labs, the University of Illinois, MIT, and many others who invent but do not manufacture a product. Instead, their ability to leverage their inventions with patents provides funding and collaboration partners to spur continued innovation, which finds its way into corporate R&D and eventually into products.

Perhaps more specifically, the U.S. Federal Trade Commission has defined PAEs as "firms with a business model based primarily on purchasing patents and then attempting to generate revenue by litigating against, or licensing to, persons who are already practicing the patented technology." This definition may not include universities or research labs, but long-standing technology innovators including, IBM, Motorola, Qualcomm, and Kodak have licensed, sued, and made money from their patents, aside from their products.

There have been, and will continue to be, bad patents, and the goal of the patent system should be to minimize their occurrence. However, the Patent Office and courts already have procedures in place to challenge and review both bad patents and bad actors. While a June 2013 White House report focuses on PAEs, a report released in August 2013 by the Government Accountability Office reveals only a slight increase in the total number of patent lawsuits over the last decade, with an increase in 2011 spurred mostly by changes in the law through the America Invents Act rather than as a result of specific actions by PAEs.

Rather than precluding patent litigation or making litigation unduly burdensome based on type of patent owner, a wide array of mechanisms already exist to reign in abusive patent litigation tactics. "Loser pays" and other proposals that have been raised but sidelined in Congress serve to punish the smaller patent owner or researcher trying to avail themselves of the legitimate benefits of their patents, and may not be effective against a savvy patent troll. Even companies on the receiving end of many patent troll threats are reluctant to put special procedures in place that may be overkill. Rather than focusing on who the patent holder is, traditional doctrines of patent misuse, unfair competition, deceptive trade practices, professional responsibility, and an increased ability for a judge to award attorneys' fees in exceptional cases can and should be used to help stop abuse of the patent system by bad actors, regardless of their form or title.

Christopher N. George (BS CompE '97, MSEE '99, JD '02) is a partner in the Chicago office of Hanley, Flight & Zimmerman, LLC. He is a member and past president of the ECE ILLINOIS Alumni Board.

"A SPOTLIGHT HAS SHONE ON ABUSIVE LITIGATION (OR THREAT OF LITIGATION) TACTICS USED BY CERTAIN PATENT HOLDERS."
-CHRISTOPHER GEORGE

SIDNEY BOWHILL

TAKING AERONOMY RESEARCH TO NEW HEIGHTS

BY JAMIE HUTCHINSON

Sidney Bowhill (right) with ECE Department Head Ed Jordan in 1966. In Bowhill's hands is a special antenna for aeronomy research, to be launched with the rocket shown. Courtesy of the University of Illinois Archives.

From deploying probes at the North and South Poles, to launching satellite payloads, to analyzing data from massive radars in distant lands, ECE ILLINOIS researchers have long contributed to our understanding of Earth's middle and upper atmosphere.

The man who put Illinois on the map for this kind of research was Professor Sidney Allan Bowhill (1927–2012), who directed the Aeronomy Laboratory from 1962 until 1987.

Born and raised in England, Bowhill did his doctoral work in physics at Cambridge University's Cavendish Laboratory. Upon coming to Illinois in 1962, he founded the Aeronomy Laboratory and quickly led the lab to a position of international respect. Bowhill's work helped explain the fading of low-frequency radio signals and dispersive characteristics of the ionosphere, high-frequency ionosphere absorption and Faraday rotation effects, electron density as a function of altitude, and photochemical and diffusion effects in the ionosphere.

Wide-ranging collaboration was a hallmark of the Aeronomy Laboratory, which hosted conferences attracting scientists from all over the world. The lab played an important role in research projects during the International Year of the Quiet Sun in 1964–65, when the sunspot cycle had ebbed to its minimum. The lab also participated in the Middle Atmosphere Program. It was a 1980s project overseen by the International Council of Scientific Unions and implemented by the Scientific Committee on Solar-Terrestrial Physics, an international organization based at the lab for a period during the 1980s.

Bowhill collaborated across disciplinary as well as national borders. Aeronomy Lab personnel specialized in physics, chemistry, electrodynamics, and meteorology; they joined forces with physical electronics experts to develop space-based lidar systems, and with antenna experts to build a radar facility near the Urbana campus. Bowhill developed an expertise in computational science and is counted among the first to adapt Monte Carlo computational techniques to study of the atmosphere.

Standing 6 feet, 7 inches, Bowhill commanded attention with his hearty laugh and colorful personality marked by a thespian streak. He was founding president, and a regular cast member, of the Champaign-Urbana Community Theater.

POCKET-SIZED TECHNOLOGY, BIG IMPLICATIONS

BY JONATHAN DAMERY

THE EVOLUTION OF MOBILE COMPUTING TECHNOLOGY HAS BEEN SO NATURAL, SO INTUITIVE, THAT IT'S ALMOST HARD FOR SMARTPHONE USERS TO REMEMBER THAT 10 YEARS AGO, MOST PHONES PERFORMED COMMUNICATIONS ONLY. WHILE OTHER PORTABLE COMPUTING TECHNOLOGIES PREDATED THE SMARTPHONE, EXPANSIVE POSSIBILITIES (AND CHALLENGES) PRESENT THEMSELVES WHEN THE DEVICE IS ALWAYS RUNNING, TUCKED IN A POCKET OR PURSE, WHEN NOT IN HAND.

"The laptop is very different from the mobile phone because mobility and computing were not happening in parallel. You would type on the laptop, close it, move to a different area, open it and do something, and close the laptop," said Associate Professor Romit Roy Choudhury (MSEE '03, PhD Computer Science '06). Roy Choudhury is affliliated with Illinois' Coordinated Science Lab, as well.

Now that smartphones are widespread, equipped with sensors that detect motion, location, imagery, and sounds, Roy Choudhury and his students have been considering the implications. Although these sensors enable novel applications, the line between intrusion and convenience can be very thin.

Take the smartphone's accelerometer, for example. Often no more than two or three millimeters square, a millimeter thick, this is the component that determines the smartphone's orientation as it rotates in your hand and bounces with your step.

Countless applications use accelerometer data, from games to heart-rate monitors. Roy Choudhury and his students even demonstrated an application, known as PhonePoint Pen, which allows smartphone users to write and draw in the air, holding nothing but the phone. This has significant utility for anyone who lacks fine motor skills, allowing him or her to compose a quick message or dial a number using broad hand gestures.

On the other end of the spectrum, however, recent research by Roy Choudhury and his students has demonstrated that data transmitted from the accelerometer can be distinguished and tracked as smartphone users carry their devices throughout the day: to the gym and the grocery store, business meetings, and vacation destinations. The research also suggests that data sent from other sensors, such as the gyroscope — a sensor that measures rotation — would possess similar signatures.

"THIS NOTION OF TRACKING IS WHAT WE ARE AFRAID OF, OR WHAT WE WANT TO TELL PEOPLE TO BE AWARE OF."

-ROMIT ROY CHOUDHURY

These signatures stem from the impossibility of manufacturing two things exactly alike. Although the micromachined structure of the accelerometer is minuscule, small imperfections make every accelerometer unique. The data generated by the accelerometers reflect those idiosyncrasies.

While users realize that a smartphone's GPS sensor can track whereabouts, that sensor can be manually turned on before sharing with a particular application, and then subsequently disabled. That's not true for applications that collect sensor data for continuous behavior monitoring. Without this protection, hackers could gain easy access to locations — a back door left unlocked.

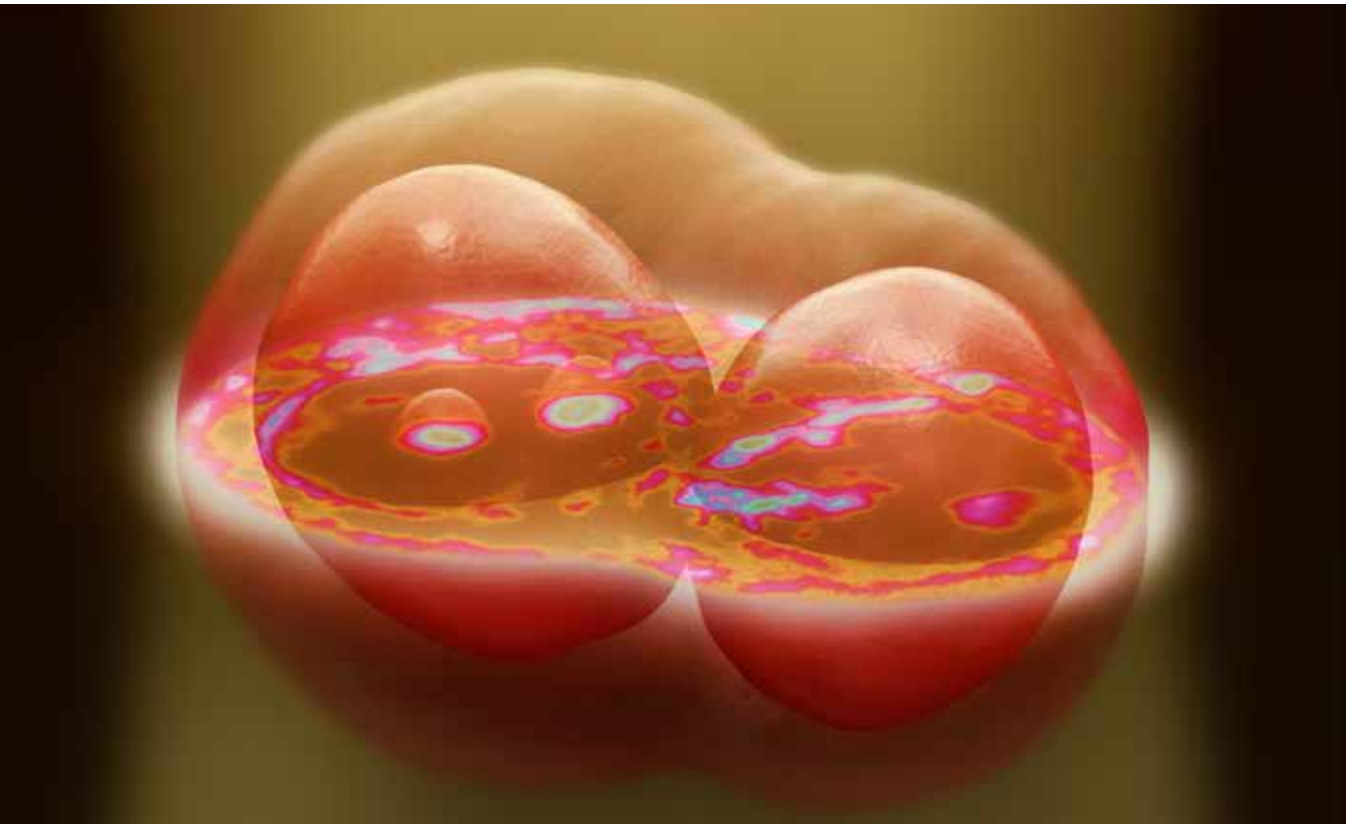
"This notion of tracking is what we are afraid of, or what we want to tell people to be aware of," Roy Choudhury said. "You don't want the cloud to track you for your lifetime or for the lifetime of your device. Even if you delete all the software and reinstall the software, it doesn't matter. It's an imperfection in the hardware, and it stays with the phone as long as the phone is in use."

Past research from Roy Choudhury's group has shown that data from the same accelerometer, coupled with the gyroscope, could indicate where fingers press and touch the screen of a smartphone. Different locations cause distinct vibrations. Using that data, hackers could steal passwords or eavesdrop on text conversations and emails.

Despite these concerns, the mobilization of these pocket-sized sensing devices offers powerful possibilities for data analytics. As recently as 2009, only a quarter of cellphone users in the U.S. connected to the Internet with their phones, according to the Pew Research Center. Now the number is well over 60 percent, indicating an ever-expanding landscape to explore, like miniature Mars rovers, exploring the terrain of society.

Researchers can study population trends and crowd patterns. Retailers could discover how shoppers navigate store aisles. With the addition of health-related biosensors to smartphones — components that are under development in industry and academic research centers, including ECE ILLINOIS — individualized, high-resolution health analytics are possible.

"One way of looking at this is like micro-data all becoming Big Data," Roy Choudhury said. "It's like droplets combing together to create an ocean."



White-light Diffraction Tomography combines microscopy and holography to reveal 3-D structures of live, unlabeled cells, as shown in this illustration based on a colon cancer cell.

PRICELESS IMAGES

ECE IMAGING LAB SHEDS NEW LIGHT ON THE LIFE OF A CELL

BY DOUG PETERSON

Gabriel Popescu's fascination with the microscope goes back to his days growing up in Prundu, a small town in Romania. When he was about 10 years old, he stumbled across an old microscope in the garage, and he played with it for weeks. His father, an agricultural engineer who managed a state-run farm, told him the microscope could make a piece of his hair look as big as a pencil, and that sparked his imagination.

"It was my first lesson in microscopy," he says. "That old Zeiss microscope used ambient light through a mirror to illuminate the sample, and it was surprisingly heavy. I understood much later that heavy microscopes tend to provide more stable images."

Today, Popescu is an ECE associate professor and is changing the field of microscopy as director of the Quantitative Light Imaging Laboratory at Illinois. He is affiliated with Illinois' Beckman Institute for Advanced Science and Technology. This lab is revolutionizing the way we look at cells by using white light to create images sharper than anything seen before.

"BEFORE THIS WORK, WE HAD NEVER SEEN STEM CELLS TRANSFORM INTO FULLY DEVELOPED NEURONS IN FRONT OF OUR EYES."

-GABRIEL POPESCU

Gabriel Popescu

"In biomedicine, we need quantitative data and instruments, and that is what drew me to the field," he says.

The lab is a leader in spatial light interference microscopy, or SLIM, a novel system that combines a microscope with light-scattering techniques. It captures dramatic images of various types of cancerous and healthy cells, and it also provides invaluable measurements such as mass, volume, and density.

Imaging with white light has been around for a long time; in the 1930s, phase contrast microscopy made a major breakthrough, leading to the Nobel Prize for physics in 1953. The images were unprecedented, but they generated no quantitative data.

Scientists have traditionally used lasers to take measurements with light-scattering imaging techniques. The problem, Popescu says, is that when you use lasers, the final image is grainy. When Popescu came to Illinois from MIT in 2007, his goal was to address that problem.

By using white light in its imaging techniques, his lab is able to capture much finer detail. In addition, the SLIM imaging system can make valuable measurements at the single-cell level.

To determine the effect of a drug on cancer, the typical approach is to make bulk "population-level measurements" on large numbers of cancer cells. But as Popescu's lab uses SLIM to study individual cells, it's shown that estrogen can cause certain breast cancer cells to move through the cell cycle much faster, thereby dividing more quickly.

"The cells don't get bigger—in fact, each cell becomes smaller," he says. "But the cycle is shorter, and this is something you cannot learn by using population-level measurements."

He did this work with molecular and integrative physiologist Benita Katzenellenbogen, an Illinois professor, and they also showed that estrogen receptor-blocking agents can slow the cell cycle.

In addition, Popescu's lab worked with Illinois professor Martha Gillette in cell and developmental biology, using SLIM to take time-lapse images and measurements of neurons as they transform from stem cells.

Researchers can see the neurons grow extensions like arms and then connect with neighboring neurons to create an extensive neural network. Once the connections are made, the neurons stop growing and begin communicating on a massive scale.

"Before this work, we had never seen stem cells transform into fully developed neurons in front of our eyes," he says. Other methods, including fluorescence microscopy, kill the cells well before their 14-day differentiation process ends.

The Quantitative Light Imaging Lab also recently developed white-light diffraction tomography, or WDT, which uses a series of SLIM maps to create 3-D images. The system doesn't require any dyes, and doesn't kill the cell. It allows for generating images over time, adding a fourth dimension to the information gathered.

Popescu says the technology will be valuable in locating tumors, characterizing them, and determining the stage of disease. He has started a company, Phi Optics, to commercialize the technology, in the hopes of "creating an instrument that doesn't require a PhD student to operate it."

He also wants to develop software that will convert microscopes into intelligent machines that scan and process images automatically.

He envisions that image data on cancer and other diseases will someday be available to physicians worldwide through a cloud service. The result, paired with a computational pattern recognition system, could make the accuracy of identifying certain diseases close to perfect.

"Who knows what we're going to find out from such images," Popescu says. "But whatever we see is going to bring fresh, new insights."

"IT'S THE PROBLEM OF HOW DOES A BUSINESS NOT JUST HAVE DATA, BUT GET INSIGHTS FROM THAT DATA AND MONETIZE THAT INFORMATION."
—HILLERY HUNTER

BY JONATHAN DAMERY

Alumna Hillery Hunter (BSEE '99, MSEE '02, PhD '04) thinks about engineering the same way that she, as an accomplished pianist, approaches the whites and ebony sharps. It's a counterpoint of roles, always planned several phrases ahead and performed across the full tonal range—spanning, in engineering, from software to market analysis, from the conceptual to the applied.

Hunter is the Senior Manager, Computer Architecture and Research Memory Strategy Lead at IBM. She is responsible for making sure that IBM research projects relating to computer memory and computer architecture move and develop in concert.

"It's a very broad role," she said of the strategic duties. "It is one of keeping the research teams across everything from silicon to software within the memory area interlocked with our development organization ... so that we're sure that we're working on things that are going to push forward the state-of-the-art for IBM systems."

IBM is an industry-leader for high-bandwidth, high-capacity memory systems, and Hunter masterminds a portfolio of projects related to these, envisioning how the systems can better handle computing challenges in the coming years, including, quite notably, the growing demands of Big Data and analytics.

"It's the problem of, how does a business not just have data, but get insights from that data and monetize that information," Hunter said. "Memory, including new memory technologies like flash and some other things that are starting to emerge, is going to be a really key piece of that overall equation for companies."

Her title denotes two jobs that are done in tandem, and as Senior Manager of the Computer Architecture Department, Hunter also oversees the architectural research supporting IBM Systems, including System z, the collective name for the company's mainframe computers.

Hunter's initial experience at IBM was in 2000, after her first year of graduate school, when she interned at the IBM Devel-

The T.J. Watson Research Center. Photo by Matt Bisanz.

opment Lab in southwestern Germany. As an undergraduate, she had studied abroad at the Technical University of Munich for one year, where she took engineering courses in German. She was essentially fluent at that time, having spent two previous summers in the country, working with children. Her aptitude for both the language and engineering was proven when she won the university's Outstanding International Student Prize.

"Having that greatly enhanced my experience at Illinois," Hunter said of the two semesters abroad. "I work now with a team that is spread everywhere from California to Zurich to Tokyo to Korea. We work globally. We source components globally. … So that experience of being somewhere else, dealing with a different culture, while still being in a technical environment, has been invaluable."

When Hunter joined IBM full time in 2005, after three additional internships at the company's T.J. Watson Research Center, she was a member of the exploratory computer systems group, where she was tasked with putting together a technical story, arguing the cost-performance benefits of incorporating eDRAM, otherwise known as embedded dynamic random-access memory, onto IBM's processor chips. Based on her work, which drew from research happening in various departments, all of the IBM processor chips released in 2010 were equipped with eDRAM.

After that project, Hunter was named the memory power lead on a project relating to DDR3, a type of off-chip memory. Because IBM does not manufacture the off-chip memory, she was responsible for interactions with external vendors, establishing specifications for the products, as well as the initial, in-house design initiatives that aimed to lower the power consumption of the devices.

"My work was largely in getting things translated across technical teams, and really making sure that technically we had good communication flow, and that we were making the right decisions based on what other teams were doing," she said.

As an undergraduate and graduate student in electrical engineering at ECE ILLINOIS, Hunter did research in the Coordinated Science Laboratory with Professor Wen-mei Hwu, a leading authority on computer architecture who was her graduate adviser, as well as with Professor Naresh Shanbhag, whose expertise lies in integrated circuits design and signal processing.

"The interdisciplinary nature of centers like the Coordinated Science Laboratory is really important in preparing students for the real world," Hunter said. "Just because in computing in general, I think we are running into problems that require people with interdisciplinary understanding and willingness to tackle problems from a different angle."

Hunter was admitted into the IBM Academy of Technology in 2012 and earned an IBM Outstanding Technical Achievement Award in 2011. Along with some 20 other awards from IBM and elsewhere throughout her career, those honors are a testament to the work that can be accomplished in those regions of interdisciplinary overlap, when disparate parts are orchestrated to act in unison, creating, like fingers on the keyboard, a collective and innovative whole.

"Everything I've done here has been interdisciplinary," Hunter said. "Absolutely."

PHD GRADUATES

The following students completed work on their PhD degrees in August 2013, December 2013, and May 2014. ECE ILLINOIS congratulates each of them for this incredible accomplishment.

Student *Employer + Title*	Adviser	Thesis Title
GRADUATED AUGUST 2013		
Amir Arbabi *California Institute of Technology : Postdoctoral Scholar*	Goddard, Lynford	Selective Mode Coupling In Microring Resonators For Single Mode Semiconductor Lasers
Sang-Yoon Chang *Advanced Digital Sciences Center (ADSC) : Postdoctoral Fellow*	Hu, Yih-Chun	Secure Protocols For Wireless Availability
Javad Ghaderi Dehkord *UT Austin : Postdoctoral Fellow*	Srikant, Rayadurgam	Fundamental Limits Of Random Access In Wireless Networks
Dong Jin *Illinois Institute of Technology : Assistant Professor*	Nicol, David	Network-Simulation-Based Evaluation Of Smart Grid Applications
Anupama Kowli *I.I.T. Bombay : Assistant Professor*	Meyn, Sean	Reinforcement Learning Techniques For Controlling Resources In Power Networks
Chao Ma *University of Illinois : Postdoctoral Fellow*	Liang, Zhi-Pei	Design Of Multidimensional Radiofrequency Pulses In Magnetic Resonance Imaging
Lydia Majure *UC Berkeley : Postdoctoral Researcher*	Levinson, Stephen	Developmental Model Of Sensorimotor Map Acquisition For A Humanoid Robot
Mustafa Mir *UC Berkeley : Postdoctoral Scholar*	Popescu, Gabriel	Quantitative Phase Imaging For Cellular Biology
Hoa Pham *University of Pittsburgh : Postdoctoral Associate*	Popescu, Gabriel	Real-Time Quantitative Phase Imaging For Cell Studies
Vrashank Shukla *Texas Instruments : ESD Design and Verification Engineer*	Rosenbaum, Elyse	Predictive Transient Circuit Simulations Of Charged Device Model ESD Events In System In Package Chips
Xiao-Long Wu *Qualcomm : GPGPU Architect/Senior Engineer*	Hwu, Wen-Mei	Tiger: Tiled Iterative Genome Assembler And Approximate Multi-Genome Aligner
Quanyan Zhu *New York University : Assistant Professor*	Başar, Tamer	Game-Theoretic Methods For Security And Resilience In Cyber-Physical Systems
GRADUATED DECEMBER 2013		
Rachit Agarwal *UC Berkeley : Postdoctoral Researcher*	Godfrey, Philip	Low Latency Queries On Big Graph Data
Phillip R. Atkins *Schlumberger : Electrical Engineer*	Chew, Weng	A Study On Computational Electromagnetics Problems With Applications To Casimir Force Calculations
Wei Chen *Synopsis, Inc. : Research Scientist*	Meyn, Sean	Value Function Approximation Architectures For Neuro-Dynamic Programming
Thomas Matthew Comberiate *Johns Hopkins APL : RF, Microwave, and Millimeter Wave Engineer*	Schutt-Aine, Jose	Using X-Parameters For Signal Integrity Applications
Quan Geng *Tower Research Capital : High-Frequency Trader*	Viswanath, Pramod	The Optimal Mechanism In Differential Privacy
John Darby Hewitt *Abilene Christian University : Assistant Professor*	Eden, James	Alkali-Rare Gas Photodissociation Lasers: Applications To Laser Physics And Atom-Atom Interactions
Ghazale Hosseinabadi *University of Illinois : Graduate Research Assistant*	Vaidya, Nitin	Exploiting Wireless Broadcast Property To Improve Performance Of Distributed Algorithms And Mac Protocols In Wireless Networks
Yen-Wei Huang *University of Illinois : Graduate Research Assistant*	Moulin, Pierre	Asymptotic Analysis For Multi-User Channels
Matthew Thomas Johnson *United States Air Force : Job Title Classified*	Choquette, Kent	Coherently-Coupled Vertical-Cavity Laser Arrays
Taylor T. Johnson *University of Texas at Arlington : Assistant Professor*	Mitra, Sayan	Uniform Verification Of Safety For Parameterized Networks Of Hybrid Automata
Sachin Kadloor *Facebook : Research Scientist*	Kiyavash, Negar	Scheduling With Privacy Constraints
Lingyi Li *Synopsis, Inc. : Research and Development*	Vasudevan, Shobha	Harmonizing Data Mining And Static Analysis To Tackle Hardware And System Level Verification

Student *Company + Title*	Adviser	Thesis Title
Juan Sebastian Ochoa Munoz *Qualcomm : Power Integrity Engineer*	Cangellaris, Andreas	Stochastic Modeling In Computational Electromagnetics
Jonathan J. Ponniah *Texas A&M University : Postdoctoral Research*	Kumar, P. R.	A Clean Slate Approach To Secure Wireless Networking
GuoJun Qi *IBM T.J. Watson Research Center : Research Staff Member*	Huang, Thomas	Information Trust, Inference And Transfer In Social And Information Networks
Joseph Augustyn Sloan *UT Dallas : Assistant Professor*	Kumar, Rakesh	Algorithmic Approaches To Enhancing And Exploiting Application-Level Error Tolerance
Fei Tan *University of Illinois : Postdoctoral Research Associate*	Feng, Milton	Signal Modulation And Relative Intensity Noise Properties Of Transistor Laser *T*echniques For And Nano-Cavity VCSEL
Andrea Carolina Trevino *Boys Town National Research Hospital : Postdoctoral Fellow*	Allen, Jont	Understanding Hearing-Impaired Perception Of Consonant Cues
Santosh Tripathi *Intel Corporation : PTD Module and Integration Yield Engineer*	Toussaint, Kimani	Optical Polarization Control In Free Space And Through Random Media Using Wavefront Shaping
Min-Hsuan Tsai *Google : Software Engineer*	Huang, Thomas	On Recommendations In Heterogeneous Social Media Networks
Joshua D. Wood *Northwestern University: Postdoctoral Fellow*	Lyding, Joseph	Large-Scale Growth, Fluorination, Clean Transfer, and Layering of Graphene And Related Nanomaterials
Wang Yao *Qualcomm : Senior Engineer*	Jin, Jianming	Accurate, Efficient, And Stable Domain Decomposition Methods For Analysis Of Electromechanical Problems
Ji Zhu *Google : Software Engineer*	Hajek, Bruce	Stability and Performance in Peer to Peer Networks
GRADUATED MAY 2014		
Veysel Buyukdegirmenci *Elektra Elecpronik : R & D, Advanced Technology Specialist*	Krein, Philip	A Framework For Dynamic Characterization And Short-Term Thermal Capability Assessment Of Electric Machines And Inverters In Motor Drive
Yi Chen *Effimax Solar : Founder*	Liu, Gang Logan	High-Throughput Plasma Nanomanufacturing And Its Applications
Vincent Dorgan *Intel : Logic Technology Development Reliability Engineer*	Pop, Eric	High-Field Transport In Two-Dimensional Graphene And Molybdenum Disulfide
Ali El Gamal *University of Southern California : Postdoctoral Research Associate*	Veeravalli, Venugopal	Interference Channels With Coordinated Multi-Point Transmission
Brian Herting *Rockwell Collins : Senior Electrical Engineer*	Bernhard, Jennifer	Analysis And Design Of Electrically Small, Circularly Polarized Cylindrical Microstrip Antennas
Hyejin Jeong *Cisco Systems : Engineer*	Choquette, Kent	Heterogeneously Bonded Vertical Cavity Surface Emitting Lasers And Thermal Modeling
David Jun *University of Illinois : Postdoctoral Research Associate*	Jones, Douglas	Managing Heterogeneous Resources For Dynamic Energy-Efficient Sensing
Vuong Le *Amazon : Engineer*	Huang, Thomas	3D Face Processing For Animation And Biometrics
Xin Miao *IBM : Advisory Scientist*	Li, Xiuling	Array-Based Planar Nanowire High Electron Mobility Transistor
Shehla Rana *Broadcom Corp. : Staff II Design Specialist*	Vaidya, Nitin and Nicol, David	Understanding The Interaction Between Reliability And Wireless Broadcast
Thomas Riedl *University of Illinois : Postdoc*	Singer, Andrew	Communication And Time Distortion
Christopher Rodrigues	Hwu, Wen-Mei	Supporting High-Level, High-Performance Parallel Programming With Library-Driven Optimization
Brian Roxworthy *University of Illinois : PhD Candidate*	Liu, Gang Logan	Plasmonic Nanoantennas For Multipurpose Particle Manipulation And Enhanced Optical Magnetism
Hui Sun *Marvell Semiconductor Inc.: System Engineer*	Başar, Tamer	L1 Adaptive Control With Quantization And Delay
Cagdas Tuna *University of Illinois : Postdoctoral Research Associate*	Jones, Douglas	Tactile Tomographic Imaging Using Robotic Whiskers
Mong-Kai Wu *Intel Corporation : Engineer*	Feng, Milton	Development Of Vertical Cavity Transistor Laser And Microcavity Laser
Feng Xiong *Stanford University : Visiting Scholar*	Pop, Eric	Scaling Study Of Phase Change Memory Using Carbon Nanotube Electrodes

TEN ANSWERS

Margaret Boehle (BSEE '11) is an electrical engineer at POWER Engineers in Fort Worth, Texas, where she does consulting work for utility power companies in the field of transmission substation design.

MARGARET BOEHLE

IN MIJAS, SPAIN.

FAVORITE ECE CLASS?
ECE 444, commonly known as the Fab Lab. Although I haven't gone into the field, IC fabrication is fascinating! I wish I could have taken more lab classes while at Illinois.

WHAT PROFESSOR HAD A PARTICULARLY STRONG INFLUENCE ON YOUR LIFE?
Professor Overbye taught ECE 476, Power Systems Analysis. He let me register a few weeks late in my last semester—that class is the reason I work in substation design.

WHAT IS ONE OF YOUR FAVORITE QUOTES?
"Structural engineering is the art of molding materials we do not wholly understand into shapes we cannot precisely analyze, so as to withstand forces we cannot really assess, in such a way that the community at large has no reason to suspect the extent of our ignorance." – Dr. A.R. Dykes (I think the sentiment is the same for all engineers, not just structural.)

WHAT IS YOUR FAVORITE FORM OF EXERCISE?
Running, although only since my last year at Illinois. I realized I needed to get into shape after sprints for the bus left me exhausted. Now I try to do two or three 5k runs each year.

WHAT'S IN YOUR FRIDGE?
Fruit, vegetables, tofu, eggs, cheese, wine, and hard cider. I cook a lot, so there are usually also plenty of leftovers to take to work for lunch.

ARE YOU A MORNING OR NIGHT PERSON?
I am a night person struggling to become a morning person. My job has a firm 8 a.m. to 5 p.m. schedule.

WHAT WAS YOUR FAVORITE CHILDHOOD TELEVISION PROGRAM?
"Arthur."

WHERE WOULD YOU LIKE TO VISIT?
I have a goal to visit all the major league baseball parks. So far I've only been to three: U.S. Cellular Field (Chicago White Sox), Wrigley Field (Chicago Cubs), and Globe Life Park (Texas Rangers). Next will probably be Coors Field in Denver.

ARE YOU MOSTLY A CLEAN OR MESSY PERSON?
I am somewhere in between. I have to work at being organized, but I really like being able to find things when I need them!

IF YOU COULD WITNESS ANY EVENT PAST, PRESENT, OR FUTURE, WHAT WOULD IT BE?
Future: first landing on Mars by humans.

TEN ANSWERS PROFILES AN ALUMNUS OR ALUMNA EACH ISSUE, ASKING THE IMPORTANT QUESTIONS. DO YOU HAVE ANSWERS? EMAIL US AND WE MAY FEATURE YOU IN A FUTURE ISSUE. TO READ MORE ABOUT ECE ALUMS, PLEASE VISIT OUR WEBSITE.

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ALMA RETURNS

After a year and a half restoration, the Alma Mater statue returned April 9 to her place on campus on the corner of Green and Wright streets. The statue, which has been on the Illinois campus since its unveiling in 1929, required conservation work due to corrosion that occurred during its 85 years on campus. The conservator's team replaced the Alma Mater's bolts and restored its surface, returning the statue to its original bronze color. Alumni donations paid for the work.

SEARCHING FOR THE NEXT UNIVERSITY PRESIDENT

A presidential search committee has been charged with finding presidential candidates to replace Illinois President Robert Easter when he retires June 30, 2015. The search committee includes three faculty members and one student from the Urbana-Champaign campus, who were selected by the University Board of Trustees and the Vice Chancellor for Student Affairs based on nominations by the Illinois Senate and the Illinois Student Senate, respectively. The final selection for president is expected by December.

ILLINOIS MAKES CARBON CREDIT DEAL WITH CHEVROLET

The university is selling about 150,000 metric tons of certified carbon credits to Chevrolet, which is retiring them on behalf of the environment. These carbon credits have been earned during the last three years by the university's carbon reductions, achieved through various energy efficiency activities, such as the improvement of heating and air conditioning systems in more than 50 campus buildings. Between Chevrolet's funding and matching funds provided by campus leadership, an expected $1 million will be newly available to Illinois to fund further projects to reduce carbon emissions on campus. These developments are part of the university's 2010 Climate Action Plan, which pledged to reach campus carbon neutrality by 2050.

STATE FARM CENTER RENOVATION BEGINS

The major renovation of the State Farm Center, formerly the Assembly Hall, began in March following the completion of the 2013-14 basketball season. In order to keep the center available during Illinois basketball seasons, the project is proceeding in phases. The current phase (March-November 2014) is focused on upgrading the State Farm Center's mechanical systems, as well as beginning work on the new east and west entrances and new south ramps and plaza areas. When it's done, the State Farm Center will include new blue seats, an expanded Orange Krush student section, premium seating opportunities, and air conditioning. The renovation should be complete for the start of the 2016-17 basketball season.

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The ceremony will be followed by a reception and tours.

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Watch a live stream at www.ece.illinois.edu.

Or, join us for the ECE Alumni Board Homecoming Open House on Saturday, October 25, 2014.

RSVP and learn more about these events at
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