

NUCLEAR

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

RESEARCH IMPACT



THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

2019

Message from the Chair

VISH SUBRAMANIAM



The Department of Mechanical and Aerospace Engineering at The Ohio State University builds on its diversity of people and ideas to cultivate a range of advancements in mechanical, aerospace and nuclear engineering

From gears to cancer research, our **mechanical engineers** are experts in an array of specialty areas. Our strengths in both aeronautical and astronautical engineering boost the impact of our **aerospace engineers**. And, with an on-site nuclear reactor—and high-achieving graduates throughout industry and government—our **nuclear engineers** value collaboration.

To best showcase the unique achievements of each of our programs, we have created separate research publications. In this *Research Impact: Nuclear*, you will see samples of our advancements in nuclear engineering over the past year.

We are investigating photovoltaic panels for early detection of nuclear detonation (page 4), realizing solutions to global problems using big data (page 6) and supporting space missions with our nuclear reactor (page 10).

All of this was accomplished with our talented students, who continue to be our primary focus. They are involved in every facet of our research and we foster a spirit of collegiality among faculty, staff researchers and students. I invite you to read to discover our recent cutting-edge innovations.

Vish Subramaniam

Chair, Mechanical and Aerospace Engineering

Professor, Mechanical and Aerospace Engineering

DEPARTMENT AT A GLANCE



DEGREES CONFERRED

Academic Year 2018 – 2019

BS	199 MECHANICAL	72 AEROSPACE	
MS	80 MECHANICAL	11 AEROSPACE	6 NUCLEAR
PHD	23 MECHANICAL	6 AEROSPACE	4 NUCLEAR

STUDENT ENROLLMENT

Autumn Semester 2019

BS	621 ME MAJOR	647 ME PRE-MAJOR	164 AE MAJOR	309 AE PRE-MAJOR
MS	107 MECHANICAL	20 AEROSPACE	3 NUCLEAR	
PHD	146 MECHANICAL	38 AEROSPACE	22 NUCLEAR	



New nuclear engineering projects target defense and security

Nuclear engineering research in the Department of Mechanical and Aerospace Engineering is expanding its reach. Professor **Raymond Cao** is leading an interdisciplinary team in a \$2.75-million project from the Department of Energy and is overseeing a \$1.05-million project funded by the United States Department of Defense.

\$2.75 million interdisciplinary nuclear nonproliferation research

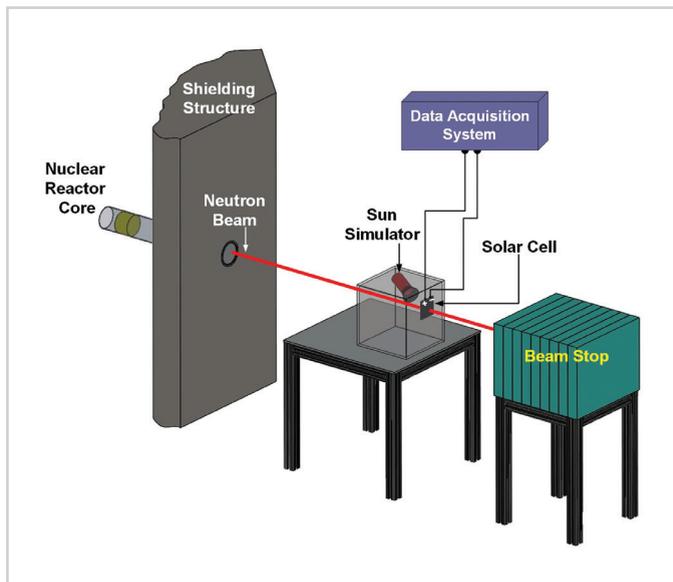
An interdisciplinary team at The Ohio State University, led by Cao, will spearhead a research thrust area within a new consortium focused on nuclear nonproliferation. The National Nuclear Security Administration, overseen by the United States Department of Energy, has established the consortium with the goal of strengthening the nation's nuclear security.

The Consortium for Enabling Technologies

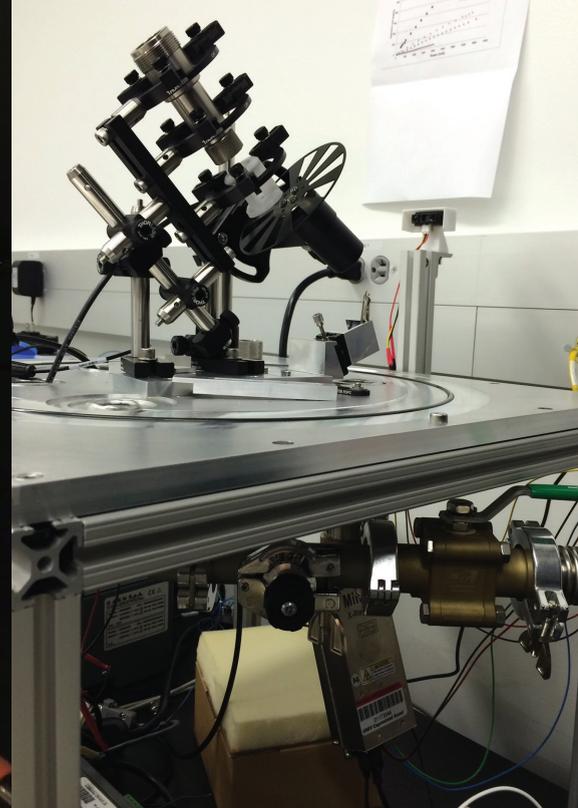
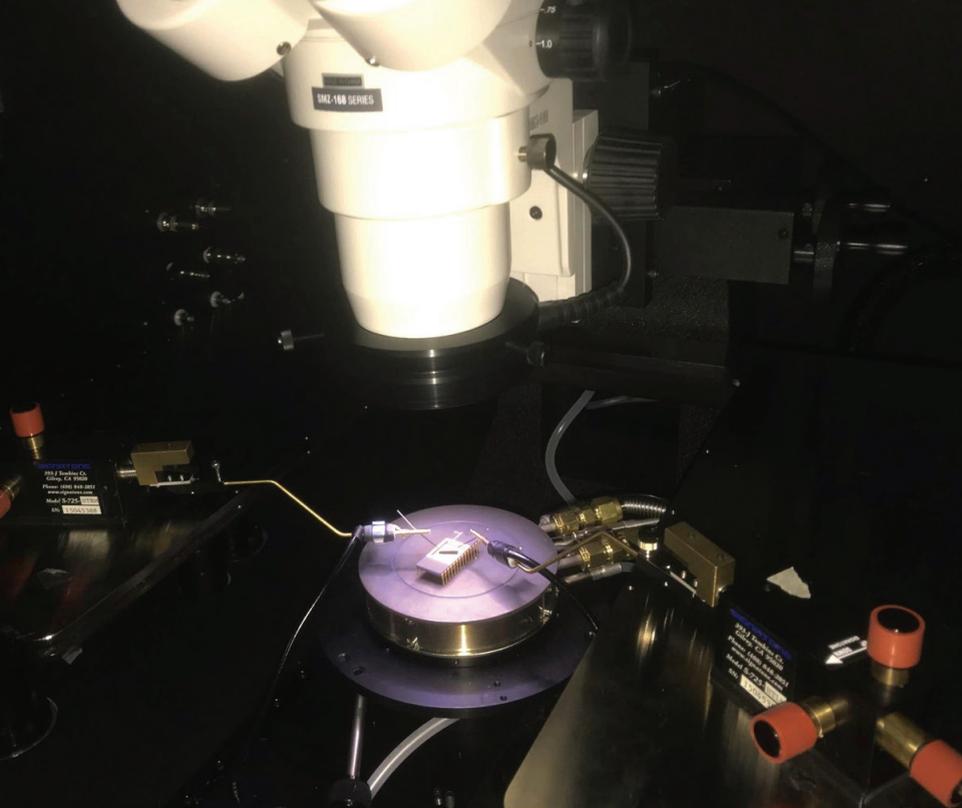
and Innovation, led by Georgia Institute of Technology, is a collection of 12 universities and 10 national laboratories that will develop and refine technologies supporting the nation's nonproliferation mission to detect and characterize the production of nuclear materials. The consortium will perform basic research in computer and engineering sciences for nonproliferation, advanced manufacturing for nonproliferation and novel instrumentation for nuclear fuel cycle monitoring.

Ohio State's Department of Mechanical and Aerospace Engineering and Department of Electrical and Computer Engineering will share \$2.75 million of the consortium's five-year, \$25 million funding.

Cao is the lead investigator for one of the consortium's three thrust areas: Novel Instrumentation for Nuclear Fuel Cycle Monitoring. In that role he will guide the technical direction of research, facilitate cross-cutting research between different thrust areas, coordinate student-faculty



A proposed experimental setup to be built at the Nuclear Reactor Lab for measuring the transient neutron and gamma-ray response of solar cells.



Left: Semiconductor devices being characterized for current-voltage and capacitance-voltage characteristics. Right: An x-ray monochromator built at Ohio State will be used for the team's investigation related to nonproliferation.

visits to labs, and organize seminars, courses and workshops.

Additionally, Cao is the principle investigator on one of the thrust area's subtopics, Microelectronic Components and SWaP (size, weight and power). Co-investigators include colleagues from Ohio State's Department of Electrical and Computer Engineering.

\$1.05 million photovoltaic panels and nuclear detonation detection

Cao will also lead a \$1.05-million project aimed at investigating the use of solar panels to detect nuclear detonation. The project— "Solar Panel for Prompt Detection and Identification of Nuclear Detonations"

—will investigate the capability of photovoltaic panels in detecting, measuring and defining the characteristic prompt signatures of a nuclear detonation. The United States Department of Defense's Defense Threats Reduction Agency is funding the investigation.

Researchers will examine whether high-energy radiation particles emitted following the initial detonation of a nuclear warhead can be detected by photovoltaic panels.

Partners are the University of North Carolina at Chapel Hill and the Air Force Institute of Technology.

Cao directs Ohio State's Nuclear Reactor Lab, as well as the Nuclear Analysis and Radiation Sensor Laboratory.



Workshop attendees during opening remarks



Nuclear Engineering Program collaborating in Energy Frontier Research Center

The Ohio State University is a collaborator on a new U.S. Department of Energy (DOE) Energy Frontier Research Center (EFRC). A cohort of 42 new and renewed centers announced in June 2018 have been established to accelerate the scientific breakthroughs needed to strengthen U.S. economic leadership and energy security.

Ohio State collaborates in an EFRC led by Idaho National Laboratory (INL), which brings together universities, industry and other organizations to conduct fundamental research in response to “grand challenges” identified by the scientific community. Researchers within the laboratory’s Center for Thermal Energy Transport under Irradiation—TETI for short—will investigate ways to

improve conduction of heat through materials in extreme irradiation environments.

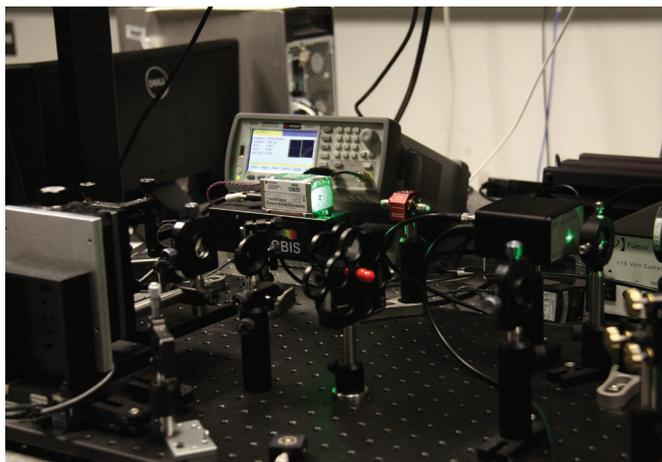
According to INL, the aim of TETI is to reveal the fundamental physical mechanisms driving heat transfer in advanced nuclear fuels under irradiation. As a collaborator, Ohio State is studying the impact of radiation-induced microstructure on the ability of materials to transport heat.

Leading those efforts is **Marat Khafizov**, assistant professor in the Department of Mechanical and Aerospace Engineering’s Nuclear Engineering Program. He’s using a laser-based experimental method—called modulated thermoreflectance—to measure thermal transport in metal oxides with tailored microstructure. The results will be used to validate advanced models of heat transport in actinides, certain radioactive metallic elements.

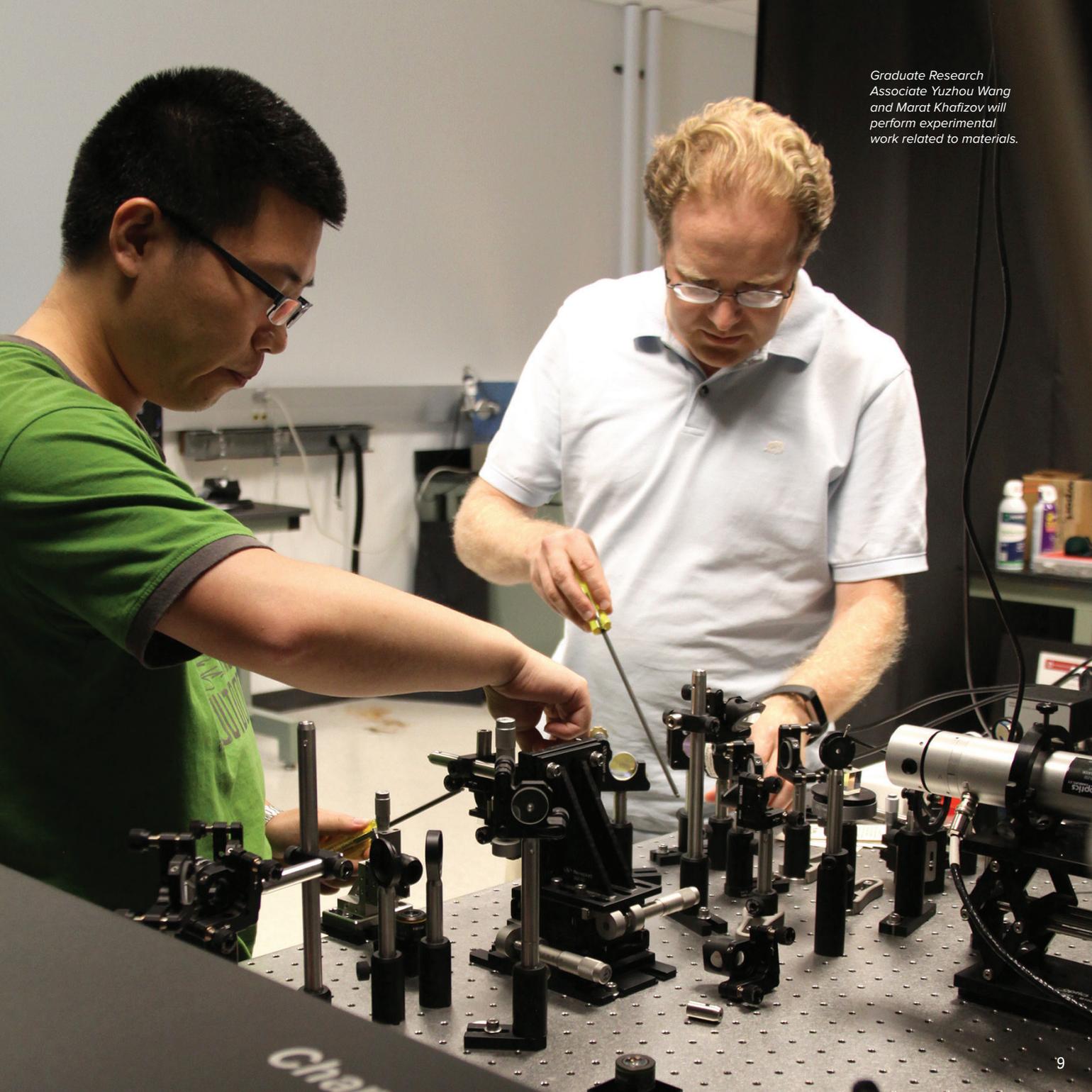
“This will have an impact on thermal management in a range of applications, including nuclear power and high-power electronics,” said Khafizov.

Funding of \$400,000 over four years will support Ohio State’s work as part of the EFRC.

Joining INL and Ohio State in TETI are Columbia University, Purdue University, Oak Ridge National Laboratory, University of Central Florida and Air Force Research Laboratory. Funding for all partners will total \$11.5 million over four years.



Related lab equipment includes lasers



Graduate Research Associate Yuzhou Wang and Marat Khafizov will perform experimental work related to materials.



Ohio's only Research Reactor part of space exploration

As NASA scientists consider the possibility of more advanced spacecraft or even entire space settlements, The Ohio State University Nuclear Reactor Laboratory has become a resource where they can simulate the radioactivity that materials will be exposed to in space.

“NASA is strategically important to us,” said Director of Nuclear Reactor Laboratory, **Raymond Cao**, professor of nuclear engineering. In fact, Ohio State's reactor is currently serving as a test site in support of a lunar project.

NASA's Kilopower project is an affordable fission nuclear power system to enable long-duration stays on planetary surfaces. After successful completion of the Kilopower Reactor Using Stirling Technology (KRUSTY) experiment in March 2018, the project team is developing mission concepts and performing additional risk reduction activities to prepare for a possible future flight demonstration. But first, the electronic components used in the flight demonstration need to be tested.

Ohio State alumnus and NASA researcher **Max Chaiken** (MS NE '18, BS ECE '14) is part of the team in the formulation phase between the ground prototype testing NASA did in 2018 and the planned lunar surface demonstration mission set to start development in 2020. His work has brought him back to his alma mater where the team is focused on qualifying electronics for the lunar surface demonstration. They are using radiation hardness testing of the electronics to help determine which components will succeed in space.

Nuclear Reactor Laboratory Senior Associate Director **Andrew Kauffman** works alongside Chaiken to perform testing for the project. “Using The Ohio State University Research Reactor to test components for use supporting space reactors such as the Kilopower reactor will help ensure that the components will reliably serve their needed function and contribute to successful missions,” he said.

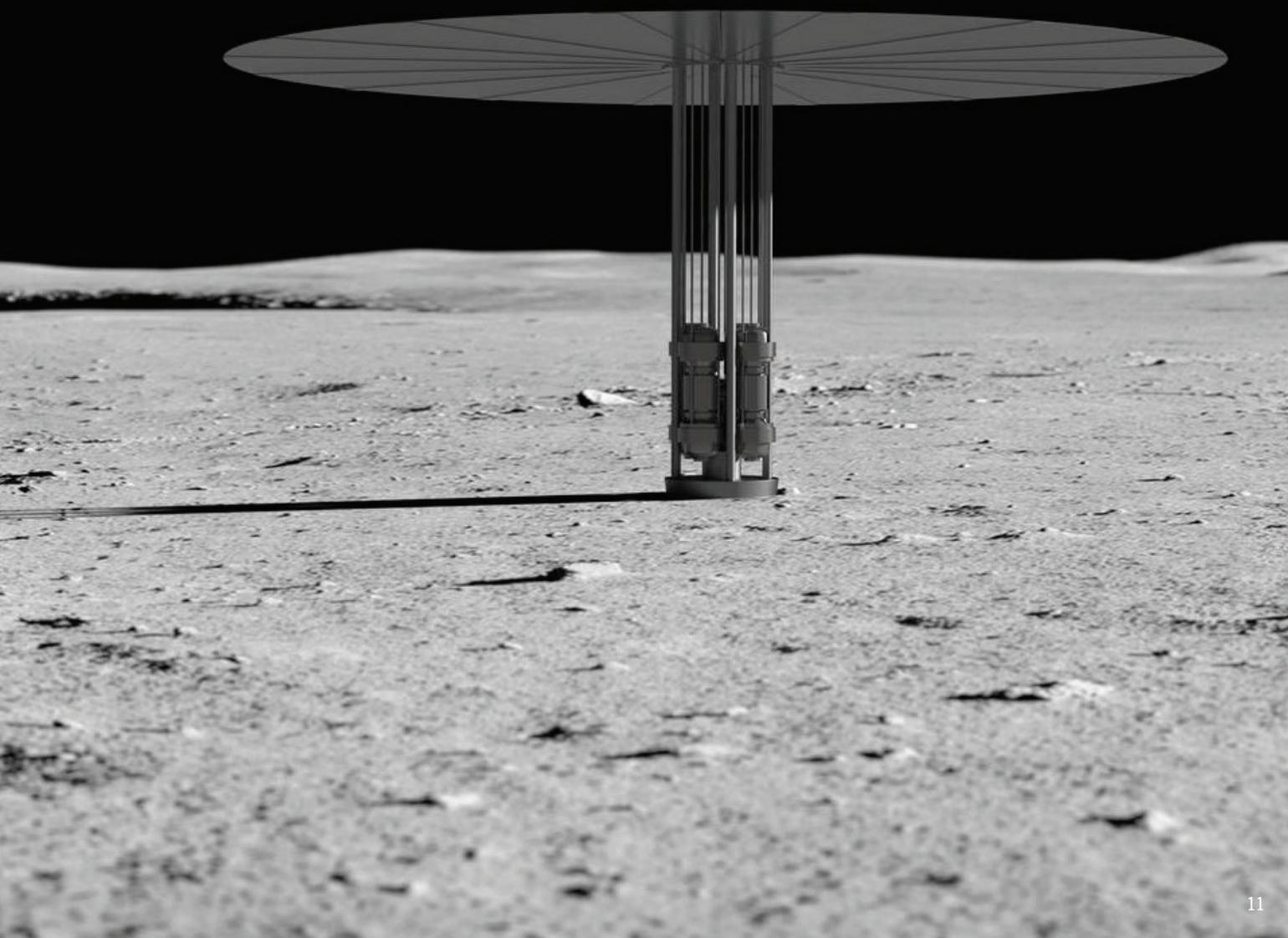
“The need for sustainable power has brought many experiments to NRL that are focused on the study of sensors and sensor materials, which support the development of future reactor designs – including reactors in space.”

A successful Kilopower demonstration in space could pave the way for future kilopower systems that power human outposts on the moon and Mars, enabling mission operations in harsh environments and missions that rely on in situ resource utilization to produce local propellants and other materials. Kilopower will be able to achieve 10 kilowatts of power — that's enough to run more advanced spacecraft or entire space settlements. And beyond simply bigger space missions, the technology could also enable spacecraft with longer lifespans and a greater array of instruments.

As the investigation of space technologies increases, researchers at Ohio State's Nuclear Reactor Laboratory look forward to contributing to the conversation and evolving science. The NRL's location and capabilities offer unique opportunities for collaboration.

– *By Maria McGraw, Nuclear Reactor Laboratory*

*Artist's concept of new
fission power system
on the lunar surface.
Credit: NASA*



FACULTY RECOGNITION AWARDS

Brain cancer research supported by grant from The Mark Foundation



Assistant Professor

Jonathan Song has received a \$187,000 grant from the Mark Foundation for Cancer

Research. The grant will support his development of a preclinical disease model to precisely interrogate how brain metastases obtain vasculature through the co-option of pre-existing blood vessels.

“Brain metastasis is not only very significant clinically, it is also quite challenging to study experimentally,” commented Song.

Song directs the Microsystems for Mechanobiology and Medicine laboratory, which applies microtechnology, principles from tissue engineering and quantitative engineering analysis for studying physical dynamics of tumor and

vascular biology. He is also a member of the Molecular Biology and Cancer Genetics Program at the The Ohio State University Comprehensive Cancer Center – The James.

Based in New York City, The Mark Foundation for Cancer Research is dedicated to accelerating cures for cancer by integrating discoveries in biology with innovative technology.

Haythornthwaite Foundation Research Initiation Grant advances Zhao’s research



Assistant Professor **Ruike Zhao** is one of four recipients of the American Society of Mechanical Engineers

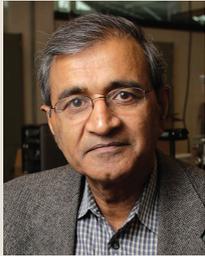
(ASME) Applied Mechanics Division 2018 Haythornthwaite Foundation Research Initiation Grant. Bestowed in recognition of excellence in theoretical and applied mechanics

research, the grant provides early-career faculty funding in support of their research objectives.

Her current research project on the development of magnetic-responsive soft materials will benefit from the grant. Project applications include soft robotics, flexible electronics and biomedical devices. A total of \$20,000 will be used by Zhao for the purchase of specialized laboratory equipment in support of the project, which proposes to combine an experimental approach with theoretical and numerical methods to investigate the macroscopic response of magnetically active soft material under external stimulation.

The studies will enable the fundamental understanding of coupled mechano-magnetic interaction of magnetic-responsive soft materials and facilitate the rational material, structure and stimulation design for reliable functional smart devices.

First-of-its-kind book highlights nature-inspired product development



The shark skin effect, gecko adhesion and self-healing materials. These advanced biomimicry topics are

among examples highlighted in **Bharat Bhushan's** newest book, *Biomimetics: Bioinspired Hierarchical-Structured Surfaces for Green Science and Technology*, Third Edition, published by Springer.

The book is the first of its kind on biologically-inspired structured surfaces. It may serve as a textbook for courses in biomimetics and applied nanotechnology, and, according to Bhushan, is intended for use by novices as well as experts in the field, practitioners, solution seekers and the curious.

Since the book's previous editions, there have been considerable advances in the emerging field of biomimetics, and related products are now commercially available.

Bhushan, an Ohio Eminent Scholar and The Howard D. Winbigger Professor, is renowned for his work in advancing the field of biomimicry, the study of the imitation

and development of nature-inspired systems and structures. Most recently he reported on the efficiency of bee and wasp stingers, citing the potential ability to develop microneedles based on their function.

Rizzoni delivers keynote at Symposium of International Automobile Technology 2019



Mechanical engineering Professor **Giorgio Rizzoni** shared his expertise in mobility as a keynote speaker

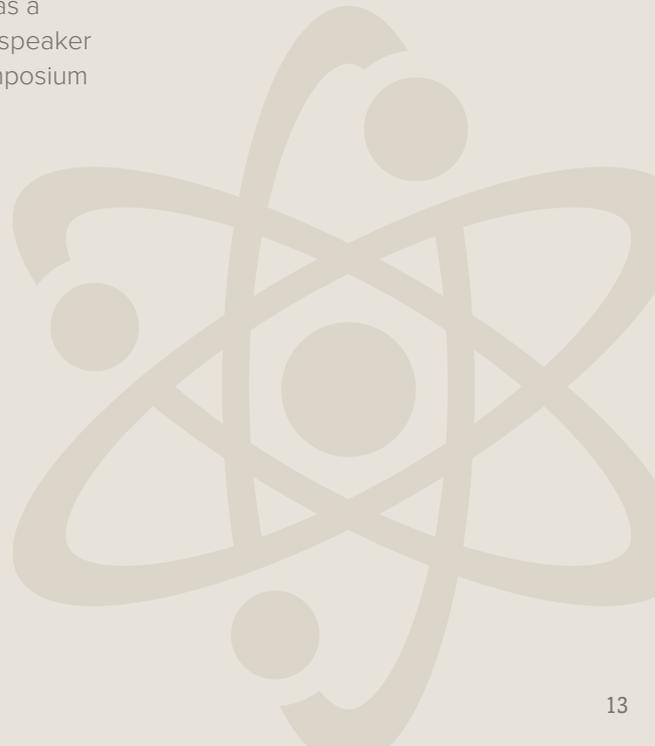
at the 16th edition of the Symposium of International Automobile Technology (SIAT 2019). The conference was held in Pune, India January 16-18, with an agenda focused on recent advances in automotive safety.

Rizzoni, who directs The Ohio State University Center for Automotive Research, delivered his keynote presentation during the session on autonomous and connected vehicles. It was Ohio State's first keynote presentation at

the symposium.

The symposium attracted national and international experts, industry leaders and regulators from the automotive segment. Additionally, officials from the government of India with two of its ministries directly participated in theme sessions.

While at the conference Rizzoni connected with the local leadership of Cummins Inc. and Eaton Corporation to discuss ongoing projects. He also had the opportunity to spend time with academic partners at the Indian Institute of Technology – Bombay and the Cummins College of Engineering for Women.



Horack to step into senior associate dean role



In January 2019, Professor **John M. Horack** began serving as Senior Associate Dean in The Ohio State University's

College of Engineering. The senior associate dean's primary role is to work in tandem with Dean David B. Williams to manage growth and optimize operations.

Horack arrived at Ohio State in 2016, when he was named the inaugural Neil Armstrong Chair in Aerospace Policy. He is a tenured professor in the Department of Mechanical and Aerospace Engineering and holds a joint appointment in the John Glenn College of Public Affairs.

Before coming to Ohio State, Horack served as the vice president for Space Systems at Teledyne Brown Engineering, vice president for research at the University of Alabama in Huntsville and vice president of the International Astronautical Federation. He spent nearly two decades as a NASA civil servant. Horack was a co-founder, president, and chief product architect of Mobular Technologies, Inc.

He is the author or co-author of over 100 scientific papers, conference proceedings, and publications across subjects including space policy, atmospheric physics, and high-energy astrophysics.

Singh builds collaborations with institutes in India



Mechanical engineering Professor Emeritus **Rajendra Singh** represented The Ohio State University during

a visit to India during November 2018. Singh is well-respected internationally for his research, teaching and consulting work in machinery vibration, acoustics, nonlinear dynamics and digital signal processing, with applications to vehicles and geared systems.

While in India Singh covered a broad agenda, organized by Ohio State's India Gateway. Topics of focus included visits to highly regarded institutions, faculty development, women in STEM and industry collaborations.

He partnered with Nikhil Tambe, PhD, director of India Gateway, to

forge new relationships with a variety of organizations. Conversations with senior leadership at academic institutes focused on collaborative engagements in India and the effectiveness of a consortium model.

Mazumder recognized for service as a journal reviewer



The review process is instrumental to the success of publishing a journal article. Professor **Sandip Mazumder** has

been honored with three awards for service as a reviewer.

Over the course of two years, Mazumder received three recognitions from Elsevier. In 2017 he was awarded for his involvement in the Journal of Quantitative Spectroscopy and Radiative Transfer and the International Journal of Heat and Mass Transfer. Then in 2018, he received an award from the International Journal of Thermal Sciences.

Reviewers work to evaluate journal article submissions to ensure the quality of the research, identify any invalid results and prevent ethical breaches by identifying plagiarism

and research fraud. Elsevier, a global information analytics business, provides a service in which researchers can volunteer to review papers in their areas of expertise. It is a lengthy and time-consuming process, one that requires the utmost care, but is rarely recognized.

Inaugural Charles F. Kettering “BUG” Award presented to UAS researchers



In honor of the 100th anniversary of the dawn of unmanned aerial systems (UAS), the Engineers Club of Dayton in collaboration

with the Sinclair College National UAS Training and Certification Center recognized The Ohio State University’s Aerospace Research Center as pioneers in the field of UAS technology. The inaugural presentation of the Charles F. Kettering “BUG” Award coincided with the exact date—October 2—of the first flight of the U.S. Army Signal Corps’ first aerial torpedo, dubbed “BUG” in 1918.

The award is presented to an individual or organization that has demonstrated outstanding improvement or advancement in UAS technology or systems.

Professor **James Gregory**, director of the Aerospace Research Center, and Research Scientist **Matthew McCrink**, both leaders in the interdisciplinary Unmanned Aircraft Systems group, represented the center at the awards ceremony. The two led the university’s effort to set a world speed record in 2017 for an unmanned aerial vehicle (UAV) of any size. Ohio State’s UAV flew autonomously with sustained average speeds of 147 mph over an out-and-back course approximately 28 miles long, which also set a record for the longest UAV flight over an out-and-back course.

STUDENT RECOGNITION

Aerospace students shine at AIAA student conference

Department aerospace students went three-for-three taking home top honors at the 2019 American Institute of Aeronautics and Astronautics (AIAA) Region III Student Conference.



Winning first place in the undergraduate category was **Collin O'Neill** (advisor: Mo Samimy) with his presentation "Active Flow Control in a Compact High-Speed Inlet/Diffuser Model." Graduate student **Braxton Harter** (advisor: James Gregory) won first place in the master's category with his presentation "Lagrangian Coherent Structures in Optimal Vortex Ring Formation." Second place in the master's category went to **Nicole Whiting** (advisor: Mo Samimy) for her presentation "Design of an Experimental Facility for Characterization of Dynamic Stall."

As first place winners, Harter and O'Neill have also earned a trip to the AIAA SciTech Forum in January 2020 to compete at the national level with other regional winners.

According to its website, the conference encourages students in aerospace-related fields to discuss research, exchange knowledge and generate interest in the field of aerospace engineering. This year's event was held at Cleveland State University and was represented by schools across the Midwest.

Tseelmaa Byambaakhuu awarded Best Paper and Best Presentation at ANS Student Conference

Nuclear engineering PhD student **Tseelmaa Byambaakhuu** received two awards at the 2019 American Nuclear Society (ANS) Student Conference. She received best paper and best presentation awards for her article "Comparison of IpCMFD with Other CMFD Based Acceleration Schemes."

Byambaakhuu's research centers on stabilizing neutron transport utilizing coarse mesh finite difference acceleration. Her paper and accompanying presentation compared popular application methods of this approach with a new approach developed at Ohio State.

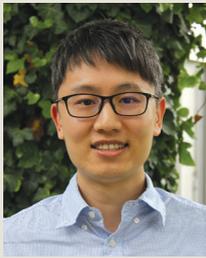
"This was an incredible opportunity to present Ohio State research to industry and research institutions, at the same time learning about the variety of



research taking place across the discipline of nuclear engineering,” she commented.

The conference was held during April 2019 at Virginia Commonwealth University. Representatives from American and international institutions were in attendance.

Distinguished Presidential Fellowships awarded to Anand Nagarajan and Meng-Hsuan Tien



Anand Nagarajan has a passion for numerical modeling and **Meng-Hsuan Tien** advances nonlinear dynamics. The mechanical engineering doctoral students will now be able to do even more, thanks to their selection as a distinguished Ohio State Presidential Fellows.



The most prestigious award given by the Graduate School, Presidential Fellowship awardees are described as embodying the highest standards of scholarship in the full range of Ohio State's graduate programs. The esteemed designation will provide the scholars with full-time financial

support for one year to allow for completion of their dissertations unimpeded by other duties.

Under the direction of Assistant Professor Soheil Soghrati, Nagarajan has devoted his dissertation work

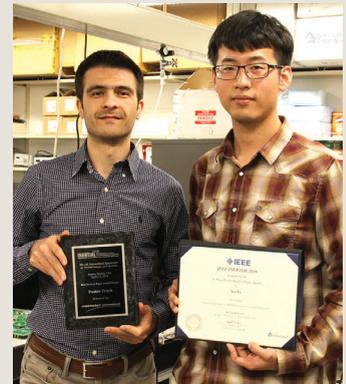
to creating an efficient numerical framework for the automated generation of high-fidelity simulation models of novel materials. Tien, who is advised by Assistant Professor Kiran D'Souza, focuses his research in the area of nonlinear dynamics. He creates novel computational methods for the analysis of piecewise-linear nonlinear dynamical systems.

They join the ranks of a number of department students who have received the Presidential Fellowship, including 16 over the past five years.

Department students win Best Paper at IEEE conference

Mechanical engineering graduate students **Jun Yu** and **Keivan Asadi** took home the award for Best Student Paper at INERTIAL 2019, the Institute of Electrical and Electronic Engineers (IEEE) Sixth International Symposium on Inertial Sensors and Systems.

The two graduate researchers, advised by Hanna Cho, submitted their work titled “Frequency and Stabilization in a MEMS Oscillator with 1:2 Internal Resonance.” MEMS—short for mechanical resonances in microelectronmechanical systems—can be used in a variety of applications, from transportation technologies to biomedical functions.



The symposium was held in Naples, Florida during April 2019. Attending representatives included industry leaders and research institutions from across the globe. The MEMS work was also recognized at the IEEE International Frequency Control Symposium & European Frequency and Time Forum. There, Yu was honored as a finalist for best paper.

RESNA selects Einstein as winner of student scientific paper competition

Graduate student **Noah Einstein** aims to innovate with a purpose toward accessibility. The mechanical engineering graduate student's scientific paper on wheelchair propulsion data was selected as one of four winning student submissions for the RESNA (Rehabilitation Engineering and Assistive Technology Society of North America) 2019 Annual Conference.

Entitled "SmartHub: Manual Wheelchair Data Extraction and Processing Device", Einstein's research focuses on extracting propulsion data from manual wheelchair users. Utilizing such data results in opportunities to reduce upper body injuries and allows users and clinicians to have a broader understanding of wheelchair utilization outside of the clinic. He is advised by Sandra Metzler.



The recognition earned the master's student the opportunity to present his paper in a conference platform section. Additionally, he received free conference registration and accommodation, a one-year RESNA student membership and the publication of his paper on the RESNA website.

American Society of Mechanical Engineers scholarship will support PhD candidate's gas turbine research



Mechanical engineering graduate student **Arif Hossain's** recognition continues for his research on innovative cooling architectures for next-generation gas turbine engines.

In addition to a Young Investigator Award bestowed in June 2018, Hossain has received the 2018-

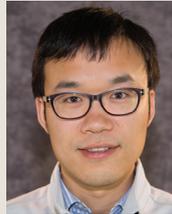
2019 Student Scholarship from American Society of Mechanical Engineers (ASME) in support of his education. The \$2000 funding was awarded by ASME's Gas Turbine Segment and its Gas Turbine Institute's Honors & Awards Program.

The innovative research project, part of Hossain's dissertation work, utilizes additive manufacturing techniques in the design and testing of gas turbine cooling methods. Hossain is advised by Professor Jeffrey Bons, director of the Turbine Aerothermodynamics Lab at the College of Engineering's Aerospace Research Center.

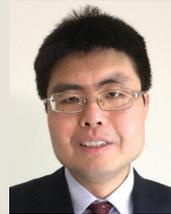
NEW FACULTY APPOINTMENTS



Qadeer Ahmed
Research Associate
Professor



Sheng Dong
Research Assistant
Professor



Lian Duan
Honda Endowed Associate
Professor in Aeroacoustics



**Golnazalsadat
Mirfenderesgi**
Assistant Professor
of Practice



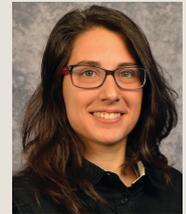
Brian Ritchie
Assistant Professor
of Practice



Satya Seetharaman
Assistant Professor of
Practice



Jeremy Seidt
Research Associate
Professor



Stephanie Stockar
Assistant Professor



David Talbot
Assistant Professor



Punit Tulpule
Research Assistant
Professor



Zhenyu Wang
Research Assistant
Professor



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AEROSPACE

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Student Research Assistant Nathan Smith supports nuclear engineering projects targeting defense and security in the department's Nuclear Analysis and Radiation Sensor Laboratory. Read more on page 4.