re:search

An inside look at innovation and discovery at Missouri University of Science and Technology /// Fall 2015

In good company

From steelmaking to signal processing, S&T consortia tackle industry challenges.

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MISSOURI S&T

Fiscal Year 2015 Summary

Proposals submitted

598

Dollars requested

$186.1 M

Proposals awarded and amendments

262

Dollars awarded

$34.3 M

Total expenditures

$40.3 M

Faculty and staff serving as principal or co-principal investigators

221

Invention disclosures

44

Patent applications filed

31

Patents issued

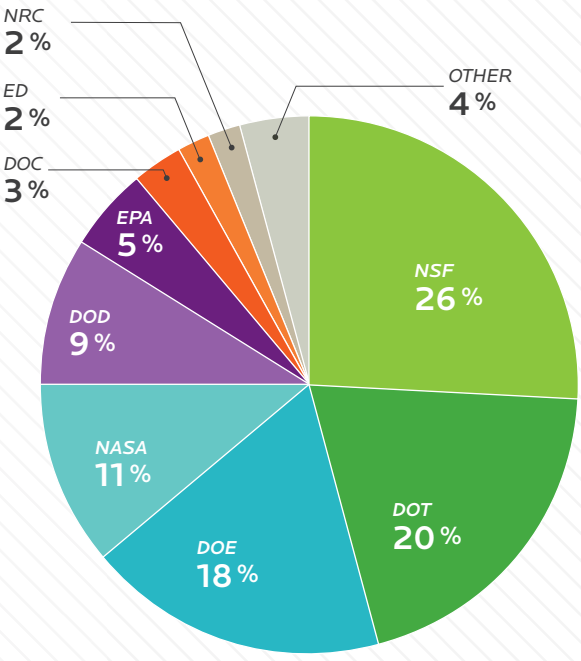
9

Licenses/Options signed

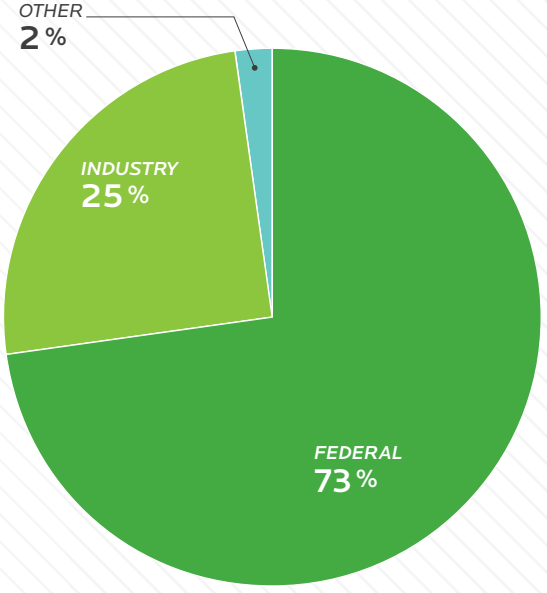
38

Licensing income

$483 K



FY15 federal awards by source (total amount: $25.1 M)



FY15 total sponsored awards by source (total amount: $34.3 M)

Dear Colleague,

Fundamental discoveries from science and engineering research and the translation of basic research to products, processes or services are important to ensure our nation's long-term economic growth and security. While there is a growing movement calling for increased federal government funding for research and higher education to close the Innovation Deficit, there are a number of other challenges facing the innovation ecosystem. They include engagement with industry as well as educating and training students on innovation and entrepreneurship.

With its focus on science and engineering, Missouri S&T is well positioned to address some of these challenges. A number of industry-driven research consortia have been established over the years at Missouri S&T to foster long-term partnerships with industry. This past year we were honored to receive four National Science Foundation I-Corps grants to transition research results to the marketplace. Read about these successes in this Fall 2015 issue of the *re:search* magazine.

Also included in this magazine are stories on some of the groundbreaking research being conducted at Missouri S&T, including pioneering research on nanomaterials that holds promise for a number of future applications, such as solar and fuel cells, structural color printing using metamaterials, Alzheimer's disease that is currently ranked as the sixth-leading cause of death in the United States, and cybersecurity that impacts everyone. Further, read about the second in the four-book series written by a leading expert on Las Vegas, a city that has captivated millions of visitors.

I should also note that past investments and technology transfer efforts are now bearing fruit. This past year was a record year for license income, and I anticipate we will be setting new records over the next few years as licensed inventions are practiced.

I hope you will take some time to learn more about the innovative research being conducted at Missouri S&T and the challenges our faculty and students are addressing.

Sincerely,

K. Krishnamurthy
Vice Provost for Research

On the cover

Inside the Electromagnetic Compatibility Laboratory's semi-anechoic chamber, Jun Fan, associate professor of electrical engineering and director of NSF I/UCRC on Electromagnetic Compatibility, tests radio emissions in a controlled environment.

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re:search is the annual report on research, innovation and discovery activities at Missouri University of Science and Technology, formerly the University of Missouri-Rolla. Published by the Office of Sponsored Programs, *re:search* highlights only a portion of Missouri S&T's vibrant, focused research program. For more information about Missouri S&T's research, contact:

Office of Sponsored Programs
Missouri University of Science and Technology
202 Centennial Hall
300 W. 12th St.
Rolla, MO 65409-1330
573-341-4134
Fax: 573-341-4126
research@mst.edu
sponsoredprograms.mst.edu

From steelmaking to signal processing, S&T consortia tackle industry challenges

Some of the world's largest corporations look to Missouri S&T — and each other — to solve their toughest research problems.

Missouri S&T brings the corporate and academic worlds together to address research issues through seven consortia, or groups dedicated to addressing industry problems.

"The agenda for these research consortia is driven by the needs of industry," says **K. Krishnamurthy**, Missouri S&T's vice provost for research. "It's a win-win for all involved. Industry gains new knowledge to help them stay current and competitive in the global economy, faculty build stronger ties with practitioners and publish their findings in leading journals, and students have invaluable learning opportunities."

One of the newest of these groups is the Kent D. Peaslee Steel Manufacturing Research Center. Through this consortium, scientists and engineers from steel companies, foundries and suppliers join with S&T faculty and students to conduct research on modern "clean" steel casting, product development, and environmental and safety issues, says **Ron O'Malley**, who directs the center.

"We're filling a niche by providing research to the industry in a cost-effective manner," says O'Malley, who is also the F. Kenneth Iverson Endowed Chair of Steelmaking Technologies at S&T.

For instance, Missouri S&T has the facilities to make and test steel in small batches — 200 pounds at a time. Big steelmakers like Nucor, where O'Malley was chief metallurgist before joining S&T, would have to make 170 tons of steel for testing. Other consortium members don't have any R&D facilities, O'Malley says.

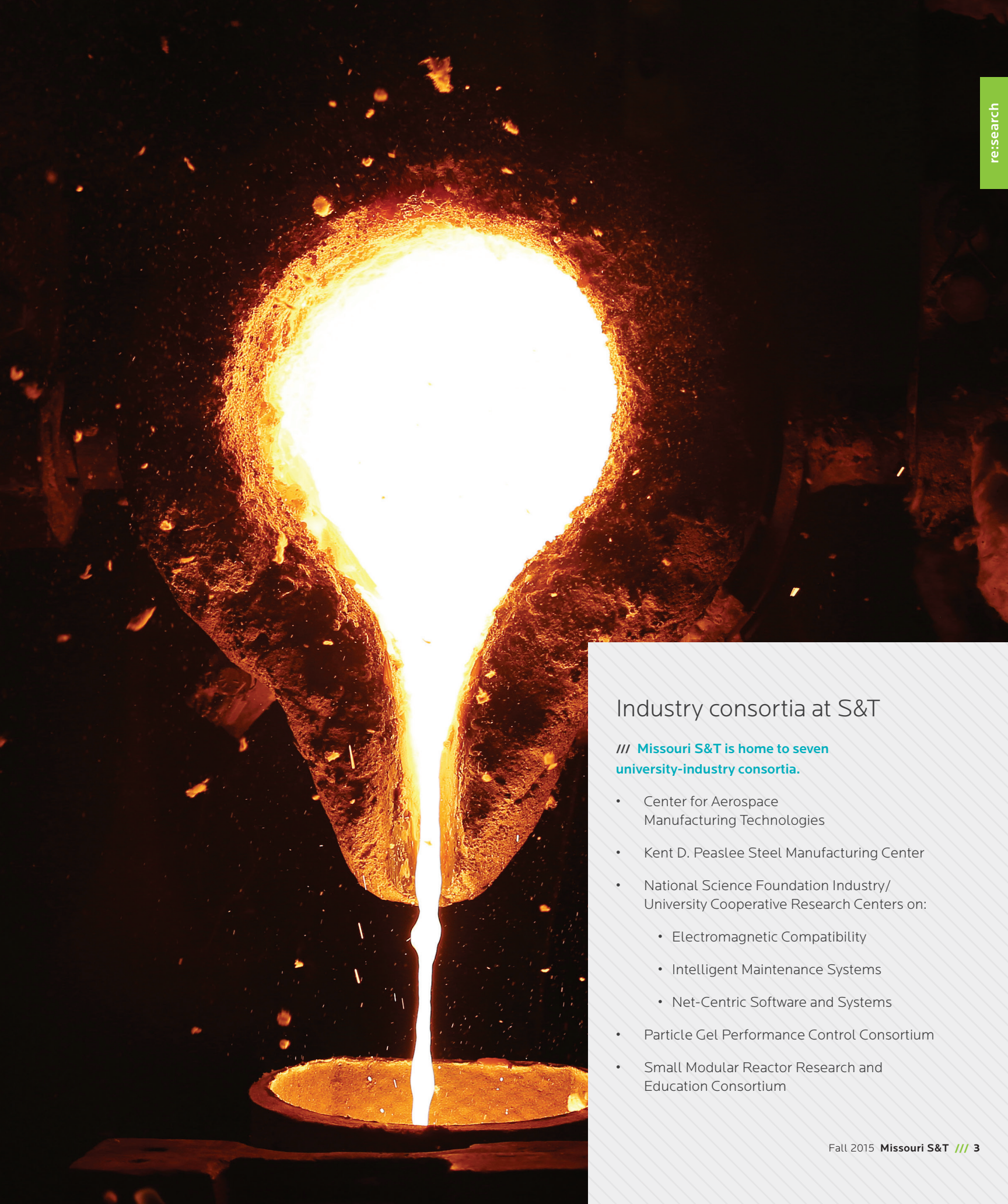
One of the longstanding and most successful consortia on campus is the National Science Foundation Industry/University Cooperative Research Center (NSF I/UCRC) on Electromagnetic Compatibility. There, Missouri S&T researchers work with companies like Cisco, Huawei, Samsung and Sony to improve electronics, computers and processes with the aim of reducing electromagnetic interference in and among devices and products. As systems grow more complex and rely on multiple on-board processors — in your car, for example — the need to ensure electromagnetic compatibility becomes even greater, says **David Pommerenke**, professor of electrical and computer engineering and assistant director of the center.

"The proliferation of wirelessly connected devices" in homes, businesses and a broad range of products presents new challenges for the electronics industry, Pommerenke says. The need to address common challenges motivates companies to set aside their competitive agenda and work jointly within the consortium toward solving those problems.

"We have created an environment where strong, competing companies share methodologies and research," Pommerenke says. "We offer an environment in which these problems can be addressed collaboratively by fellow industry researchers with faculty and graduate students who often join these companies after graduation." ■

Steel made to order

In the Peaslee Steel Manufacturing Research Center at Missouri S&T, researchers can make and test small batches of steel.



Industry consortia at S&T

/// Missouri S&T is home to seven university-industry consortia.

- Center for Aerospace Manufacturing Technologies
- Kent D. Peaslee Steel Manufacturing Center
- National Science Foundation Industry/ University Cooperative Research Centers on:
  - Electromagnetic Compatibility
  - Intelligent Maintenance Systems
  - Net-Centric Software and Systems
- Particle Gel Performance Control Consortium
- Small Modular Reactor Research and Education Consortium

Rewiring the world at the nano level

For years, nanomaterials researchers have focused on constructing objects at the atomic scale. At Missouri S&T, researchers now are improving how one class of those materials — called nanowires — are made in order to get them into devices that can advance energy conversion, computing and medicine.

Nanowires are slender cylinders that transport electrons. Most nanowires are only a few billionths of a meter in diameter. At that size, they possess unusual properties not seen in bulk materials.

Missouri S&T chemists **Jay A. Switzer** and **Manashi Nath** are taking different approaches to make nanowires more usable. Switzer, the Donald L. Castleman/Foundation for Chemical Research Professor of Discovery, is constructing nanowires from germanium through a process known as the electrochemical liquid-liquid-solid process, or ec-LLS. Germanium conducts electrons better than silicon, which makes the substance "ideal for lithium-ion battery applications," Switzer says.

Conventional methods of making germanium nanowires are costly, he says, because they require high temperatures. But through support from the U.S. Department of Energy's Office of Basic Energy Sciences, Switzer has shown that the nanowires could be grown at room temperature, with no significant difference in quality and at a lower cost. His work was reported in the journal *ACS Nano* in August 2014. Earlier this year, he was named a Materials Research Society Fellow for his pioneering work in electrodeposition.

Nath, an associate professor of chemistry at Missouri S&T, is producing entire arrays of nanowires with a pre-determined diameter and length and a uniform consistency by essentially printing them on a medium — like ink on copy paper. She does this by writing a file that creates a pattern for the desired shape and size. Then, using electron beam lithography, she stamps the pattern onto a polymer matrix and applies electric current to grow the nanowires.

This approach could improve efficiency of solar cells and fuel cells, and maximize heat production in hyperthermia treatment of cancer, Nath says. ■

Small thinking, big results

Manashi Nath (left) and Jay A. Switzer are leading innovative research on nanowires.

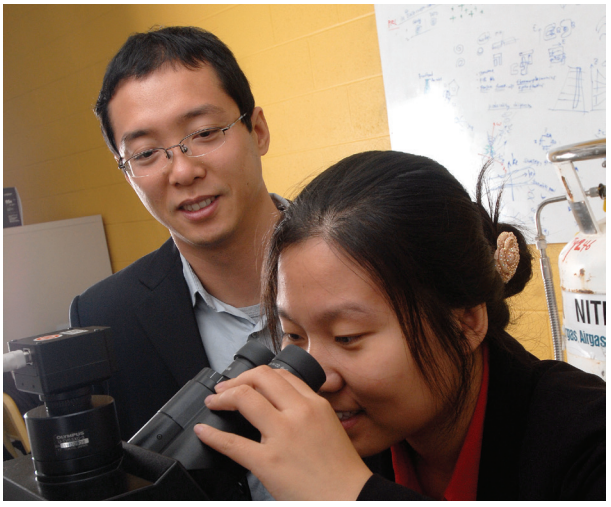
Printing with light

Creating brilliant colors without the use of pigments might seem impossible, but that's just what the natural world has done for peacocks, butterflies and many other creatures. It's called structural color — color formed not by properties of molecules but by tiny structures that reflect and adsorb light. Now Missouri S&T researchers have helped unlock the secrets of these nanoscale structures to efficiently print without using ink.

Their work was recently published in *Scientific Reports*, the Nature Publishing Group journal. Co-authors **Xiaodong Yang** and **Jie Gao**, two assistant professors, illustrated their technique by reproducing the Missouri S&T athletic logo on a nanometer-scale surface. A nanometer is one billionth of a meter, and some nanomaterials are only a few atoms in size.

Their method used thin sandwiches of nanometer-scale metal-dielectric materials known as metamaterials that interact with light in ways not seen in nature. Experimenting with the interplay of white light on sandwich-like structures, or plasmonic interfaces, the researchers developed what they call "a simple but efficient structural color printing platform" at the nanometer-scale level. They believe the process holds promise for future applications, including nanoscale visual arts, security marking and information storage.

"To reproduce a colorful artwork with our nanoscale color palettes, we replaced different areas in the original image with different nanostructures with specified hole sizes to represent various visible colors," says Yang, who leads the Nanoscale Optics Laboratory at Missouri S&T. "We chose the athletic logo to fill that need."



Tiny structures, bright colors

Xiaodong Yang (left) and Jie Gao are using light to print.

Gangster, yes. Pathological killer, no.

/// Pop culture depicts gangster Bugsy Siegel as either a pathological killer or a visionary who first understood Las Vegas' potential as a spectacular resort city. Historian Larry Gragg says both characterizations are false.

In his latest book, *Benjamin 'Bugsy' Siegel: The Gangster, the Flamingo, and the Making of Modern Las Vegas*, Gragg dispels these and other myths. He follows Siegel through his early life in New York's Lower East Side through his role in the construction of the Flamingo Hotel and Casino to his 1947 murder.

Gragg, a Curators' Teaching Professor of history and political science at Missouri S&T, used over 2,400 pages of FBI files on Siegel and referenced documents from the New York City Municipal Archives and the 1950-51 testimony before the Senate committee on organized crime. He also interviewed the mobster's daughter.

This is the second in Gragg's four-book series on Las Vegas. *Bright Light City: Las Vegas in Popular Culture*, was published in 2013. ■

Using flies to unlock Alzheimer's sleep secrets

Researchers in Missouri S&T's Center for Statistical and Computational Modeling of Biological Complexity are using fruit flies to help unlock some of the secrets surrounding sleep and Alzheimer's disease.

Dreamtime for Drosophilia

Courtney Fiebelman, a graduate student in applied and environmental biology, studies fruit flies in a Schrenk Hall laboratory.

Offering clues

Fruit flies are helping researchers figure out the sleep patterns of Alzheimer's patients.

According to the Alzheimer's Association, many people with Alzheimer's experience changes in their sleep patterns as a result of the disease's impact on the brain.

Matt Thimgan, assistant professor of biological sciences, is working with **V.A. Samaranayake**, Curators' Teaching Professor of mathematics and statistics, and **Gayla Olbricht**, assistant professor of mathematics and statistics, to develop a mathematical model of sleep in the fruit fly, *Drosophila melanogaster*.

"Not only might sleep deprivation increase one's likelihood of developing Alzheimer's disease, but the patterns of sleep and wake may indicate the severity of the disease," Thimgan says. "It's something that everyone can relate to; sleep deprivation affects a huge portion of the population."

Samaranayake uses time-series modeling techniques to look at the presence of hidden cyclical behaviors that relate to underlying biological mechanisms that drive the sleep-wake cycle. He and Olbricht also use statistical models to see if there are any differences in activity patterns and sleep parameters between flies of different genotypes and between healthy flies and those exhibiting Alzheimer's-like characteristics.

Using computational modeling makes the process exponentially faster, the researchers say.

The flies don't actually have age-related onset Alzheimer's disease, but using fly genetics, the researchers "induce the human proteins that are thought to be hallmarks of the disease in the fly brain to produce Alzheimer's-like characteristics in these flies," Thimgan says.

"We can induce different severities of Alzheimer's and determine if it affects the outcome of our mathematical modeling and how the severity might affect lifespan." ■

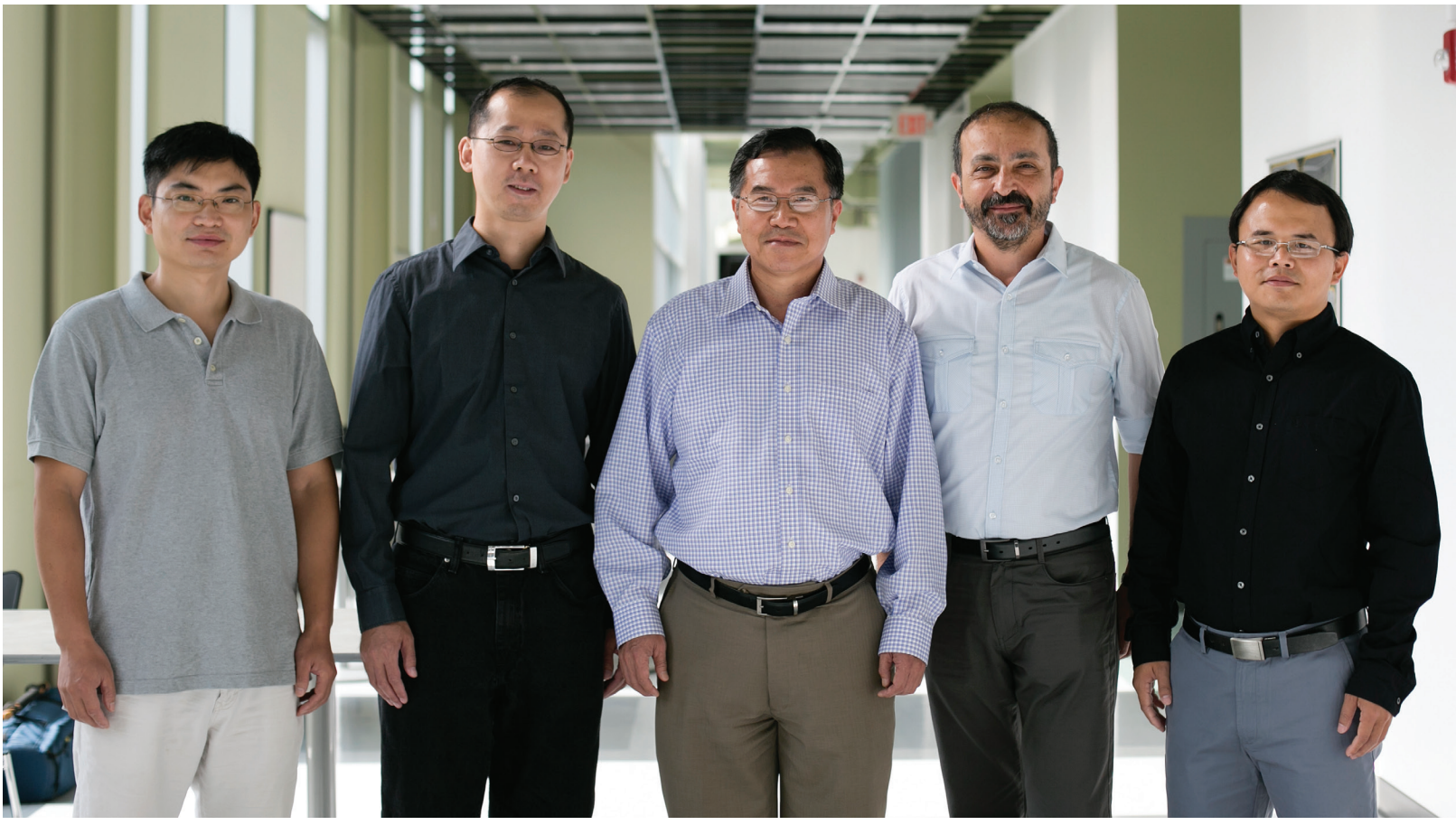
S&T chemist on trail of Alzheimer's disease

/// Imagine a single treatment method — one that could lead to a cure for cancer, HIV and Alzheimer's disease. A Missouri S&T chemist has patented a treatment method for diseases that currently have no cure.

V. Prakash Reddy, an organic chemistry professor at Missouri S&T, and his team of researchers were awarded a patent in March. And early in 2015, Reddy published his first book, *Organofluorine Compounds in Biology and Medicine*.

The patent is for purine-based neuroprotective compounds. The compounds, which are part of the book's focus, could be generalized to apply to multiple diseases. They work at the molecular level to regulate the cell cycle and help control the progression of Alzheimer's disease and various cancer-related diseases.

"Alzheimer's disease is like a cancer of the brain cells," Reddy says. "In the presence of our compounds, the neuronal cell death is dramatically attenuated, and the cells live longer. Our fluorine compounds thus have neuro-protective effects." ■



Research + innovation = prosperity

Imagine that instead of wearing a Fitbit around your wrist to track your steps, a flexible device attached unobtrusively to your skin like a temporary tattoo not only tracked your activity, but monitored other health patterns as well.

That's the goal of **Xian Huang**, assistant professor of mechanical and aerospace engineering at Missouri S&T. He is one of four S&T researchers who received I-Corps funding from the National Science Foundation this year. Read more about his work on the next page.

NSF recognizes that America's prosperity is due at least in part to the ability to capitalize on groundbreaking discoveries in science and engineering research. Through its I-Corps Teams program, NSF hopes to take fundamental research into the marketplace, encourage collaboration between academia and industry, and train faculty, students and other researchers to understand innovation and entrepreneurship.

In the past year, Missouri S&T has received the following I-Corps awards.

Stimulating technology commercialization

S&T researchers received four I-Corps awards from the National Science Foundation this year. From left are Zhaozheng Yin, Wei Jiang, Ming Leu, Umit Koylu, and Xian Huang.

Bio-inspired fuel cells

Small veins supply water and minerals from a plant's roots to its leaves and in turn transport nutrients throughout the plant. **Umit Koylu** and **Ming Leu** found that mimicking this natural nutrient flow in polymer electrolyte membrane (PEM) fuel cells results in a 30 percent increase in peak power density. Koylu, a professor of mechanical and aerospace engineering, and Leu, the Keith and Pat Bailey Missouri Distinguished Professor of Integrated Product Manufacturing, found that the bio-inspired flow field reduces transport losses inherent in existing flow field designs and could improve performance of PEM fuel cells and increase their efficiency.

Smartphone attendance tracker

Zhaozheng Yin is developing a smartphone app to take classroom attendance using a few seconds of video footage. At the beginning of class, an instructor sweeps a smartphone camera across the classroom, taking a brief video of all the students present. That initial video is stored and, using facial recognition algorithms Yin developed, is compared with videos from subsequent classes to record attendance automatically. Yin, an assistant professor of computer science, says it will save time for instructors who typically spend up to 10 percent of a 50-minute lecture checking attendance.

Safer social networks

Most social networking sites give users options to guard or control their personal data. However, that data is stored on a network server, which still leaves it vulnerable. Existing privacy-preserving sites are difficult to use, not suitable for mobile devices and often still open to security breach. **Wei Jiang** is developing an attractive, user-friendly social network called You&Me that truly protects user privacy. You&Me is an alternative implementation of privacy-preserving social networks that outsources nearly all computation to remote servers. Jiang, an associate professor of computer science, says that You&Me can be easily accessed through any mobile device.

Wearable Health-Beacons

Using bendable electronics that conform to human skin, **Huang** is creating wearable health and activity trackers for smart living. Called Health-Beacons, these innovative sensors use intelligent sensor data analytics techniques, predictive modeling, and contextual visualization and interaction to give users a quantified "smart living dashboard" based on health and activity tracking. The system uses Bluetooth beacons to transmit data to users' smartphone or smart watch. ■

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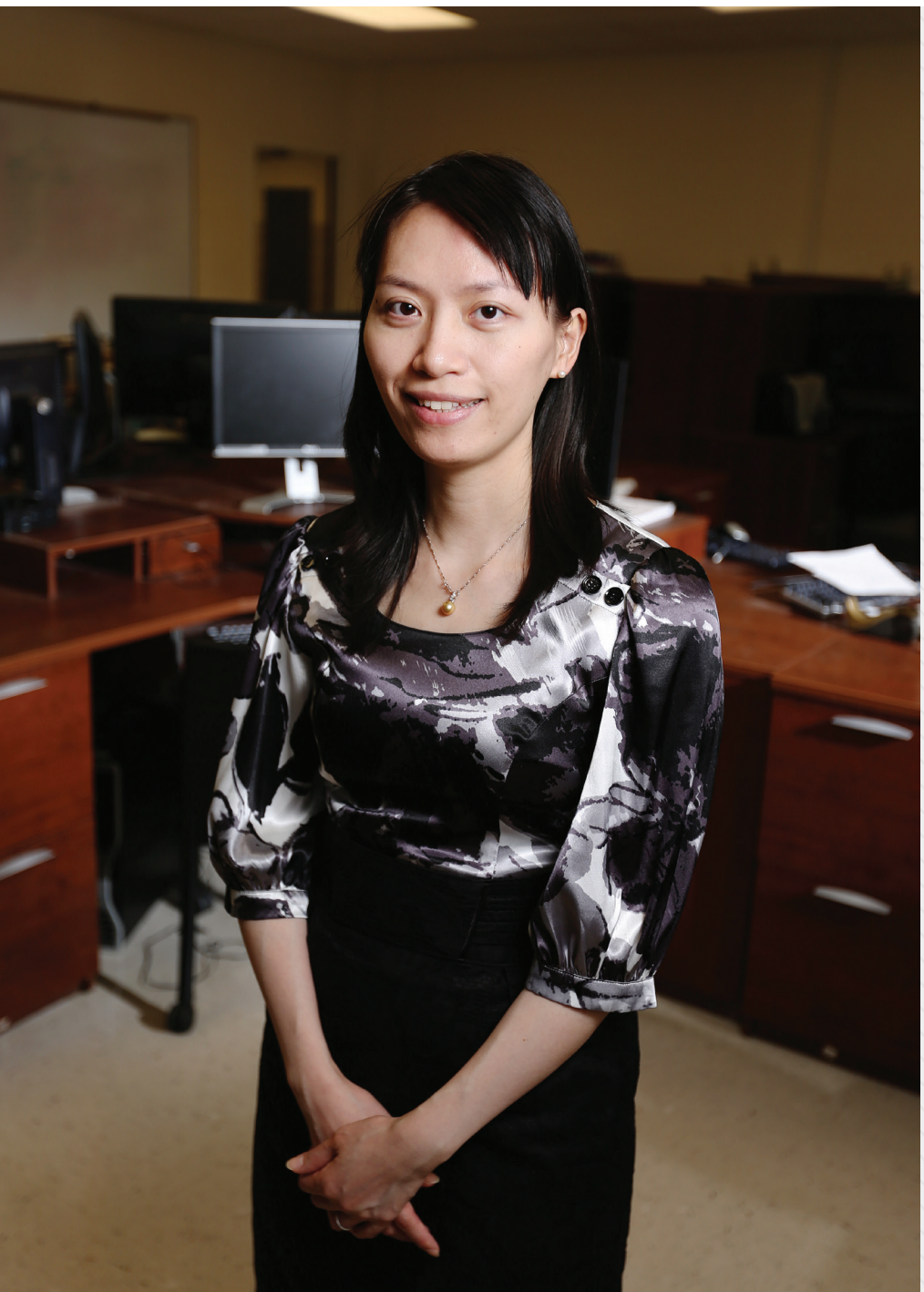
Missouri University of Science and Technology
Office of Sponsored Programs
202 Centennial Hall
300 W. 12th St.
Rolla, MO 65409-1330



Practice safe cyber

/// With a $3 million grant from the National Science Foundation, Missouri S&T will train 16 master's and Ph.D. students to specialize in cybersecurity as part of the U.S. government's CyberCorps Scholarship for Service.

"Cybersecurity is often taken for granted by Internet users," says **Dan Lin**, associate professor of computer science and director of the cybersecurity lab leading the program. "Without it, online banking, shopping, social networking and more would be severely impacted."

Missouri S&T was recently re-designated as a National Center of Academic Excellence for Information Assurance Education by the National Security Agency. It was the first institution in the state to receive the designation and has held the distinction since 2007. ■