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# re:search

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

## THE MIRRAGEN MIRACLE

Developed at S&T, glass product speeds healing of open wounds

pg. 2

MISSOURI  
**S&T**

## MATERIALS WITH MEMORY

You can bend, fold or twist this material, and it will bounce back to its original shape. Polyurethane aerogels developed at Missouri S&T have a rubber-like elasticity that allows them to “remember” their shapes.

“The specific kind of polyurethane aerogels we have created are superelastic, meaning that they can be bent in any direction or be smashed flat and still return to their original shape,” says **Nicholas Leventis**, lead researcher on the project and Curators’ Distinguished Professor of chemistry at Missouri S&T. These strong yet lightweight materials “are different from rubber in that they can on-command return to a specific form. That is, they also show a strong shape-memory effect, meaning that they can be deformed and cooled and keep the deformed shape forever.”

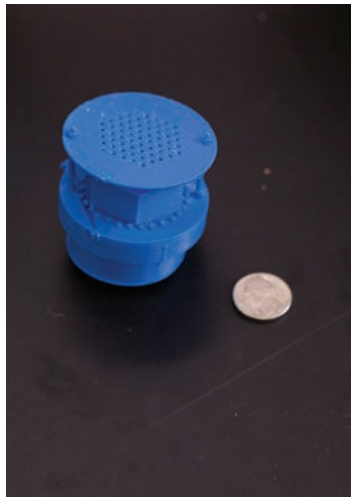
The shape-memory effect is nothing new in materials science, Leventis says. Shape-memory alloys and polymers have been around for years. But shape-memory aerogels are new and “represent the last frontier in lightweight” materials, he says.

Leventis believes shape-memory aerogels hold promise for biomimetic applications, such as prosthetic hands that can grasp and release objects. “Their flexibility, combined with elasticity, greatly enhance the range of possible uses,” he says.

The research was published in the May 2 issue of the American Chemical Society journal *Chemistry of Materials*.



A time-lapse photo of a polyurethane aerogel flexing from a closed position back to its original straight shape. Photo by Sam O’Keefe/ Missouri S&T.



## FUTURE-FOCUSED INFRASTRUCTURE



Bridges fabricated on site with 3-D printers. More earthquake-resistant buildings, fortified by walls containing rubber from recycled tires. Fly ash from coal-fired power plants diverted from landfills and used to create longer-lasting concrete for bridges and highways.

These far-fetched ideas could become reality through Missouri S&T's Advanced Materials and Construction Laboratory. When completed in 2019, the 16,000-square-foot expansion to S&T's High-bay Structures Laboratory will provide room for researchers to experiment with and develop new materials for tomorrow's highways, bridges and buildings.

The ACML will bring some 35 pieces of specialized testing equipment under one roof on campus. It also will support Missouri S&T's Advanced Materials for Sustainable Infrastructure signature area, which involves four research centers and six academic departments.

"Infrastructure is the foundation that connects the nation's business, communities and people, driving our economy and improving our quality of life," says **Kamal H. Khayat**, the Vernon and Maralee Jones Professor of Civil Engineering. "Missouri S&T has existing strengths in this area and with further emphasis, we can become a best-in-class leader."

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# THE MIRRAGEN MIRACLE

## DEVELOPED AT S&T, GLASS PRODUCT SPEEDS HEALING OF OPEN WOUNDS

It began as a graduate student's research into the effect of borate-based glasses on soft tissue. Today, it is a new medical product that could revolutionize the way physicians treat hard-to-heal open sores and wounds.

Mirrugen Advanced Wound Matrix, approved by the U.S. Food and Drug Administration for human use, is now available on the commercial market.

**Steve Jung** laid the groundwork for Mirrugen while earning a master's degree in ceramic engineering and a Ph.D. in materials science and engineering at Missouri S&T. Jung is now chief technology officer at Mo-Sci Corp., a specialty glass manufacturer that continued the product's development in collaboration with ETS Wound Care. Both companies are based in Rolla, Missouri, which is also home to Missouri S&T.


"The recent FDA approval is a significant milestone," says Chad Lewis, president and CEO of ETS Wound Care, a subsidiary of Engineered Tissue Solutions. "We're pioneering an entirely new therapeutic option for wound care."

Jung's doctoral advisor at Missouri S&T was **Delbert E. Day**, a pioneering glass engineer who co-founded

Mo-Sci more than three decades ago as a spinoff company to manufacture radioactive glass spheres that he and his students had developed to treat patients with inoperable liver cancer. Day, a member of the National Academy of Engineering and the National Academy of Inventors, is now a Curators' Distinguished Professor emeritus of ceramic engineering at S&T.

"As a student, it's hard to understand the potential impacts of your work," says Jung, who also received a Missouri S&T bachelor's degree. "So it's very exciting to now see this research commercialized to do exactly what was intended — to help people."

Mirrugen is a wound dressing solely composed of microscopic glass fibers and particles that are absorbed by the body. Both flexible and moldable, the cotton candy-like



Mirrugen, the wound-healing bandage, is made up of tiny glass fibers that give it the appearance of fluffy cotton candy. The material — a nanofiber borate glass — was developed in the laboratories of S&T's Graduate Center for Materials Research and the Center for Bone and Tissue Repair and Regeneration, and marketed by Mo-Sci.



## THE INVENTOR: DELBERT DAY

When it comes to productivity and ingenuity, few researchers are in the same league as **Delbert E. Day**. The Curators' Distinguished Professor emeritus of ceramic engineering holds nearly 50 patents and a long list of accolades, including membership in the National Academy of Engineering. Now, Day has another honor to add to that list: membership in the National Academy of Inventors.

Day was inducted into the NAI in April during a ceremony at the John F. Kennedy Presidential Library & Museum in Boston. He was cited for his "highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development and the welfare of society." Those inventions include the wound care product Mirragen, treatments for inoperable cancer and methods to grow bone tissue. All of those medical products and processes stem from Day's expertise with an unlikely therapeutic ingredient: glass.

"Del Day is an inspiring teacher, an outstanding glass scientist and a very successful entrepreneur," says **Richard K. Brow**, who, like Day, is a Curators' Distinguished Professor of ceramic engineering. "While Del is best known for his work with using glass materials to treat cancer and other medical issues, his ingenuity extends to other fields where specialty glasses can be used to solve various engineering problems. His work is world-famous, and all of us at Missouri S&T are very proud of our colleague and this well-deserved recognition."

Day has served Missouri S&T for over 50 years in various teaching, research and administrative capacities. He also is the co-founder of Mo-Sci Corp., which manufactures specialty glasses for medical applications.

Long before branching out into the field of biomaterials, Day worked with NASA to create the first U.S. glass-melting experiments in micro-gravity on a space shuttle mission. He also conducted more down-to-earth research, co-inventing "Glasphalt," which recycles waste glass by using it as part of the aggregate in asphalt paving.

“ The Mirragen story perfectly illustrates how federal support of university research can translate into broader economic and social benefits.”

wound dressing can be easily customized, while its fiber structure allows Mirragen to absorb fluid from the wound site and facilitate healing.

"Anyone who is treating or experiencing discomfort from acute or chronic wounds will immediately recognize its benefits," says Peggy Earl, a wound care specialist at Phelps County Regional Medical Center in Rolla, where clinical trials of Mirragen were conducted. "It has the potential to reduce the required number of episodes and duration of wound care treatment, while allowing the body to effectively heal a variety of wounds, both acute and chronic."

A similar product, Rediheal, also stemming from Jung's research at S&T, has been successfully used by veterinarians for the past three years to heal major wounds in animals.

**Keith Strassner**, director of the university's office of technology transfer and economic development, calls the new wound care product a successful example of the real-world benefits of academic research. "The Mirragen story perfectly illustrates how federal support of university research can translate into broader economic and social benefits," he says, noting the early support of Jung's work by a U.S. Department of Defense grant. "Then, we were able to create a strong partnership with Mo-Sci and transfer the technology to allow the company to make the necessary investments in its commercialization and the regulatory approval process." □

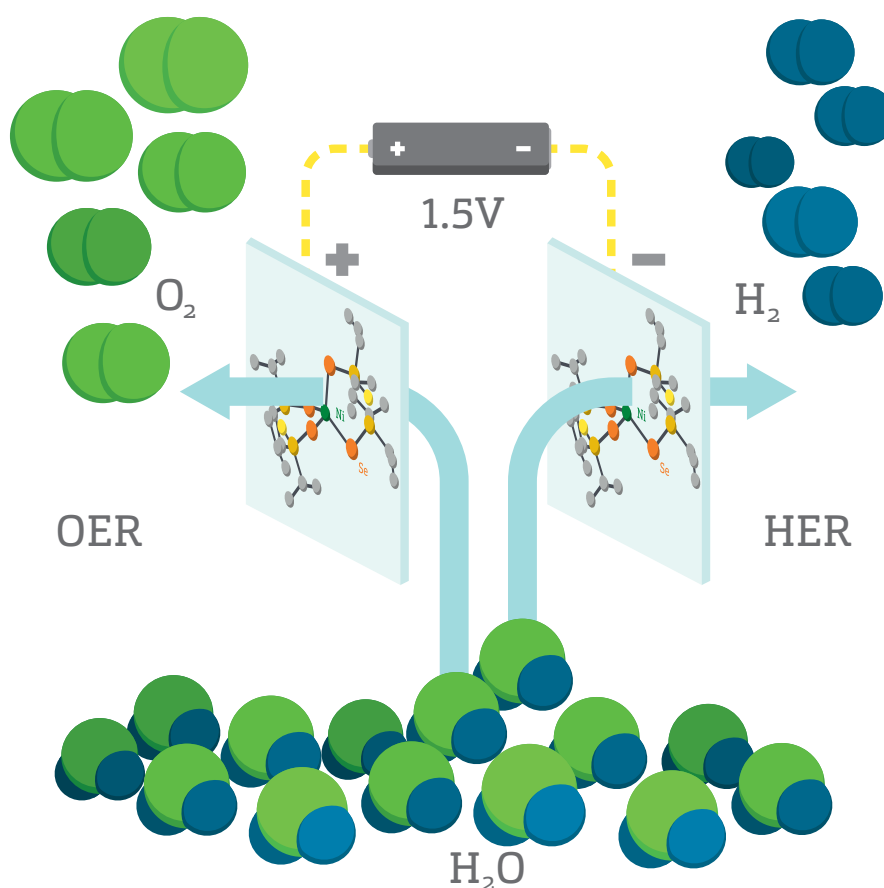
# PARTING THE WATERS TO CAPTURE A PROMISING ENERGY SOURCE

The future of hydrogen as a fuel source depends on the ability to create the element without depleting earth's natural preserves. Missouri S&T's **Manashi Nath**, working with researchers from Greece's National and Kapodistrian University of Athens, has found a more efficient, less expensive way to capture hydrogen, and it involves splitting water molecules into their elements of hydrogen and oxygen.

Writing in the journal *ChemSusChem* (Chemistry & Sustainability Energy & Materials), Nath and her colleagues describe a method to split water via electrolysis. It involves the use of a catalyst that includes the metal nickel tetrahedrally coordinated to selenium. The use of nickel, which the researchers describe as an "earth-abundant" resource, could make the process of water splitting more feasible as a means to develop clean hydrogen as an energy source from water.

Most methods for producing hydrogen and oxygen from water require large amounts of energy and are cost-prohibitive, Nath says. In addition, the best catalysts to obtain hydrogen from water require the use of expensive precious metals, such as platinum, which makes the process much more expensive than traditional energy production processes.

But the research by Nath and her colleagues show that an electrocatalyst containing nickel and selenium can produce hydrogen and oxygen from water in a more efficient, less expensive manner than other methods.



"Our work shows that it is possible to obtain a full water splitting with high production efficiency and stability with a simple and affordable catalyst containing nickel and selenium," Nath says. "The novelty of this work is twofold. First, nickel is the main catalytic center which is known to be earth abundant, and second, that same catalyst can be used for both hydrogen and oxygen generation, which dramatically reduces complexity and the cost of the device."

"Very few reports are available where the same catalyst can be used for both oxygen and hydrogen production," Nath adds.

"I strongly believe that developing technology for clean and renewable energy generation is crucial," she says. "In this quest, materials innovation plays an even bigger role. Being chemists, our duty is to try to design environmentally friendly new functional materials with high performance for the next generation of energy devices."

"This discovery will significantly benefit the search for an efficient water-splitting catalyst," write the researchers in the cover profile of the Nov. 17, 2016, issue of *ChemSusChem*.

Nath's co-authors on the journal article include **Jahangir Masud**, a post-doctoral researcher at Missouri S&T.



George Holmes, one of dozens of GAANN Fellows at Missouri S&T, is working toward his Ph.D. in control system engineering, which focuses on the design of robotic systems.

# PREPARING THE NATION'S FUTURE RESEARCHERS

Many of the nation's future engineering and science researchers are preparing for their careers in Missouri S&T's labs, thanks to more than \$2.2 million in federal funding through a program designed to encourage more students to pursue Ph.D.s in those fields.

The program, called Graduate Assistance in Areas of National Need, or GAANN, is a U.S. Department of Education effort designed to draw more Ph.D. students into the nation's universities and encourage them to pursue research careers in academia, national laboratories or the private sector. The program provides GAANN fellowships for graduate students with excellent academic records who demonstrate a financial need.

Increasing the number of Ph.D. students in the U.S. is critical to the nation's future

global competitiveness, says **Mariesa Crow**, vice provost for research at Missouri S&T.

"Numerous studies have pointed out the need in our country for more professionals in the STEM (science, technology, engineering and mathematics) fields in order to remain competitive in the world economy," she says. "We also need educators in these fields to prepare future generations of engineers and scientists. Programs like GAANN can help provide more educators and researchers

in these disciplines to help meet our need for a STEM-focused workforce."

In recent years, Missouri S&T has received over \$2.2 million through GAANN and is expected to receive another \$1.47 million. The funds support master's and Ph.D. students in five academic departments at Missouri S&T: civil, architectural and environmental engineering; electrical and computer engineering; materials science and engineering; mechanical and aerospace engineering; and mining and nuclear engineering.

Currently, 19 Missouri S&T students are supported through the GAANN program, with funds available for five more.

Previous GAANN fellows at Missouri S&T have pursued careers in research as well as higher education. One former GAANN fellow, **Laura Bartlett**, returned to Missouri S&T last fall as the Robert V. Wolf Professor of Metallurgical Engineering. She earned her Ph.D. in metallurgical engineering from Missouri S&T in 2013.

# A NEW PROCESS FOR BIORESORBABLE ELECTRONICS

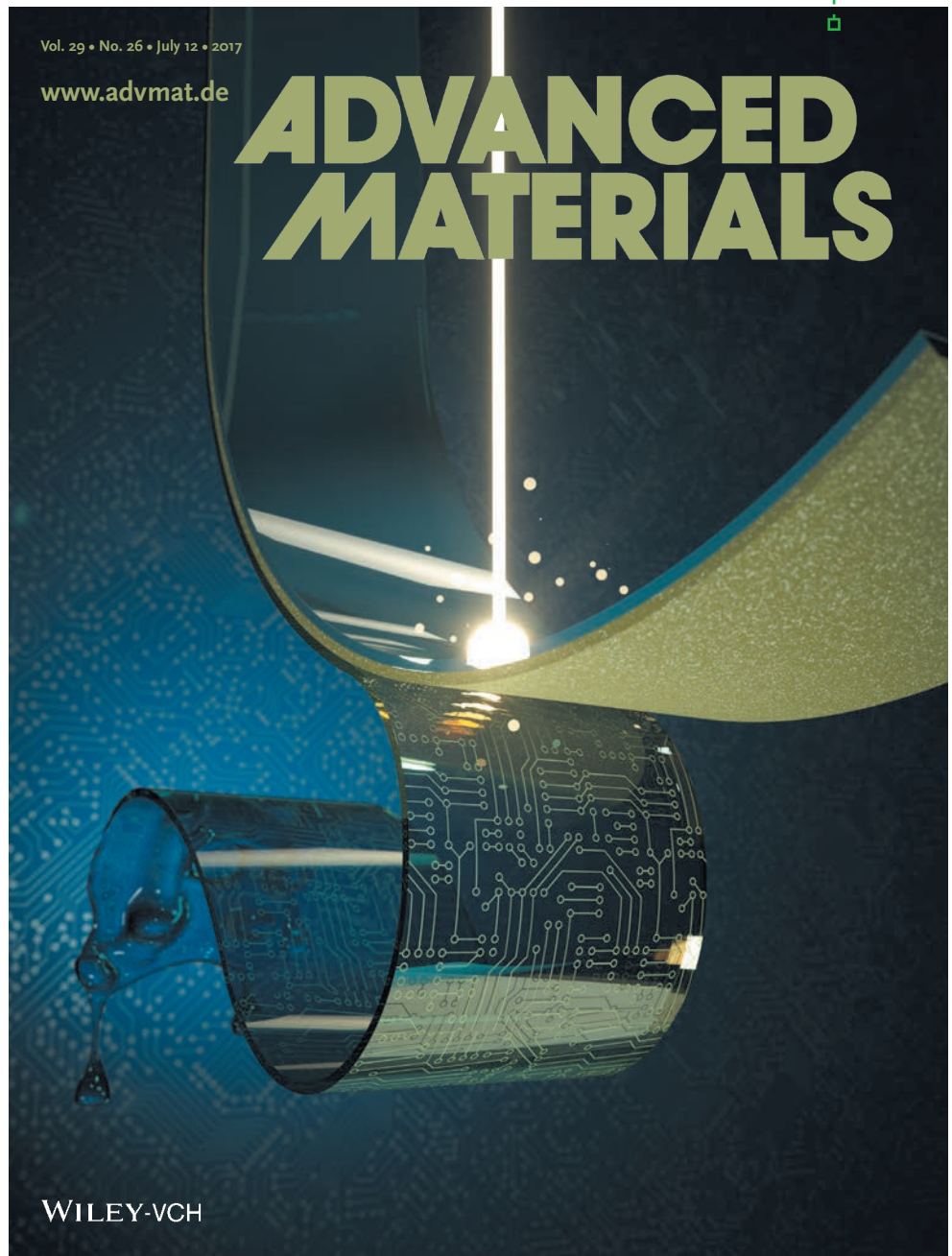
Electronic devices that can not only be implanted in the human body but also completely dissolve on their own — known as “bioresorbable” electronics—are envisioned by many as one of medical technology’s next frontiers.

A new study by Missouri S&T researchers published in the journal *Advanced Materials* suggests that a laser printing technique using nanoparticles could help unlock a more cost-effective approach to building sturdier and safer components.

The research team, led by **Heng Pan**, assistant professor of mechanical and aerospace engineering at Missouri S&T, and **Xian Huang**, a professor of biomedical engineering at Tianjin University in China, used lasers to process print-ready zinc nanoparticles, then used them to print tiny electronic components.

Pan says bioresorbable electronics (or transient electronics) that use traditional microchip fabrication methods require costly optical patterning and vacuum deposition processes. Laser printing is far more cost-effective — but potentially exposes zinc, magnesium and other necessary ingredients to oxygen, nitrogen and other ingredients that could cause adverse interactions.

The new process allows for zinc nanoparticles to be sintered together through an evaporation and condensation process that avoids surface oxides. The fabricated, oxide-free zinc conductors demonstrated high electrical conductivity, mechanical durability and water dissolvability, the researchers report.



“The new method can direct-print patterned zinc conductors on bioresorbable polymers with conductivity close to bulk values,” Pan says. “And the fabricated patterns on bioresorbable substrate can be readily integrated with high performance electronics.”

Co-authors with Pan and Huang are Missouri S&T mechanical engineering Ph.D. students **Xiaowei Yu**, **Wan Shou**, **Brandon Ludwig**, and **Joshua Staggs**, and **Bikram K. Mahajan**, a master’s student in mechanical engineering at S&T.



--- Cover from *Advanced Materials* where Missouri S&T researchers demonstrate a way to print tiny electronic components by using lasers to process print-ready zinc nanoparticles.

## MAKING ELECTRONICS WEARABLE

Pan's interest in pushing the frontiers of electronic components extends to those that can be elongated or twisted — known as “stretchable” electronics. These devices could soon be used to power electronic gadgets, the onboard systems of vehicles, medical devices and other products. Key to the future of stretchable electronics is the surface, or substrate. And as Pan, Shou, Yu and Mahajan write in a recent issue of the journal *Micromachines*, a 3-D printing-like approach to manufacturing may help.

Pan's research team focuses on a type of conductor that can be built on or set into the surface of a polymer known as elastomer. Elastomer, as its name implies, is a flexible material with high elasticity that can be bent, stretched, buckled and twisted repeatedly with little impact on its performance.

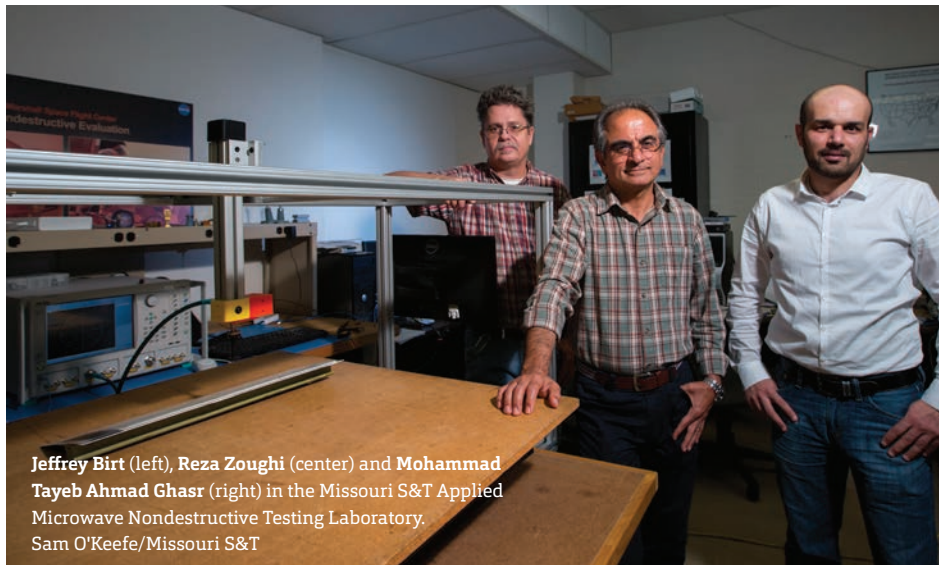
Semiconductors are commonly manufactured using photolithography, a subtractive approach.

In their paper, Pan and his colleagues suggest additive manufacturing could be used to “print” very thin layers of highly conductive materials onto an elastomer surface. Additive manufacturing allows manufacturers to create three-dimensional objects, layer by layer — much like 3-D printing, but with metals, ceramics or other materials.

Pan and his colleagues see additive manufacturing as a relatively economical approach to creating these new devices. At Missouri S&T, they are testing an approach Pan calls “direct aerosol printing.” The process involves spraying a conductive material and integrating with a stretchable substrate to develop sensors that can be placed on skin.

“With the increase of complexity and resolution of devices, higher requirements for patterning techniques are expected,” they write. “Direct printing, as an additive manufacturing method, would satisfy such requirements and offer low cost and high speed in both prototyping and manufacturing. It might be a solution for cost-effective and scalable fabrication of stretchable electronics.”

Before stretchable electronics become widely used, researchers will need to develop stretchable batteries that can store energy and ensure stretchable electronics and the malleable surfaces they're built upon perform and age well together. But Pan and his colleagues are optimistic. They foresee a growth in the types of materials that could be used as efficient conductors of electricity and as flexible surfaces on which to build stretchable electronics. ■



Jeffrey Birt (left), Reza Zoughi (center) and Mohammad Tayeb Ahmad Ghasr (right) in the Missouri S&T Applied Microwave Nondestructive Testing Laboratory. Sam O'Keefe/Missouri S&T

## A NEW VISION FOR TESTING MATERIALS

Researchers in Missouri S&T's Applied Microwave Nondestructive Testing Laboratory (amntl) are known worldwide for their expertise in testing materials for potential flaws without damaging the materials. They have tested items ranging from space shuttle spray-on foam insulation to cement-based materials for detecting alkali-silica reaction gel, a cause of deterioration in concrete. They also have developed a real-time, high-resolution, 3-D and portable microwave camera. Recently, these researchers have worked with The Boeing Company to establish a new nondestructive evaluation laboratory at one of Boeing's facilities to help the aerospace company improve the detection of potential flaws in coatings, surfaces and materials.

The S&T-designed lab is now in use at the Boeing Research & Technology Center in Charleston, S.C., where the company conducts R&D in areas of advanced manufacturing with a focus on composite fuselage and propulsion systems production.

The field of nondestructive evaluation, or NDE, “encompasses a variety of techniques to achieve many critical objectives, including maintenance assurance, quality control, structural health monitoring and product safety, to name a few,” says amntl director **Reza Zoughi**, the Schlumberger Distinguished Professor of Electrical and Computer Engineering at Missouri S&T. Microwave and millimeter-wave NDE techniques, spanning the range of approximately 300 megahertz to 300 gigahertz, have proven effective for addressing many of these needs over the past three decades, Zoughi adds. As a result, these techniques “have been steadily receiving greater attention as potential NDT methods.”

“Recent advances have made these techniques more attractive from a nondestructive evaluation perspective,” says Don Palmer Jr., Boeing Technical Fellow and NDE expert. Microwave and millimeter-wave NDE can be used to detect flaws under attenuative materials, make precise thickness measurements of dielectric coatings and even detect small surface cracks in metallic structures. Boeing and amntl researchers are working together to investigate a millimeter-wave crack-detection approach that could significantly improve ultrasonic and eddy-current approaches currently used for small-crack detection associated with widespread fatigue damage.

“The ability to detect smaller cracks simplifies required repairs and, in turn, extends the life of the structure,” Palmer says.

This increasing potential of microwave and millimeter-wave techniques to address complex inspection problems led to Boeing's decision to work with Missouri S&T to establish the laboratory. It will be used to address a number of needs spanning materials characterization and high-resolution imaging.

Working with Zoughi to design the lab were **M.T. Ghasr**, assistant research professor of electrical and computer engineering; **Jeffrey Birt**, a technical assistant in the ECE department; and recent graduates **Matthew R. Dvorsky** and **John R. Gallion**, both of whom are now ECE graduate students.

“This collaborative endeavor allows Boeing to be at the forefront of microwave and millimeter-wave NDT technology for years to come,” says Zoughi.



# FUELING FUTURE SPACE FLIGHT

After nearly a decade of study in Missouri S&T's aerospace engineering program, earning bachelor's, master's and Ph.D. degrees, **Steven Berg** joined SpaceX, the company founded by Elon Musk with the goal of exploring and colonizing Mars. It was 2015, and Berg worked as a propulsion engineer and test engineer on the Falcon 9 rocket's second stage in Texas and southern California.

It was heavy stuff for a 20-something engineer, but months into the job, Berg decided to return to Rolla as a postdoctoral researcher to pick up where he left off: Studying multi-mode micropropulsion and possibly spinning off those efforts into a commercial venture.

Berg's thesis advisor approached him about the position, and the now-former SpaceX

employee didn't hesitate to trade lunches at Manhattan Beach for a windowless office in the basement of Toomey Hall. "This may be my only chance to do this," he says.

With the help of several graduate student researchers, Berg is seeking to advance spacecraft propulsion by combining its two traditional systems, chemical and electric,

into one that can tap into either, depending upon circumstances. As he explains, "There's chemical propulsion, which produces a lot of thrust but is not very fuel-efficient. You can get somewhere very fast in space, but you're limited in how far you can go. And there's electric propulsion, which uses electromagnetic fields to accelerate ionized gases and is very fuel-efficient. So you can go farther in space, but it's going to take you a long time to get there.

"Traditionally, propulsion systems have been either one of those separately, but not both. Our propulsion system does both in a single package: one propellant, one tank, one feed line and one thruster."

The advantage of such a system? The ability to change course on the fly and react to unforeseen circumstances, from shifting weather patterns to unexpected military maneuvers. The dual fuel options are being



“Traditionally, propulsion systems have been either one of those separately, but not both. Our propulsion system does both in a single package: one propellant, one tank, one feed line and one thruster.”

developed for microsattellites (those under 100 kilograms, or about 220 pounds) and nanosatellites (between 2.2 and 22 pounds), part of a broader category known as small satellites, or “small sats” for short.

“Most missions are planned out meticulously beforehand. If you start from scratch and have a mission, you have to select a propulsion system for that mission ahead of time, and design the rest of the satellite in parallel,” he says. “That’s contrary to the primary benefits of small satellites: rapid concept-to-flight time and low cost.”

“Our system would save a huge amount of time and money in development costs, since you have the flexibility to significantly change the flight profile as needs arise, or requirements change, without adjusting the propulsion system hardware. You wouldn’t have to retest all the components you design, or redesign all the components you already tested.”

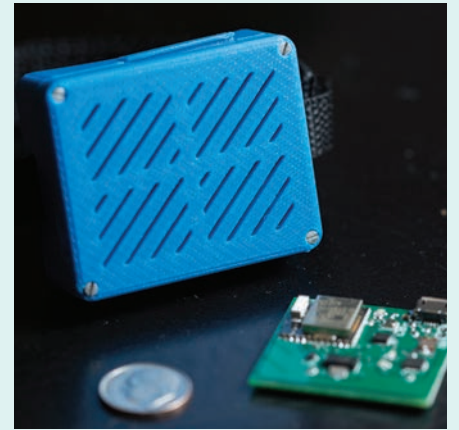
Even with a global downturn in 2016 caused by launch delays, market forecasts for small sats remain bullish. In its 2017 Nano/Microsatellite Market Forecast, the Georgia company SpaceWorks projects that nearly 2,400 nanosatellites will launch between now and 2023, a growth spurt that some refer to as a “new space race” led by Silicon Valley venture capitalists and Fortune 500 companies.

Berg is now preparing for a NASA-supported test launch that will send his thruster into space on a satellite currently being designed by the student-run Missouri S&T Satellite Research Team, or M-SAT.

While fine-tuning the propulsion system in the lab, Berg is also immersed in a crash course on business start-ups. Working with the university’s technology transfer office, he’s applied for a federal patent for the multi-mode propulsion system, which uses a monopropellant electro-spray thruster. He consults with potential customers to assess their needs while also courting prospective investors.

“You have to not only be well-versed in your technology but also be able to explain it to someone who knows nothing about it,” he says. “You really pick their brains to find out what they actually need. And then you adjust your research and development to fit those needs.” ■

Steven Berg is seeking to advance spacecraft propulsion by combining its two traditional systems, chemical and electric, into one. Sam O’Keefe/ Missouri S&T.



## WEARABLE WELLNESS

Researchers liken it to a Fitbit “on steroids.” That’s because this wearable wristband could help physicians track the fine-grained motor movements and behaviors of patients with dementia. It could also help the military monitor the well-being of soldiers during combat training.

The device was created by **Sajal Das**, the Daniel St. Clair Endowed Chair of Computer Science, and **Debraj De**, a postdoctoral fellow. It can track a person’s movements, ambient environment, bio-signals and more. Das hopes the device also gains approval for use during military training at Fort Leonard Wood, the Army installation located about 30 miles southwest of Missouri S&T.

Das and De also developed a sensor-embedded smart chair — called the “Care Chair” — that could help doctors, nurses and home health care providers gain greater insight into the activity level of elderly patients who have dementia or are recovering from a stroke or related health impairments. Both the wristband and the chair are being tested for patient rehabilitation and routine evaluation at Phelps County Regional Medical Center in Rolla.



# SAFER MINES AND CLEANER WATER IN GHANA

As a doctoral student in mining engineering, **Kenneth Bansah** works, learns and lives nearly 10,000 miles from his boyhood home of Tarkwa, Ghana, a gold mining hub in western Africa.

But even as he fine-tunes his dissertation on mitigating sinkhole hazards and other karst formations — and takes care of three young children while his wife completes her own graduate studies in Michigan — the subsistence gold miners of Ghana are never far from Bansah's mind.

Or his heart.

It's known as "galamsey," illegal mining by untrained workers who routinely brave dangerous conditions and toxic exposure to feed their families, in some cases using picks and shovels to sift through the leftovers ignored by industrialized mining operations. The term is derived from the English phrase, "gather them and sell."

The World Bank estimates that more than 20 million people globally practice small-scale or artisanal mining. In Ghana, such mining (both legal and illegal) accounts for nearly one third of gold production in a nation that before gaining its independence 60 years ago was known as the Gold Coast.

Government regulations enacted in the late 1980s to monitor artisanal mining have failed to keep pace with the growth of the market. Modern-day

gold rushers left behind pockmarked forests, abandoned mines susceptible to collapse, and rivers contaminated by the mercury used to extract gold.

The artisanal miners who remain often engage in those same harmful practices, but on a smaller scale, says Bansah. Many are women whose children are forced by economic necessity to work. Pulled from school at an early age, the children usually remain trapped in the cycle of poverty, he says.

"I was fortunate," says Bansah, a police officer's son who taught at Ghana's University of Mines and Technology after earning an advanced degree there. "But there are many people in my country who have no source of income other than subsistence farming. They can't take care of their children. So they look at mining as a means of survival."

In 2016, Bansah created the nonprofit group Mining & Community Research. Its goal: using scientific rigor and technical expertise to promote sustainable development. He recently returned to Ghana to work on three projects: a series of "Getting Children Out

Left: Ph.D. student Kenneth Bansah has formed a nonprofit organization in his native Ghana to improve working conditions for female artisanal miners who do so as means to survival. The mining engineering student is pictured in the Rock Mechanics Explosive Research Center, his campus home.

Top: Women in Ghana play a vital role in artisanal and small-scale mining, often traveling many miles to work in an effort to escape poverty.

Bottom: Two boys swim in the Tano River near Ghana's western border with Ivory Coast. Contamination from artisanal mining has rendered the river's water unfit for human consumption.

of Galamsey" community workshops; skills training for female artisanal miners; and an infrastructure improvement effort to raise money for a village's new clean water drinking system.

"Often times, we do a lot of research that is not directly affecting the lives of the people we do the research about," Bansah says. "You spend a whole lot of money doing research, and the reports gather dust on a shelf."

Once Bansah completes his studeies, he plans to return to his home university and continue working at both the nonprofit and the Safety & Environmental Research Consultancy, a firm he established in 2010.

"The little things I can do, I have to do," he says. "Many of the stories you hear would break your heart."



Photo courtesy of Mining & Community Research archive



Photo by Kenneth Bansah

# ON THE FLY

## New approaches to inspect and monitor bridges will benefit from home-grown autonomous machines

Unmanned aerial vehicles and robots being developed by students and researchers at Missouri S&T will soon play a key role in keeping bridges and highways safe — and keeping your commutes to and from work freer from the disruptions of road repair.

Thanks to a \$1.4 million grant from the U.S. Department of Transportation's Office of the Assistant Secretary for Research and Technology, Missouri S&T researchers are developing robotic tools to inspect and maintain bridges and portions of highway from the air or from the side of the structure. The University Transportation Centers (UTC) tier 1 grant supports an initiative called INSPIRE, or Inspecting and Preserving Infrastructure through Robotic Exploration.

"We plan to develop a robotic arm for both flying and climbing unmanned vehicles to inspect and maintain bridges and other transportation infrastructure," says **Genda Chen**, the Robert W. Abnett Distinguished Chair in Civil Engineering at Missouri S&T and director of the new UTC. "Once this technology is developed and in use, we will never need to close traffic for bridge or highway inspection and preservation."

Instead, robotic unmanned aerial vehicles (UAVs) or robots capable of crawling up along the sides of bridges will inspect or fix bridges from beneath the flow of traffic, Chen says. The robotic arms could also apply sealant or paint to bridge sections, while engineers guide the work remotely and monitor on a screen to visually verify the results as needed. Chen envisions equipping the robots with sensors and microwave cameras capable of detecting potential problems inside bridge beams and decks before they become problematic.

"With the arrival of the robotic era, we expect bridge inspection to be reinvented and transformed into a more consistent, reliable and rapid process," Chen says.

He's being helped by members of S&T's office of research support services (RSS), an arm of the campus' information technology department. In recent years, students employed by RSS have developed UAVs to aid Missouri S&T researchers on a variety of projects that benefit from a bird's-eye perspective. The service, known as MinerFly, provides UAVs to gather data, capture and transmit video or photos, collect traffic data, and scan areas to determine foliage health, measure tree or building heights, or explore oil and gas reserves.

Missouri S&T leads a consortium of 10 colleges and universities in the INSPIRE effort.

In addition to the research, a portion of the grant will be used to "train and expand the transportation work force," Chen says.

Missouri S&T faculty working with Chen on the project are **Suzanna Long**, professor and chair of engineering management and systems engineering, who serves as associate director of the center; **Zhaozheng Yin**, assistant professor of computer science; **Ruwen Qin**, associate professor of engineering management and systems engineering; **Reza Zoughi**, the Schlumberger Distinguished Professor of Electrical Engineering; **John Myers**, professor of civil engineering; **Leslie Sneed**, associate professor of civil engineering; **Mohamed Elgawady**, associate professor of civil engineering; and **Hongyan Ma**, assistant professor of civil engineering.

## ADVANCING INNOVATION: MISSOURI S&T'S CAREER AWARDEES

Three young faculty researchers at Missouri S&T are recipients of the 2017 National Science Foundation Faculty Early Career Development Awards. NSF CAREER awards support the early career development of researchers who are most likely to become academic leaders.



**Jie Gao**, assistant professor of mechanical and aerospace engineering, whose work in the field of singular optics could lead to advances in optical communications, beam shaping, optical sensing images and more.



**Edward C. Kinzel**, assistant professor of mechanical and aerospace engineering, who is developing new approaches to manufacturing by using self-assembled microsphere arrays in microsphere photolithography.



**Caizhi Zhou**, assistant professor of materials science and engineering, whose investigation of metallic nanolayered composites holds promise for producing metal alloys with stronger, improved properties.



As smartphones get smarter and self-driving cars speed closer to reality, solving the problems of electromagnetic interference will become increasingly important. That's where Missouri S&T's Electromagnetic Compatibility Laboratory comes in.

The EMC Lab, led by **Jun Fan**, professor of electrical and computer engineering, works with a consortium of companies and government agencies to address problems related to electromagnetic compatibility. As digital devices and the so-called internet of things become ubiquitous, more electromagnetic radiation is sent out, and there's a real danger in getting our metaphorical wires crossed. What might happen if signals from tomorrow's 5G smartphone, with greater processing power than today's slow-poke 4G versions, interfere with the onboard computers of your self-driving car? Or what if your autonomous vehicle, stopped at a railroad crossing, emits signals that interfere with the instrumentation aboard that approaching train?

Google is making progress on getting driverless cars to market, but it wants to make sure all of the onboard processors are up to snuff. Thanks to a grant from Google, Fan is helping the company solve this computing conundrum. "We need to make these devices, phones and cars, work in a real-world setting," Fan says.

His work in the EMC Lab involves testing of current cellphones to understand the interference and its effect on the performance of over-the-air multiple-input, multiple-output (MIMO) systems. He works in a fully enclosed electromagnetic quiet room equipped with wave-absorbing material on three walls and the ceiling. Here Fan and other researchers gauge the radiation from electronic devices' transmitters and receivers.

What Fan gleans from studying cellphones can be applied to autonomous vehicles, he says. Just as reducing interference in phones can lead to better performance, reducing interference in and among self-driving cars will make them safer when multiple vehicles are on the road. Of course, infrastructure investment in and surrounding roads will be necessary to keep the communications between autos clear and direct.

"Google wants to see if results to de-bug fail, what went wrong," Fan says. "If it was interference, what kind of interference is it?"

# A BIOMEDICAL PARTNERSHIP TAKES ROOT



**Nuran Ercal** is working to open new doors of collaboration for Missouri S&T researchers with interests in biomedical research. She's doing so through the Ozark Biomedical Initiative, a partnership formed in July 2015 between the university and Phelps County Regional Medical Center.

"I would love to have had this opportunity when I first arrived in Rolla," says Ercal, the Richard K. Vitek/ Foundation for Chemical Research Endowed Chair in Biochemistry at Missouri S&T. "We are just getting started with this project, but I hope it will lead to greater collaboration and new research over time."

The partnership's chief goal is to support biomedical research, she says. Toward that end, PCRMC and S&T each contribute \$25,000 annually to award to joint research proposals that involve individuals from both entities. That funding provides seed money for research and testing that can support future proposals to major funding agencies like the National Institutes of Health.

The partnership gives S&T researchers access to specialized medical equipment only available at the medical center while providing access to PCRMC's Delbert Day Cancer Institute, which opened last December. Named after Day, a Curators' Distinguished Professor emeritus of ceramic engineering, the institute will provide the OBI with two floors of lab and meeting space.

In her role as chair of the OBI's research and education council, Ercal leads a group of S&T researchers and PCRMC physicians that reviews the joint proposals. Last year — the first full year of OBI funding — the panel considered five proposals and awarded grants to each.

Each project involves a distinct approach to a health or medical issue. One research team plans to characterize the sex pheromones of brown recluse spiders — a necessary step for a proposed method to lure and trap the poisonous spiders. Another project involves the fabrication of a biodegradable brachytherapy implant that could deliver concentrated radiation therapy to target cancerous tumors. Another research group proposes developing "nanorods" as vessels to treat breast cancer, while another is investigating urine-sampling techniques to detect biomarkers that could indicate traumatic brain injuries. A fifth research team will study fetal heart rate patterns to develop a computational model to predict the risk of fetal hypoxia and acidosis after a mother has entered labor.

For more information, visit [obi.mst.edu](http://obi.mst.edu).



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# THIS IS YOUR BRAIN ON MARKETING

Researchers led by **Keng Siau**, professor and chair of business and information technology at Missouri S&T, are examining new cognitive neuroscience methods to study the effects of marketing on our brains. Here, **Nikhil Dusane**, a graduate student in information science and technology,

places an EEG headset on IST senior **Samuel Smith**. Siau discusses the future of cognitive neuroscience in the article "Cognitive Neuroscience in Information Systems Research," published in the January 2016 edition of the *Journal of Database Management*.