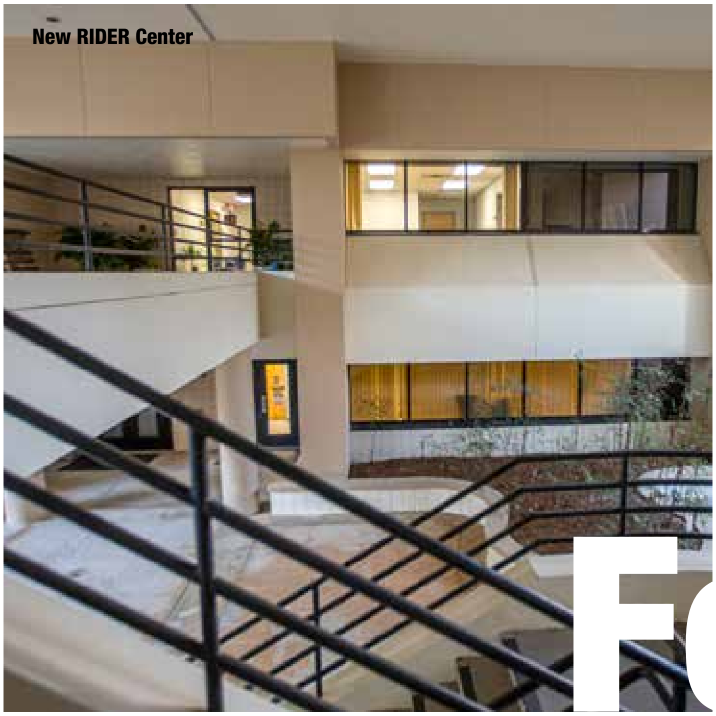
2020–21 Annual

RESEARCH REPORT

FAMU-FSU Engineering

Forward momentum

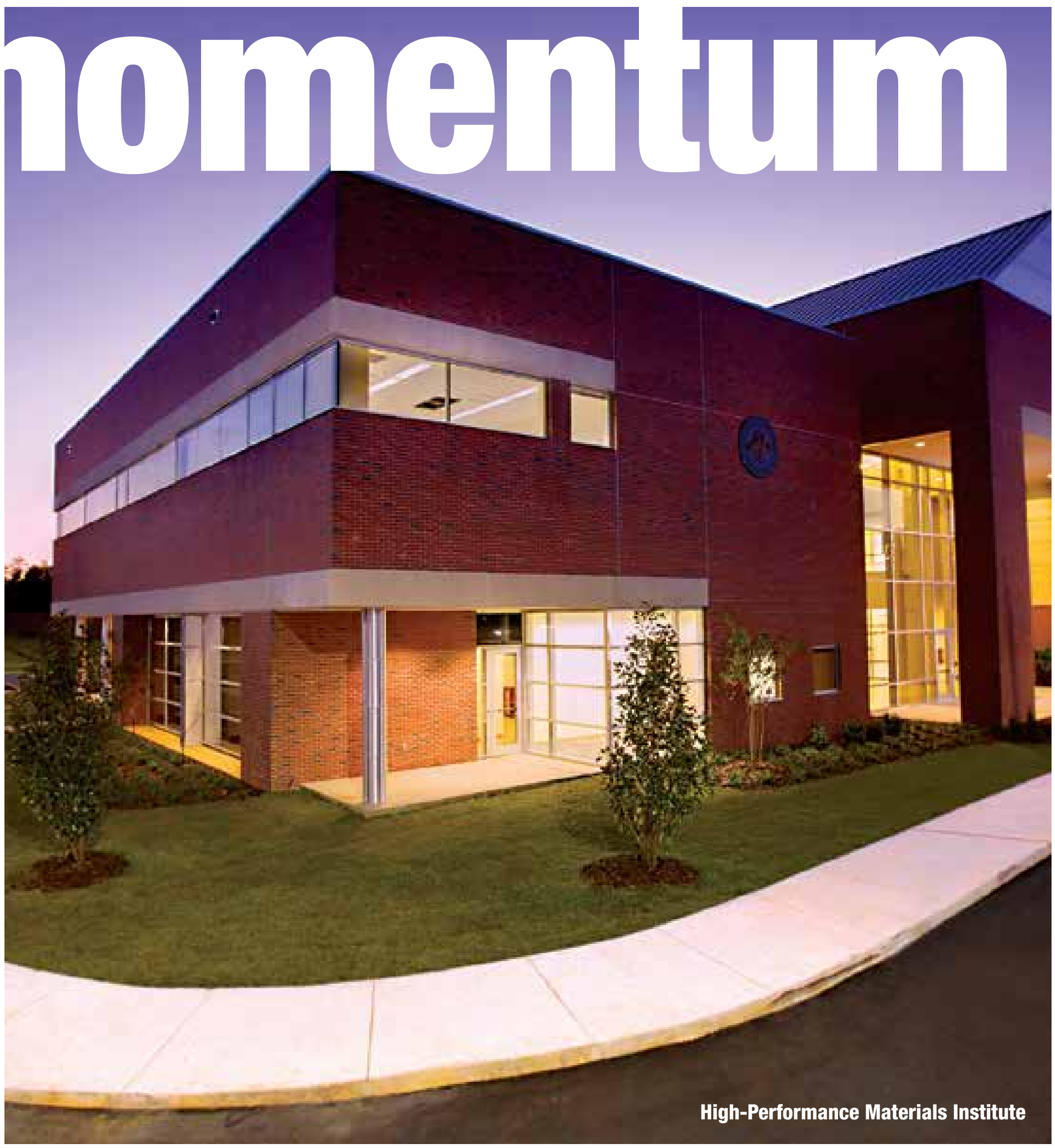


New RIDER Center

Engineering building B

Center for Advanced Power Systems

AME Center



High-Performance Materials Institute

Despite challenges from COVID-19, FAMU-FSU Engineering continues its forward momentum

In many ways, despite the challenges of COVID, this has been a very good year for the FAMU-FSU College of Engineering. In particular we are delighted to see our substantial rise in the national *US News and World Report* rankings. These represent progress in the metrics, see page 8-9, but also increasing recognition for our unique partnered model and its impact. We are now ranked the #2 doctoral-granting undergraduate engineering school in Florida, including all public and private schools. While we admire the scale and impact of the one engineering institution in the state that ranks above us, we note that we compare well with them in per faculty metrics, but are one third their size. Our smaller and very diverse environment is quite attractive for students.

When asked in the elevator about our major research initiatives, I say: hypersonics, power systems, nanomaterials and sustainability/resilience. You will see some new results from these in this short report, with a focus on junior faculty, but can find many more in the **research news on our website.**

We have taken over management of FSU's Aero-propulsion, Mechatronics and Energy (AME) research center this year, and I am especially proud of our newest center in **Resilience and Disaster Recovery (RIDER)**, led by civil engineering faculty member Eren Ozguven. In Florida and beyond, disaster recovery has become a major issue, and it needs a highly interdisciplinary approach. We are especially focusing on improving resilience for under-served communities. We are working not just on hurricane disasters, but also on wildfires. The hallmark of the center is to bring social science, science and engineering together to understand disaster response, with an aim to increase community resilience. The research includes everything from big data analysis to waste disposal. One of our recent senior design projects addressed a community need for temperature-controlled medication storage without electric power.

There are challenges ahead. The residue of the COVID pandemic is likely to be budget cuts at the state level that will challenge our growth plans in the short term. Nonetheless, there have been learning experiences in terms of improved remote learning and organizational resilience which will position us better to capitalize on the normal times when they return.

When I first joined the college as dean four years ago, my focus was on positioning us as an equal and partnered institution. I believe that our joint identity has helped us gain recognition. The growing recognition of endemic social injustice in our country inspires us to use the unique diversity of our partnered school as a platform for change. Now is the time to focus on the inside and strive to remove barriers to equal opportunity and support for our students, faculty and staff. We are not there yet, for certain. We in the college have started a major program that we call Lets Start Here to improve diversity, equity and inclusion at the college. To follow our progress please visit our **Let's Start Here web page.**

J. Murray Gibson
Dean, FAMU-FSU Engineering

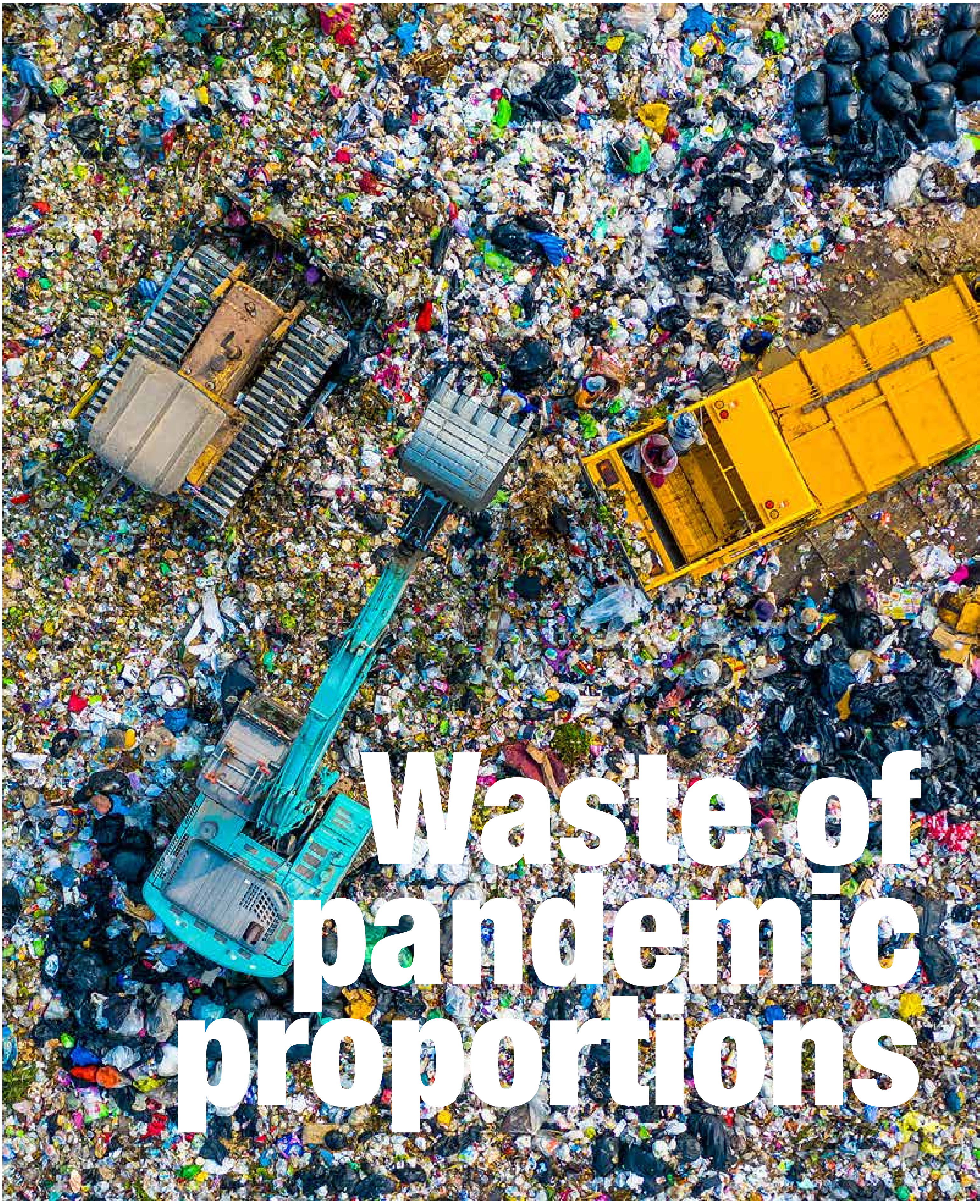
TOP 40
AMONG PUBLIC UNIVERSITIES
BEST
UNDERGRADUATE
ENGINEERING
PROGRAMS WITH DOCTORATE
2021

GRADUATE
ENGINEERING
+21 spots
over **3** years

Greater than ***40%*** increase in research expenditures over last three years

PER FACULTY MEMBER:

$270K – external award expenditures
PhD students – ***3***



Waste of pandemic proportions

Measuring the pandemic's impact on local solid waste management facilities

COVID RESEARCH

FAMU-FSU College of Engineering researchers are studying the impact of the COVID-19 pandemic on municipal solid waste management systems with the help of a Rapid Response Research grant from the National Science Foundation. They are also hoping to catalogue the debris that may be reusable for sustainability goals.

"There has been a lack of understanding of how the COVID-19 pandemic affects our waste management industry," Assistant Professor of Civil Engineering Juyeong Choi said.

Choi and fellow researcher, Professor of Civil Engineering Tarek Abichou, will examine waste management system-related challenges in the pandemic environment across several states. They plan to produce an informational database that allows development of a more proactive, resilient approach for future pandemics.

"To date, most pandemic-related studies have focused on the virus' impact on public health systems," Choi said. "Despite the importance of waste management systems, there is a limited understanding of how a pandemic might impact them."

One of the problems researchers are trying to identify is how different waste management systems adapt to the challenges posed by the pandemic.

"People working from their homes to prevent the spread of the coronavirus are generating more residential waste than normal," Choi said. "We want to know how different facilities are adapting to this situation."

The researchers are looking at several municipal solid waste management systems throughout Florida, California and New York to identify and characterize a broad range of waste management challenges faced by different stakeholders and municipalities. They want to understand adaptive measures that facilities take to adequately operate and hope to develop recommendations for best management practices during a pandemic.

Juyeong Choi, assistant professor of civil engineering, won a NSF RAPID grant to conduct research on the pandemic's impact on solid waste.

> The pandemic has caused people to generate more residential waste than normal. We want to know how different facilities are **adapting** to this situation."
>
> —J. CHOI, CIVIL ENGINEERING ASSISTANT PROFESSOR

"While people are generating more residential waste, the capacity of these waste-management facilities are being constrained by the increasing number of unavailable workers due to self-quarantining," Choi said. "Travel bans have isolated these facilities, and we hope to identify and track how different systems successfully adapt to these challenges."

Other effects of the pandemic on solid waste also contribute to the problem, including additional medical wastes: over 149 million Covid-19 tests have been conducted in the U.S. alone, and experts estimate that billions of disposable masks have been sold worldwide. Many items, such as reusable shopping bags and laminated restaurant menus, are being replaced by disposable versions in an effort to limit transmission of the virus through product handling. Additionally, an increase in package delivery results in more cardboard trash, when compared to purchasing the same items in a brick and mortar location.

Much of the waste contains high latent value recyclable material like plastic and cardboard. Choi hopes one of the outcomes of the project might be to minimize the environmental impact of waste by making it possible to promote sustainable options. He was recently funded by NSF to establish the Sustainable Material Management Extreme Event Reconnaissance (SUMMEER) organization to study sustainable management of disaster materials and looks at the pandemic as another type of extreme event.

"The RAPID grant project will serve as a stepping stone to help my research team better understand waste management-related issues," Choi said. "We hope a broader impact of this study will be to minimize the impact of the pandemic by accommodating the increased volume of waste through sustainable options like recycling."

Choi and Abichou received $152,000 through the NSF RAPID grant program to conduct this research. The one-year grant began in May 2020.

Sealed and delivered

"We believe that the new proposed drug-loaded biomedical **adhesives** can be used to treat diseases and cancers that need the delivery of **small molecule** drugs. Because the drug can stay in a specific area or internal organ, many side effects can be **prevented.**" —H. CHUNG, BIOMEDICAL ENGINERING ASSISTANT PROFESSOR

Researchers land grant for new wet tissue bioadhesive that delivers drugs and a reliable seal

BIOMED RESEARCH

Biomedical adhesives are an important new biomaterial, which stably bind two tissue surfaces to replace and enhance surgical suturing. The new adhesives are needed because existing biomedical adhesives have significant limitations like poor wet adhesion and complex application methods. There are also safety concerns regarding some of the materials that are used.

Researchers in engineering and medicine recently proposed biomedical adhesives designed to overcome these problems with bottlebrush polymer architectures that are biodegradable. The multifunctional biomaterial can deliver antibiotics and anticancer drugs to a localized area of the internal organ. The team was recently funded by the National Science Foundation to further test the technology.

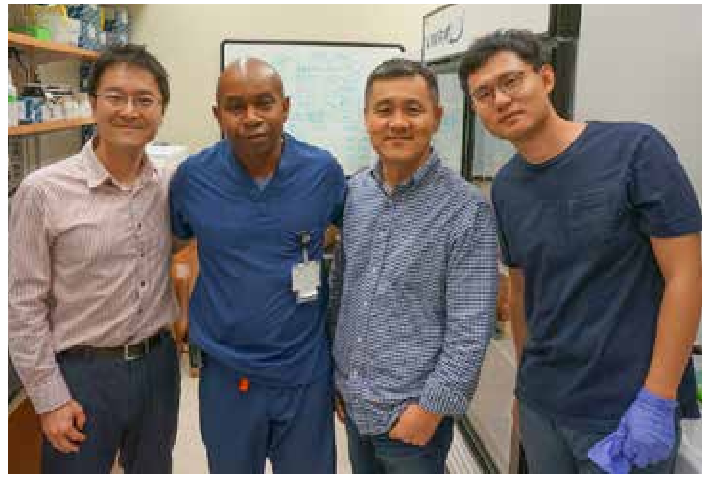
"We are hoping this could reduce high mortality rates associated with difficult surgeries such as intestinal anastomosis," said Choogon Lee, associate professor of the FSU College of Medicine and one of the project researchers.

Anastomosis usually involves a surgical connection between tubular structures such as blood vessels or intestines. When a section of the intestine is removed, the remaining ends usually are sewn or stapled together. Bacterial infections can contribute to anastomotic leakage and delay wound healing.

Ho Yong Chung, an assistant professor of chemical and biomedical engineering, is the principal investigator on the study, which is a collaboration between the FAMU-FSU College of Engineering and the FSU College of Medicine. Chung's group oversees the development of drug-loadable, fully degradable bio-adhesives for internal organs, while Lee's group is testing the biomedical effectiveness and toxicity of the bio-adhesives.

In preliminary work, these adhesives have shown drug delivery capabilities and improved biocompatibility and are superior to other adhesives currently in use.

The proposed drug-loaded biomedical adhesive will prevent physical leakage from the site and deliver antibiotics to control the bacteria population near the surgery site. In addition, localized anticancer drug delivery to prevent cancer reoccurrence can be beneficial after cancerous anastomosis surgery.

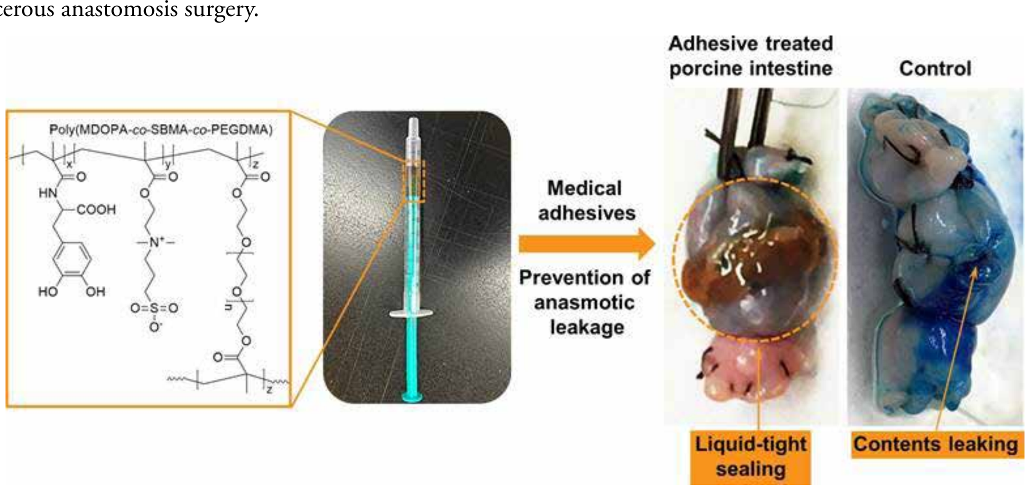


(L to R): **Hoyong Chung,** Wade Douglas, Choogon Lee, and Minkyu Kim.

Bottlebrush polymers look somewhat like a bottle brush used to clean a test tube. Compared to conventional linear polymers, bottlebrush polymers have unique super-soft elastomer features that enable efficient adhesion to internal organs in a wet living environment. The super-soft elastomer is stable and flexible and has unique features that have not previously been used in biomedical adhesives.

"We believe that the new proposed drug-loaded biomedical adhesives can be used to treat diseases and cancers that need the delivery of small molecule drugs," Chung said. "Because the drug can stay in a specific area or internal organ, many side effects can be prevented."

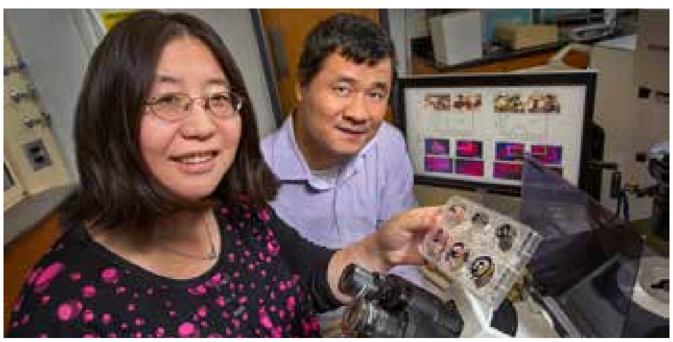
The NSF award for this project is $500,000 over three years.



COVID **FACTORY-IN-A-BOX**

Two researchers hope a new concept called "factory-in-a-box" may provide a solution for disruption in the supply chain that occurs in a disaster. The idea is to bring a fully functional mobile factory to the people directly affected by a disaster. Once the need is met, the factory can be packed up and moved to another location. The logistics involve many moving parts, from setting up the facility, to delivering raw materials, to finding suppliers. // Timing is everything according to **Hui Wang,** an assistant professor of industrial engineering. Wang is the principal investigator for a $300,000 National Science Foundation (NSF)-funded research project developing analytical tools for decision-making in supply chain network design and assembly planning for factory-in-a-box manufacturing. The NSF Excellence in Research (EiR) grant provides funding for operations engineering research and includes an educational component for undergraduate research. // Wang's three-person team includes **Maxim Dulebenets,** an assistant professor of civil and environmental engineering, and Weihong Guo, an assistant professor of industrial and systems engineering at the Rutgers School of Engineering. // Research from this project could help build a framework for supply chain network design and provide valuable insight into the logistics of materials planning and delivery.

BIOMEDICAL **NEW TOOL FOR STEM CELL GROWTH**

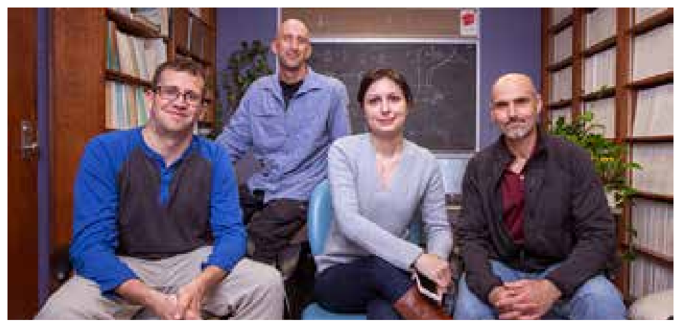


Biomedical engineering researchers are developing a high-tech material currently used in athletic equipment and prosthetics into a special tool to better develop stem cells. The work could improve drug screening, disease modeling, precision medicine and cell therapy. // **Yan Li,** an associate professor in chemical and biomedical engineering, and **Changchun Zeng,** an associate professor in industrial and manufacturing engineering, received a $400,000 grant from the National Science Foundation for this research to explore ways to better control the fate of stem cells. // Their project will examine induced pluripotent stem cells, which are stem cells developed from mature cells and changed into a state that allows them to develop into any tissue in the body. Using a unique, high-tech material developed by Zeng called auxetic foam, they will build three-dimensional scaffolds on which the cells can grow. // Li and Zeng are interested in how the scaffolds' mechanical properties influence the fate of the stem cells they surround. Their goal is to understand how three-dimensional scaffolds that surround growing stem cells influence the extracellular structures and the proteins those cells secrete, and therefore, the types of cells they become.

BIOMEDICAL **SPECIALIZED MRI FOR TUMOR SURVEILLANCE**

Sam Grant, a biomedical engineering associate professor, uses a technique called chemical exchange saturation transfer (CEST) to study the progression of glioma. // CEST allows scientists to detect structures or processes in the body that traditional MRI can't visualize. MRI scanners are typically used to detect the hydrogen in the body's water; that information generates an image of structures in the body. In CEST, hydrogen atoms from specific molecules interchange with hydrogen atoms in free water within the body, highlighting the interactions of those target molecules in MRI scans. // Grant and his colleagues have been optimizing the technique for experiments in the MagLab's 21.1 tesla MRI magnet. Using CEST, they can identify metabolites, neurotransmitters and other molecules involved in tumor progression. // "Looking at the chemical exchange allows us to identify unique patterns in the spectra that correspond to a tumor that is changing dynamically as it's growing," said Grant.

RESILIENCY **IMPROVING PRESCRIBED BURNS**



A $2.2 million Department of Defense grant funds an investigation into the dynamics of smoke from prescribed burns, giving land managers a better understanding of when and how to best use the technique. // Understanding how smoke plumes develop and travel is an interdisciplinary problem. FSU researchers from the Department of Scientific Computing, the FAMU-FSU College of Engineering's Department of Mechanical Engineering and the Geophysical Fluid Dynamics Institute are partnering with the forest research station Tall Timbers, Los Alamos National Laboratory and others to understand the complexities of wildland fires. // Partnering with investigators who have fire management experience helps researchers take what they discover at an academic level and transition it to a practical application. Existing knowledge about how fires burn informs their model. They refine that with new parameters, such as the topography and distribution of vegetation that acts as fuel in a burn plot, the way wind moves through the plot, the fuel moisture and the heat radiated from the fire—then collect data from an actual fire to make a more accurate model of how smoke plumes rise from a prescribed burn. // "We want our models to capture the true physics and our simulations to be as close to what really happens in the field as possible," said **Neda Yaghoobian,** an assistant professor of mechanical engineering. "This requires parameters that can take input from fire managers and other researchers to refine our model."

FACILITIES LEADING LABS ALIGNMENT

The Aerospace, Mechatronics and Energy (AME) building and Florida Center for Advanced Aero-Propulsion (FCAAP) in Tallahassee's Innovation Park adopted new management models and leadership under the FAMU-FSU College of Engineering on July 1, 2020. This was the culmination of a three-year transition period which began in July 2017. // The largest centers within the building are the **Florida Center for Advanced Aero-Propulsion (FCAAP)** and the **Center for Intelligent Systems, Control and Robotics (CISCOR).** FCAAP was formed to meet the needs of a rapidly evolving and highly competitive aerospace industry. Its main facilities include polysonic, subsonic, supersonic and anechoic wind tunnels, as well as a short take-off and vertical landing (STOVL) jet facility. // CISCOR is a state-of-the-art robotics and mechatronics research space developed to engineer practical solutions to problems in systems, control and robotics for applications in industry and government. It houses the Scansorial and Terrestrial Robotics and Integrated Design (STRIDe) and Optimal Robotics Laboratory laboratories, both led by mechanical engineering professors. // In addition to FCAAP and CISCOR, the AME building is home to environmental engineering labs and chemical wet laboratories for chemical and civil/environmental engineering faculty, as well as administrative and graduate researcher office space.

RESILIENCY RIDER CENTER DISTASTER TECH HUB

Eren Erman Ozguven, professor of civil and environmental engineering, is the director of the newly-formed Resilient Infrastructure and Disaster Response (RIDER) Center. // "Unfortunately, we have gotten to see firsthand the destructive power of hurricanes over the past several years. While our work is broadly applicable to both coastal and inland regions, we have seen the toll rural communities endure. Rural areas often have more infrastructure limitations and communication challenges than their urban counterparts," Ozguven said." Working closely with the impacted communities, the RIDER center will address these challenges and serve as a technical repository on disaster response and recovery. // The RIDER center will be an information research hub that will provide a central location for resiliency and disaster research. One of the main focuses of the center is to establish and develop emergency plans that fit the needs of both urban and rural communities. // The new center will be led by research faculty from the civil and environmental engineering department at the college. They will act as technical leads, with expertise on everything related to disaster response and resilience. Their research specialties range from structural design and wind engineering to the handling of debris, logistics, transportation issues, flooding and storm surge as well as coastal engineering. The center will also collaborate with other social science and engineering disciplines such as industrial and electrical, with a focus on infrastructure networks, sustainability and reliability.

AEROSPACE HYPERSONIC AERODYNAMICS

The U.S. government is interested in developing hypersonic weapon systems for the nation's defense and their scientists are working with researchers at the FAMU-FSU College of Engineering to develop essential research data needed to accomplish this. The need for this research could not be greater as nations scramble to compete for this technology. // **Rajan Kumar,** an associate professor in mechanical engineering, was awarded two grants that together total over $1 million to assist the U.S. military with the design of Hyper Velocity Projectiles. High-speed projectiles are necessary to develop hypersonic weapon systems. // "This research involves the study of a flight vehicle operating at hypersonic speeds," Kumar explains. "The graduate students involved in this research will become next-generation engineers and scientists, and will significantly benefit from working on these challenging problems."

MANUFACTURING 3D PRINTING WITH MAGNETS

Researchers from the High-Performance Materials Institute, FAMU-FSU College of Engineering have developed and investigated a new technique for 3D printing that could produce much stronger materials that could be used in a variety of engineering applications. // In a paper published in the journal Additive Manufacturing, **Madhuparna Roy** (a Spring 2020 Florida State Unviersity doctorcal graduate from the college) and advising professor **Tarik Dickens** showed the possibility of using magnetic fields near a 3D printer to change the alignment of fibers inside an object as it was being printed—a term Dickens calls 'magneto-assisted printing.' This tweak in the mechanical properties of the material could greatly improve its overall quality and strength. // "3D-printed materials are not strong on their own because they're just plastic layers sitting on top of each other," said Roy, the paper's lead author. "The gap in the research world is to improve mechanical properties. With improved mechanical properties, you could create solutions for any kind of application, depending on what that particular application requires." // This paper showed the possibility of using this technique for a material with low viscosity, so future investigations could study the process with a more viscous material that requires a stronger magnetic field to realign the interior fibers, Roy said. Mechanical tests of the finished 3D-printed product are planned.

MATERIALS ADVANCING PARTICLE ACCELERATORS

Mechanical Engineering Associate Professor **Wei Guo** and his team use cryogenics to study liquid helium and its use related to superconducting particle accelerators, to make them safer and more efficient. Guo is the Director of the Cryogenics Lab located in the National High Magnetic Field Laboratory (NHMFL). // The U.S. Department of Energy (DOE) has a vested interest in the safe operation of these facilities and provided a $600,000 grant to study several projects in the Cryogenics Lab operated by Guo and his team. One project supported by DOE is to study "Sudden vacuum loss in helium-cooled tubes." Guo and his team have set up a unique model system for experimentation, using a vacuum tube immersed in liquid helium and connected, through a fast-acting solenoid valve, to a gas reservoir at known

CONTINUED ON PG. 16

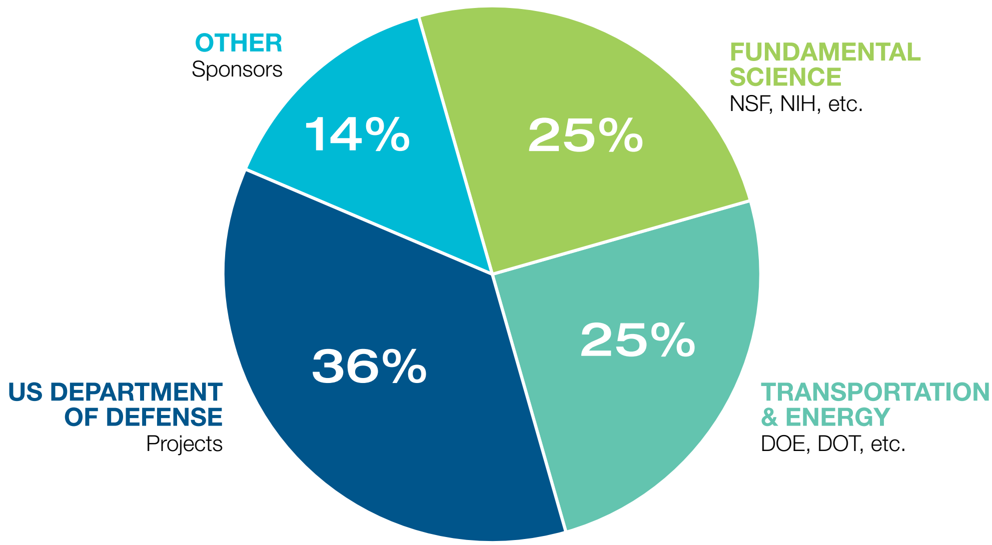
FAMU-FSU
College of Engineering

GRADUATE ENGINEERING
#4 in Florida
among public schools
2021

Some of Our Most Generous Corporate Sponsors 2017–2020

Aerosonic
Baidu USA
Bruker Biospin AG
CERN
Cummins Inc.
Curtiss-Wright Electro-Mechanical Corp.
Cytec Engineered Materials
Danfoss Turbocor Compressors
Duke Energy
Environmental Research and Education
EPRI
ExxonMobil Chemical Company
Ford Motor Company
Geosyntec Consultants
General Atomics Electromagnetics
Infineum USA
Korea Basic Science Institute
L3Harris Technologies
L-3 Maritime System
LG Chem
Lockheed Martin Corporation
Major Tool and Machine
Mitsubishi Heavy Industries
Nikon Instruments
Northrop Grumman Systems Corporation
OMICS
Reliance Industries Limited, India
Rolls-Royce
SentiMetal Journey
SGRI North America
Texas Instruments
Total Raffinage Chimie

FY 2020 Sponsored Research Expenditures
$28.4M**



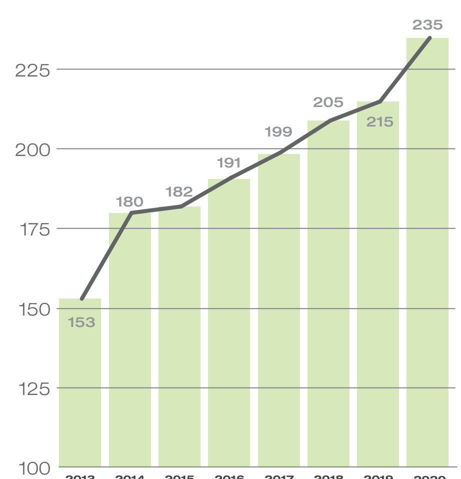
Junior faculty awards
17 TOTAL
7 ACTIVE
- 6 NSF CAREER
- 1 DARPA YIP*

*Young Investigator Program

RESEARCH TOTALS '19–'20

165 RESEARCH AWARDS *(received)*
$31.4M TOTAL AWARDS VALUE
203 PROPOSALS SUBMITTED
67 RESEARCH LABS & CENTERS
30 PATENTS ISSUED

PhD Enrollment



22 FACULTY FELLOWSHIPS

- American Association for the Advancement of Science
- American Institute of Chemical Engineers
- American Physical Society
- American Society of Civil Engineers
- American Society of Mechanical Engineers
- Institute of Electrical & Electronics Engineers
- Institute of Physics (UK)
- Materials Research Society
- National Academy of Engineering
- National Academy of Inventors
- Royal Academy of Engineering (UK)
- Royal Microscopical Society (UK)

**Numbers are approximate as of July 31, 2020; FY 2020: July 1, 2019 – June 30, 2020

#2 in Florida
AMONG ALL UNIVERSITIES
BEST
UNDERGRADUATE ENGINEERING
PROGRAMS WITH DOCTORATE
2021

Generated ***nearly half*** of all patent applications filed by both universities in 2019

STUDENT POPULATION

2,604 students
2,230 undergraduate
374 graduate

2013

40% increase in GRADUATE enrollment since 2013

15% increase since 2019

TOTAL ENGINEERING DEGREES AWARDED 2019–20

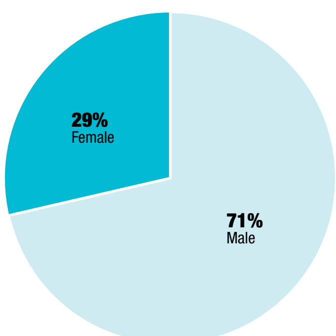
BS **398** GRADUATE **121**

Graduate Student Fellowship Awards
2019–2020

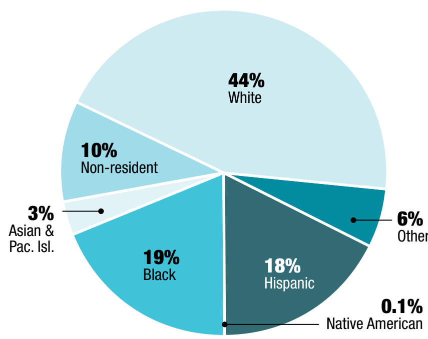
- NIH Pre-Doctoral Fellowship
- DOE Science Graduate Student Research
- McKnight Fellowship (2)
- GEM Associate Fellows (4)
- GEM Intel Fellow
- DoD SMART Scholar
- FSU Legacy Fellowship
- NSF Graduate Research Fellowship (5)

GRADUATE & UNDERGRADUATE STUDENT POPULATION

By Gender
Fall 2020



By Race
Fall 2020

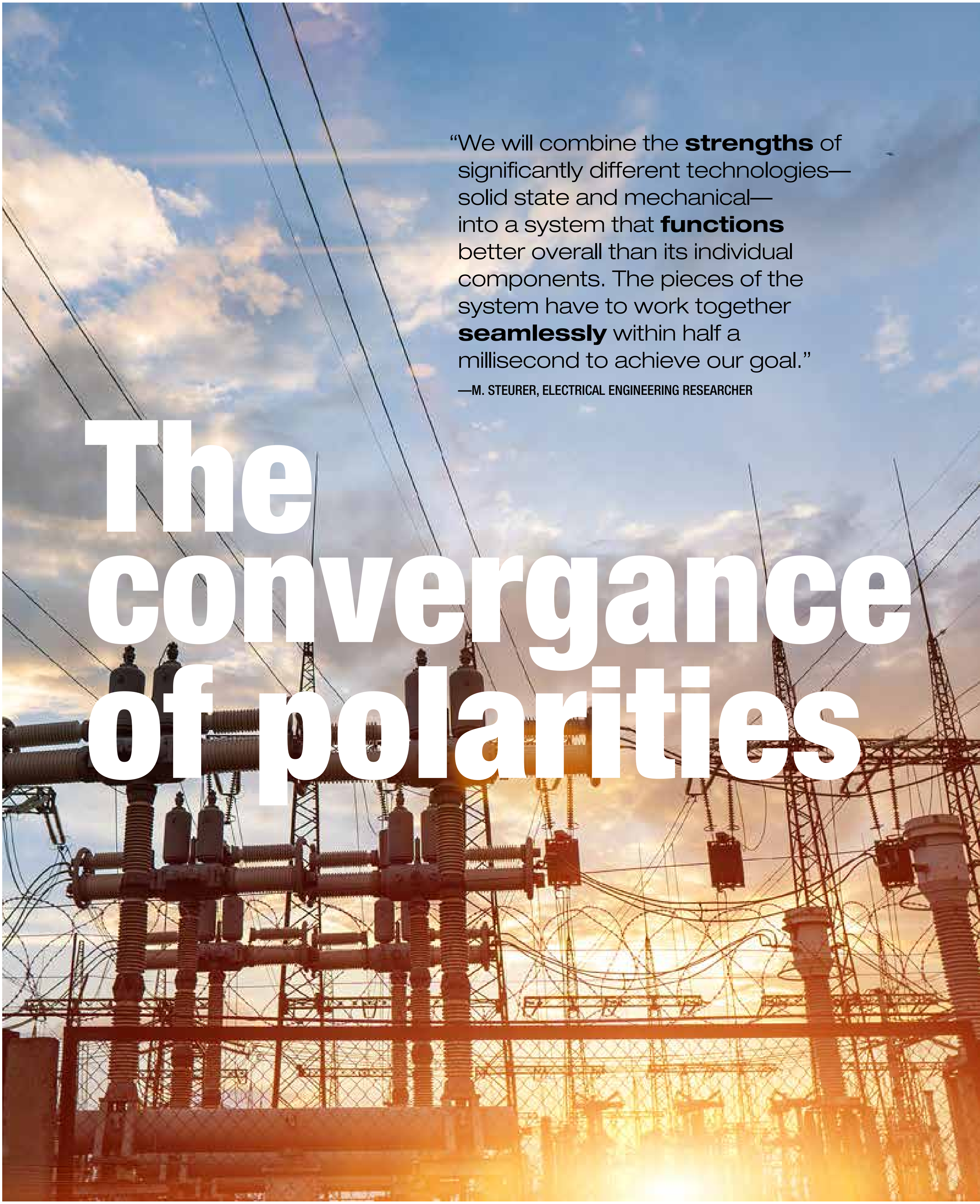


FAMU (HBCU)
doctorate enrollment
doubled since 2016

ASEE DIVERSITY RECOGNITION PROGRAM
BRONZE
ASEE
2019 Exemplar

#4
producer of African-American PhDs in engineering nationwide

#1
in percentage of African-American engineering faculty at an R-1 university



"We will combine the **strengths** of significantly different technologies—solid state and mechanical—into a system that **functions** better overall than its individual components. The pieces of the system have to work together **seamlessly** within half a millisecond to achieve our goal."

—M. STEURER, ELECTRICAL ENGINEERING RESEARCHER

The convergance of polarities

Partnered with Georgia Tech, researchers make direct current practical in high power applications

Michael "Mischa" Steurer, research faculty member in electrical engineering, is at the Florida State University Center for Advanced Power Systems (CAPS) and associated with the college.

Major power users depend on alternating current (AC), which cycles on and off 60 times per second. Among the reasons: AC is simple to turn off when there's a problem—known as a fault—such as a tree falling on a power line.

More and more systems are transitioning to DC power, but researchers are still trying to find the perfect way to turn off the power in these DC systems. A new collaboration between FAMU-FSU Engineering faculty and Georgia Tech could solve that problem.

The ARPA-E BREAKERS program in the Department of Energy awarded Florida State University and Georgia Tech researchers $3.3 million to develop innovations in power electronics, piezoelectric actuators and new insulation materials to make highly efficient, high-power DC circuit breakers feasible.

The project is known as Efficient DC Interrupter with Surge Protection (EDISON).

"The transition from AC to DC, which is already happening, will open up a new paradigm for efficiently and controllably managing power in future electrical systems and military platforms," said Michael "Mischa" Steurer, a research faculty member at Florida State University's Center for Advanced Power Systems (CAPS) who is associated with the FAMU-FSU College of Engineering. "This will be enabled by the amazing developments that have happened over the past two decades in power electronics."

Direct current could be particularly useful as more renewable energy comes online. Photovoltaics in the west may still be generating power after the sun sets in the east. Wind turbines may be producing power in the mid-section of the country while clouds cover other parts of the country. Transmitting power from one location to another could therefore become more important.

The hybrid circuit breaker under development by the research team will use stacks of very large transistors to switch off the DC when necessary. Semiconductors are less efficient at conducting current than conventional mechanical switches, so under ordinary conditions, the current will flow through mechanical switches. But when the power must be turned off, current will be briefly routed through the power electronics until the mechanical breakers can be opened.

"We are proposing a hybrid DC circuit breaker in which the current will have two paths," explained Lukas Graber, an assistant professor in the School of Electrical and Computer Engineering at Georgia Tech. "One path will be through the semiconductors, which can interrupt the current when needed. The second path will be through mechanical switches, which will provide a much less resistive path that will be more efficient for normal operations."

The transistors that will be used in DC switching are a square centimeter in size, and dozens or hundreds of them would be combined in series or parallel to provide enough capacity for switching thousands of volts. After the current has been moved to the solid-state transistor pathway, piezoelectric actuators will quickly separate the contacts in the mechanical switches before temperatures can rise too high in the transistors. Once separated, the flow through the transistors can be switched off.

"We need to be extremely fast," Graber said. "We have to separate the contacts within 250 microseconds and to completely break the current within 500 microseconds—just half a millisecond. For that reason, we cannot use spring-loaded or hydraulic actuators common to AC breakers. Devices that rely on the piezoelectric effect can do that for us."

The Georgia Tech and FSU researchers have developed intellectual property for components of the proposed DC breakers and will work together to combine the technologies.

"We will combine the strengths of significantly different technologies—solid state and mechanical—into a system that functions better overall than its individual components," Steurer said. "The pieces of the system have to work together seamlessly within half a millisecond to achieve our goal."

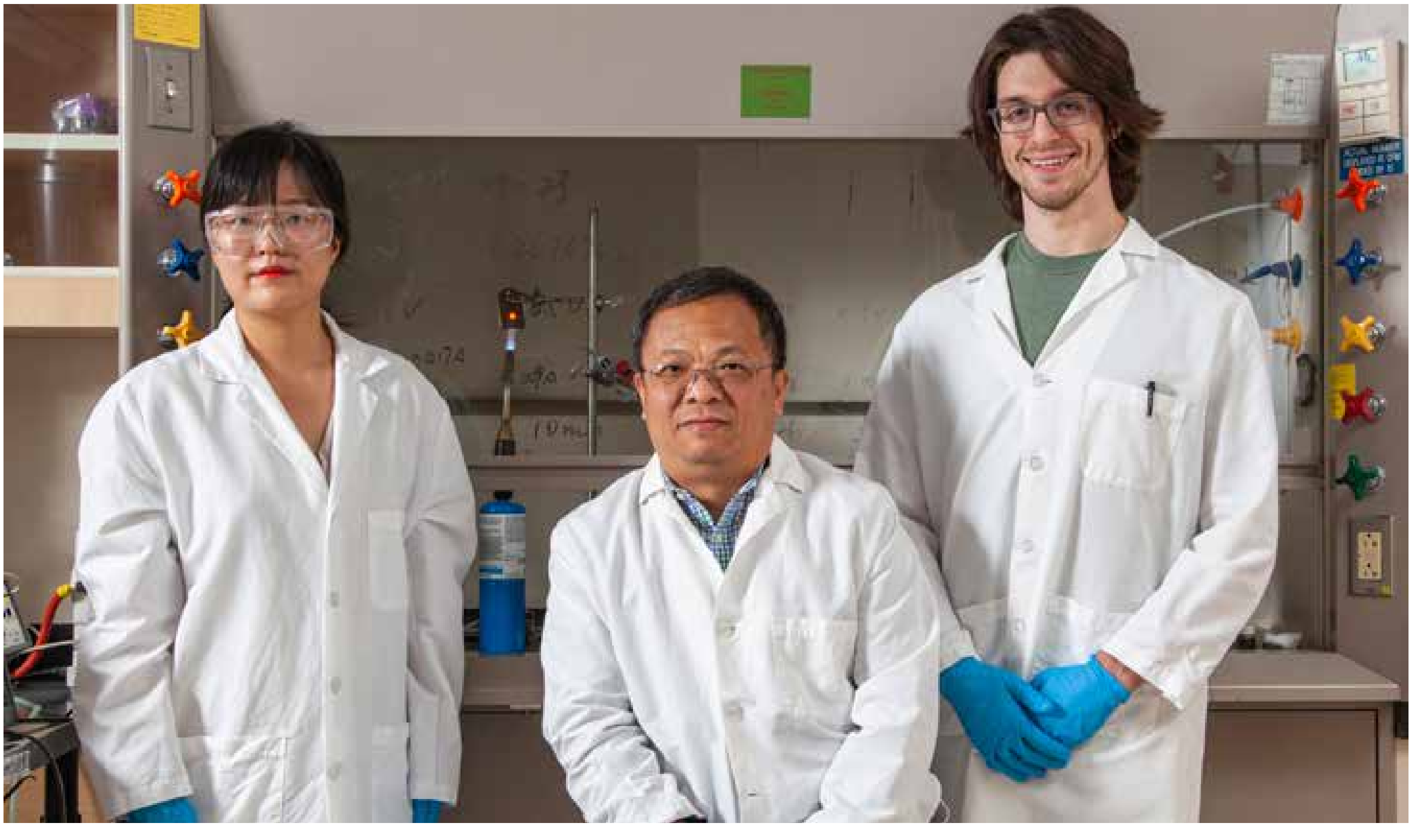
The researchers—including Associate Professor Maryam Saeedifard, VentureLab Principal Jonathan Goldman, and Postdoctoral Fellow Chanyeop Park at Georgia Tech and FAMU-FSU Engineering Professor Fang Peng, Research Faculty Karl Schoder, and FAMU-FSU Engineering Assistant Professor Yuan Li—expect to build a prototype that will be tested within three years. The development and testing will be done in collaboration with a team of industrial partners who will ultimately transition the DC breakers to commercial use.

Thin-skinned strength

By soaking **buckypaper** in a resin made of a compound called **phenol,** the team created a lightweight, flexible material that is also **durable** enough to protect the body of an aircraft from the intense heat it faces while flying at high speeds.

Researchers develop thin heat shield for superfast aircraft

MATERIALS RESEARCH



Ayou Hoa, Ph.D., Zhiyong (Richard) Liang, Ph.D., (director of the High-Performance Materials Institute) and doctoral candidate at HPMI **Yourri-Samuel Dessureault**

The world of aerospace increasingly relies on carbon fiber reinforced polymer composites to build the structures of satellites, rockets and jet aircraft. But the life of those materials is limited by how they handle heat.

A team of FAMU-FSU College of Engineering researchers from Florida State University's High-Performance Materials Institute (HPMI) is developing a design for a heat shield that better protects those extremely fast machines. Their work was published in the November 2019 edition of *Carbon.*

"Right now, our flight systems are becoming more and more high-speed, even going into the hypersonic range, which is five times the speed of sound," said Professor Richard Liang, industrial and manufacturing engineering faculty member and director of HPMI. "When you have speeds that high, there's more heat on a surface. Therefore, we need a much better thermal protection system."

The team used carbon nanotubes, which are linked hexagons of carbon atoms in the shape of a cylinder, to build the heat shields. Sheets of those nanotubes are also known as "buckypaper," a material with incredible abilities to conduct heat and electricity that has been a focus of study at HPMI. By soaking the buckypaper in a resin made of a compound called phenol, the researchers were able to create a lightweight, flexible material that is also durable enough to potentially protect the body of a rocket or jet from the intense heat it faces while flying.

Existing heat shields are often very thick compared to the base they protect, said Ayou Hao, a research faculty member at the center.

This design lets engineers build a very thin shield, like a sort of skin that protects the aircraft and helps support its structure.

After building heat shields of varying thicknesses, the researchers put them to the test.

One test involved applying a flame to the samples to see how they prevented heat from reaching the carbon fiber layer they were meant to protect. After that, the researchers bent the samples to see how strong they remained.

They found the samples with sheets of buckypaper were better than control samples at dispersing heat and keeping it from reaching the base layer. They also stayed strong and flexible compared to control samples made without protective layers of nanotubes.

That flexibility is a helpful quality. The nanotubes are less vulnerable to cracking at high temperatures compared to ceramics, a typical heat shield material. They're also lightweight, which is helpful for engineers who want to reduce the weight of anything on an aircraft that doesn't help the way it flies.

The project received second place among peer-reviewed posters at the 2019 National Space and Missile Materials Symposium and received third place at the Society for the Advancement of Material and Process Engineering 2019 University Research Symposium.

That recognition is helpful for showing the United States Air Force Office of Scientific Research, which partially supported the work, the promise of further research, Hao said.

Heavy metal handling

Microwave treatment is an inexpensive way to clean heavy metals from treated sewage

ENVIRO RESEARCH

A team of FAMU-FSU Engineering researchers studying new methods to remove toxic heavy metals from biosolids—the solid waste left over after sewage treatment—found the key is a brief spin through a microwave.

The method removed three times the amount of lead from biosolids compared to conventional means and could reduce the total cost of processing by more than 60 percent, making it a possible engineering solution to help produce fertilizer and allow more people to live with clean soil and water. The research is published in the *Journal of Cleaner Production.*

"Biosolids are a valuable resource, but heavy metals prevent their use," said Gang Chen, a professor of civil and environmental engineering.

As the human population of the planet grows and more people move to cities, sewage treatment plants around the world are producing more biosolids. Those byproducts are often disposed of in landfills or incinerators, but there are drawbacks to those solutions, such as high costs or secondary pollution from the treatment process itself.

Another option is to compost the biosolids, using them as an ingredient in fertilizer that finds a second life in agriculture. In the United States, about half of all biosolids are recycled.

Before disposal or recycling can happen, they need to be made safe to use. One obstacle is the presence of heavy metals, so named for their high atomic weight. Because these potential toxins can leach into the environment from biosolids, it's important to extract them. However, that extraction can be expensive.

Chen and his team turned to their knowledge of energy to develop a more efficient process.

The investigation started from theory. They calculated the amount of energy that was needed to break the bonds that attached the heavy metals to the rest of the biosolid but would not destroy the biosolid itself. Somewhere on the electromagnetic spectrum, Chen's group found the radiation with the right amount of energy.

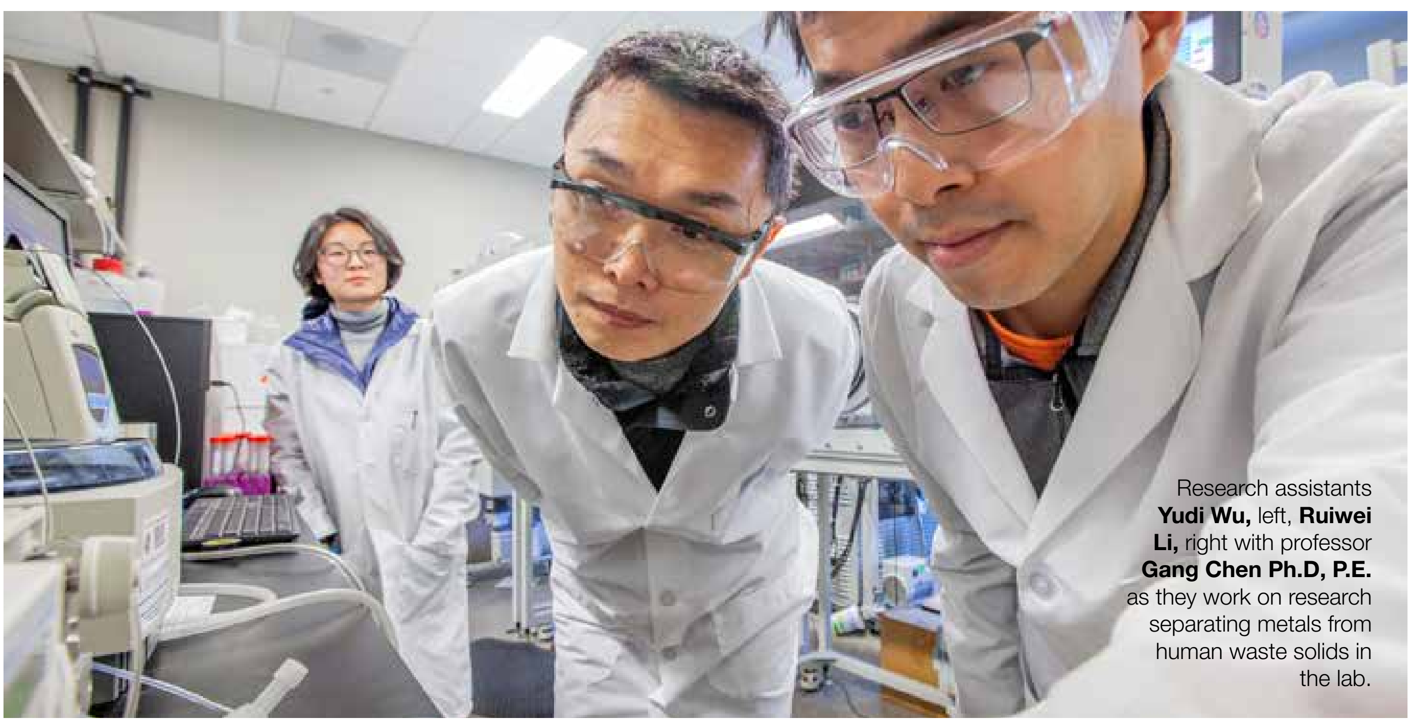
Microwave radiation seemed to be just right. After treatment in a microwave, researchers were able to remove the heavy metals from biosolids with a lower dosage of treatment chemicals than traditional extraction requires.

It's a technique that can be scaled up to facilities that service a city or a region to give them a less expensive way to make biosolids safe, Chen said.

It's important work, because if heavy metals remain in biosolids that are applied to soil, those metals can be absorbed by plants, which become part of the food chain for animals or humans. As they accumulate in the body, they can cause intellectual disability in children, dementia in adults, central nervous system disorders and damage to organs.

"We want to break the loop," Chen said.

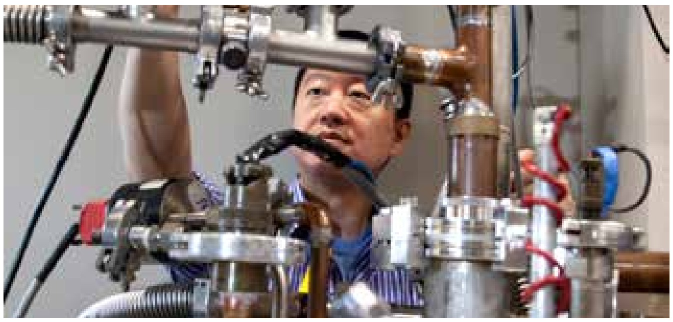
Former doctoral student Simeng Li, a current assistant professor in the Department of Civil Engineering at California State Polytechnic University, Pomona; Runwei Li, a doctoral candidate in the FAMU-FSU College of Engineering; and Youneng Tang, an assistant professor of civil and environmental engineering at the FAMU-FSU College of Engineering, contributed to this study. This research was supported by the Hinkley Center for Solid and Hazardous Waste Management.



Research assistants **Yudi Wu,** left, **Ruiwei Li,** right with professor **Gang Chen Ph.D, P.E.** as they work on research separating metals from human waste solids in the lab.

FROM PG. 7

gas pressure and density. By setting up a controlled failure experiment, these scientists calculate metrics involving airflow and heat deposition. This type of information is valuable and is relevant to the safe operation of those systems. // Another project supported by DOE is called "Quench spot detection." Many modern particle accelerators utilize superconducting cavities to accelerate charged particles. There is a strong demand to reach higher accelerating fields in these cavities so that the particles can gain higher energies over shorter



distances. The prospect of shorter accelerators is significant due to their high costs, on the order of 1 billion U.S. dollars per mile. The maximum accelerating field is limited by cavity quenching caused by heating from tiny surface defects called quench spots. By locating and subsequently removing those defects, the maximum accelerating field can be significantly improved. There is a long-standing research effort in the accelerator field is to develop reliable methods to detect those sub-millimeter defects. // "The technique we plan to use is the molecular tagging velocimetry (MTV) method that we developed in our lab," Guo said. "We are the only lab that is capable of performing MTV in helium in the world. Some groups in the U.S. and other countries are considering to construct a similar set up to ours, so we will be involved in some collaboration to help them set up their systems."

MATERIALS LIGHTWEIGHT COMPOSITES FOR DEFENSE

In a new study, researchers are collaborating with the Massachusetts Institute of Technology (MIT) and Brookhaven National Lab to study 3D printed composites. // **Subramanian Ramakrishnan,** a chemical engineering professor and researcher, and his team received $659,000 from the Department of Defense to support discoveries for the next three years. Ramakrishnan explains the research is not only about making new materials, but also about providing scientists information and guidelines that will result in the development of lighter and stronger materials. // "We are asking the question of why and how things happen," Ramakrishnan said. "We want to know how to develop novel materials, and help to advance design rules for processing them." // Ramakrishnan's collaborators at the college include **Theo Siegrist,** chemical and biomedical engineering professor and **Tarik Dickens,** associate professor of industrial and manufacturing engineering. At MIT, **James Swan,** associate professor of chemical engineering, is collaborating. // "We will be looking at thermoset resin, a polymer that can be 3D printed to produce devices," Dickens said. "We want to see how properties develop during

the print process and how we can control it to achieve the desired property." // The materials have caught the eye of the Department of Defense and industry leaders such as Boeing for their combination of characteristics. Substantial attention from research by the Air Force Research Lab showed the 3D print process of thermosetting polymer matrix composite resins can produce high-temperature-capable, reinforced polymer composite parts for next-generation materials. These materials can withstand extreme conditions in high-temperature environments. // The material can play a role in increasing aircraft range and a reduction of fuel consumption because of these unique properties. The new manufacturing possibilities of the material show promise, but issues in the structure of these materials need further research. // The research team will conduct simultaneous 3D printing and x-ray scattering experiments at the Brookhaven National Lab to understand the processing of the materials. Swan will be performing theoretical simulations and calculations to predict material properties.

EDUCATION BUILDING STUDENT SUCCESS & RETENTION

Thanks to a new $1 million grant from the NSF, select engineering students at the FAMU-FSU College of Engineering have a new tool in their arsenal to help them overcome barriers to academic success. // The grant, called "Retaining Undergraduate Engineering Students through Experiences in Industry, Entrepreneurship, Community Engagement and Research," supports a new program called Educating Engineering Students Innovatively (EESI). The program aims to improve the success and retention rates of Florida A&M University undergraduate engineering students at the joint college—specifically by targeting sophomores and juniors. // "The grant is based on a new program we piloted last year," **Charmane Caldwell, Ph.D.,** the Director of Student Access and the principal investigator for the new NSF grant explains. "The idea is to introduce students to different engineering tracks based on their interests and to fund their passion with scholarships that allow them to focus on their studies." // The grant provides multi-year scholarships for more than 40 students over the next five years. EESI targets sophomores and juniors because those are the years usually overlooked nationally when considering persistence of engineering students. In addition to scholarships, the program supports evidence-based academic and professional development activities within four major tracks: industry, entrepreneurship and innovation, community engagement and research.

Jamel Ali, Ph.D. and his team of researchers are working on biofilm innovations.

Michael Sheehan joined the Florida Center for Advanced Aero-Propulsion (FCAAP) from SpaceX.

(Above): Hui Wang, Ph.D. industrial and manufacturing engineering faculty member.

Okenwa Okoli, Ph.D., Industrial & Manfacturing Engineering chair

Rufina Alamo, Ph.D., (right) working alongside Ph.D. candidate Stephanie Marxsen

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