THE UNIVERSITY OF MEMPHIS®

Department of Mechanical Engineering

2026 ANNUAL REPORT

Dr. Daniel Foti leads groundbreaking cavitation research improving naval system performance

Read more on page 13

Photo credit: Benjamin Naylor/The Daily Memphian

HERFF BY THE NUMBERS...

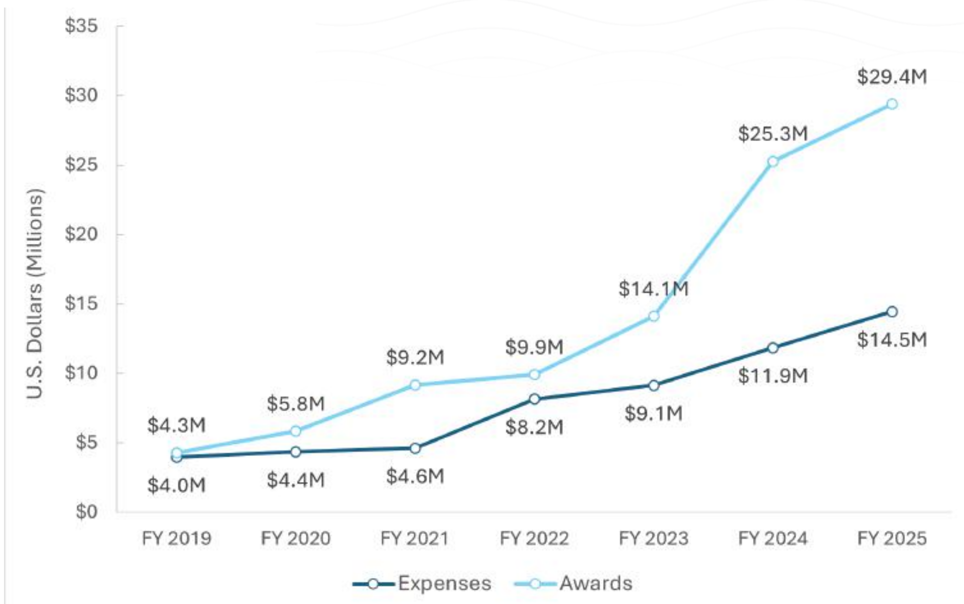
31 Tenured Faculty

9 Instructional Faculty

14 Tenure Track Faculty

10 Research Faculty

MEMPHIS RESEARCH



FY2025 Metrics

$14.5M in expenditures

123 proposals totaling $54.5M

64 awards totaling $29.4M (52% success rate)

$2,675,112 in indirect cost recovery

Chair's Message:

Building momentum through innovation...

On behalf of everyone in Mechanical Engineering at the University of Memphis, I am proud to present our annual report with just some of the tremendous successes for our students, faculty, staff, alumni and friends. The stories presented within these pages showcase the unwavering dedication and innovation of our faculty and students in pursuit of research excellence.

Our strategic plan is well underway, and we have a lot to celebrate this year, from our students and their accomplishments to the continued growth in our research portfolio. Our faculty and students work across disciplinary boundaries and continue to make significant advances. This report offers an overview of our achievements and the breadth of our impact. I hope you enjoy reading it.

Sincerely,

Dr. Ali Fatemi
Ring Companies Endowed Professor, Chair
Director of Fatigue and Fracture Research Lab

Expanding Pathways for Student Success in Mechanical Engineering

The Mechanical Engineering undergraduate program continues to evolve, offering students greater flexibility to align their education with their interests and career goals. Through a range of concentration options and interdisciplinary opportunities, the program is preparing graduates to succeed in an increasingly diverse and dynamic engineering landscape.

Current undergraduate concentrations include advanced manufacturing, biomedical engineering, materials for engineering applications and thermal-fluid systems. Each pathway provides a strong foundation in core engineering principles while emphasizing hands-on, applied learning experiences that connect classroom concepts to real-world challenges.

Beginning in Fall 2026, the program will expand with new concentrations in systems engineering and construction engineering management. These additions are designed to align with evolving industry needs and give students more opportunities to specialize in high-demand areas.

Students can also enhance their academic experience through a minor in mechatronics, gaining interdisciplinary skills in robotics, automation and integrated systems. This combination of technical depth and cross-disciplinary knowledge prepares graduates for careers in fields such as healthcare, manufacturing, energy and infrastructure.

By continuing to expand its academic offerings, the Mechanical Engineering program ensures students are not only prepared for today’s workforce but equipped to adapt and lead in the industries of the future.

Connecting Students With Industry Through Real-World Experience

The ASHRAE Student Branch at the University of Memphis continued to strengthen connections between classroom learning and professional practice through a series of industry-focused events and experiential learning opportunities.

The academic year began with recruitment and community-building activities, including the organization’s “Party on the Patio” event, which welcomed students and introduced opportunities within the HVAC industry. Students also participated in career-focused seminars featuring industry professionals Amanda Rushing and Ryan Henderson of OGCB, who shared insights into career pathways and emerging opportunities in the field.

Hands-on learning remained a central focus throughout the year. Students toured the University’s Physical Plant and later visited FedExForum to explore large-scale mechanical systems in a real-world environment. Additional networking events and a technical presentation from Meagan Garrett of Daikin provided students with valuable exposure to industry expertise and innovation.

Through technical engagement, networking and industry interaction, the ASHRAE Student Branch continues to prepare students for successful careers in mechanical systems and building technologies.

AIAA Students Showcase Research at Regional Conference

AIAA Student Chapter stand together at the conference in South Carolina.

Students in the University of Memphis chapter of the American Institute of Aeronautics and Astronautics (AIAA) represented the department at the AIAA Region II Student Conference in Columbia, South Carolina, where they presented research on advanced aerospace and engineering topics.

The student team presented three technical papers during the conference, covering topics including fan array wind tunnel design, turbulence modeling and structural optimization of 3D-printed aerospace components. The presentations highlighted student research in fluid dynamics, advanced manufacturing and structural analysis while providing valuable experience in professional communication and technical collaboration.

Participation in the conference reflects the continued growth of the AIAA chapter as students expand research involvement and prepare to return to the organization's Design, Build, Fly competition in the coming year.

Professional Experiences Strengthen Student Success

The University of Memphis ASME Chapter continued to provide students with valuable professional development opportunities and hands-on exposure to the engineering industry throughout the year. Members participated in several industry tours, including visits to Medtronic, Smith+Nephew, and the TVA Southaven Plant. These tours gave students the opportunity to see engineering principles applied in real-world manufacturing, medical device production, and power generation environments while also allowing them to connect directly with professionals working in the field.

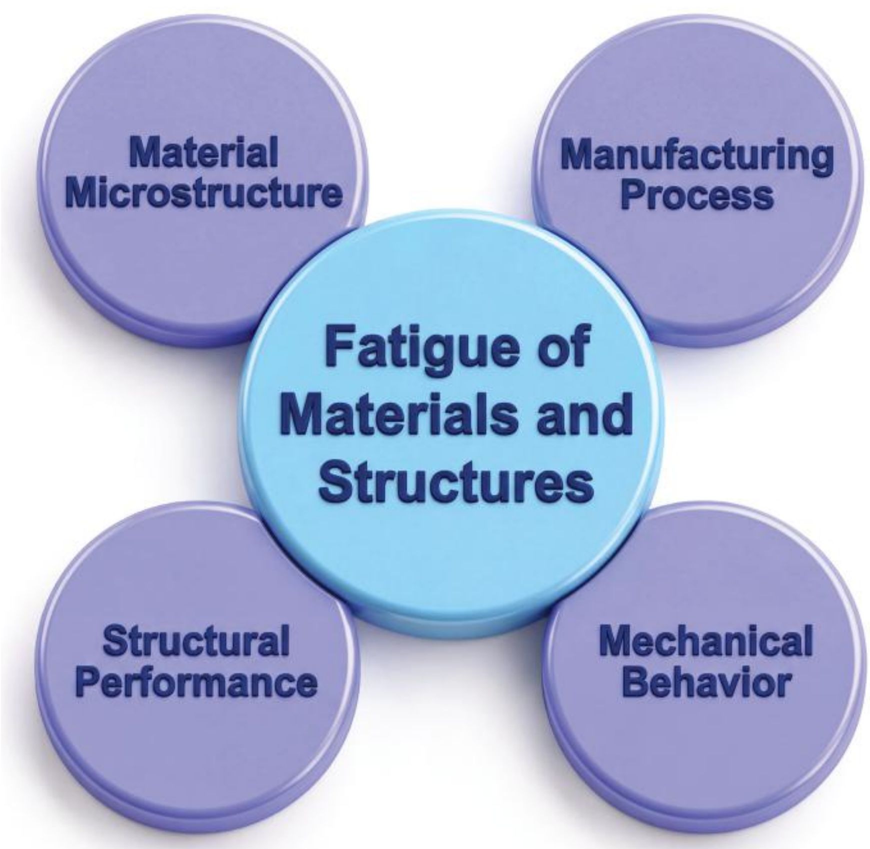
ASME 2025-26 Leadership Team (left to right) – Olivia Ganavazos, promotional chair; Craig Bowlin, secretary; Bryan Johnson, Engineering Student Council representative); Shaun Bowlin, president; Tyler Owens, vice president; and Dr. Alexander Headley, faculty advisor

Advancing Fatigue Technologies for Failure Prevention in Engineering Materials and Structures

From simple household items like copper wires near the plug-in phone chargers to aircraft fuselage and Jet engine turbine blades, fatigue failures caused by repeated stress are the most common type of mechanical failure. Fatigue failures often occur suddenly and without obvious warning, even when stresses are below design limits, which can lead to catastrophic accidents, loss of life, and significant economic loss. As a result, considering fatigue failure is essential for ensuring reliability, safety, and long-term performance in engineering systems.

At the University of Memphis Fatigue and Fracture Research Lab, Dr. Ali Fatemi and his research team test materials under repeated or cyclic complex loading representative of service loading conditions to understand fatigue crack initiation and growth mechanisms. The materials investigated include metals, polymers, and composites. This understanding helps develop advanced fatigue life prediction models for engineering design applications to prevent fatigue fractures and improve durability performance. The Fatemi-Socie multiaxial fatigue theory developed in 1980's is currently the most cited fatigue life prediction model and used in commercial simulation software.

Current sponsored research projects in the lab include fretting fatigue where contacting surfaces experience small repeated relative motion, fatigue of welded joints for automotive applications where welds are often the weakest locations in the structure under cyclic loads, and fatigue of additive manufactured, otherwise known as 3D printing, of metals and castings where manufacturing process defects govern fatigue performance.



Study of fatigue is a multidisciplinary engineering subject involving materials science, mechanics of solids, manufacturing process technologies, and structural engineering. A recent multimillion dollar project in collaboration with the U.S. Naval Sea Systems Command on the Rapid Applied Materials and Processing (RAMP) project is a manifestation of this approach with the objective of accelerating the transition of advanced materials and manufacturing technologies from laboratory research into real-world naval applications.

SHAPING THE WORLD AROUND US

Build. Discover. Lead On.

Mechanical engineers power nearly every product you use each day — from aerospace systems to biomedical devices. At the University of Memphis, the broadest engineering discipline meets world-class research and real-world opportunity.

BY THE NUMBERS

$105K
AVG. ANNUAL SALARY

$25/hr
CO-OP AVG. PAY

10
RESEARCH AREAS

ABET
ACCREDITED PROGRAM

CAREER PATHS

- Aerospace engineering
- Biomedical devices
- Manufacturing engineering
- Automotive engineering
- Renewable energy
- Robotics and automation
- Materials engineering
- Heating and cooling systems

CO-OP PROGRAM

Spend one to three semesters in paid, full-time work with industry partners including NASA, Ferrari and Boeing — earning real engineering experience before you graduate.

STUDENT ORGANIZATIONS

ASME | AIAA | SAE | TAU BETA PI | NSBE | SWE

RESEARCH AREAS

01 Materials — failure prediction, biomaterials and computational materials
02 Advanced manufacturing including 3D printing
03 Computational fluid dynamics
04 Cryogenic propellant management
05 Wind energy
06 Aerosol science
07 Fatigue and fracture mechanics
08 Energy efficiency
09 Heat transfer, exchangers and thermal management
10 Gas turbines

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Precision control at the microscale is opening new pathways for understanding and treating complex diseases.

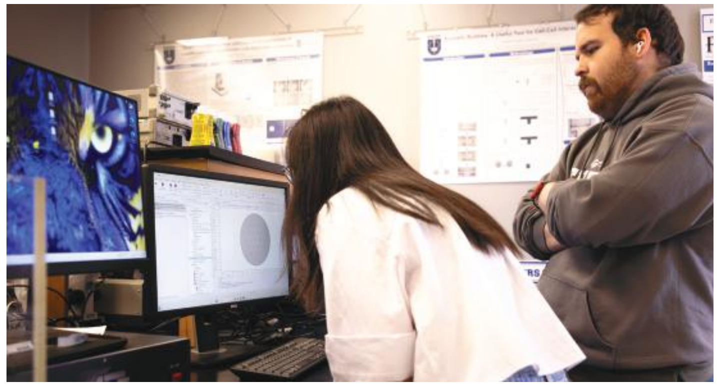
ADVANCING BIOMEDICAL INNOVATION AT THE MICROSCALE

Researchers are developing precision technologies to transform diagnostics and human health.

New approaches to controlling microscopic environments are opening doors to faster, more accurate disease diagnostics and therapeutic testing. Led by Dr. Yuan Gao, the lab brings together expertise in microfabrication, acoustics, fluid dynamics and bioengineering to develop highly controlled microscale environments.

At the core of this work is the ability to precisely manipulate cells, particles and fluids—capabilities that are essential for understanding complex biological systems and improving diagnostic and therapeutic approaches. By operating at the microscale, the lab is able to recreate and control biological conditions with a level of accuracy that is difficult to achieve through conventional methods.

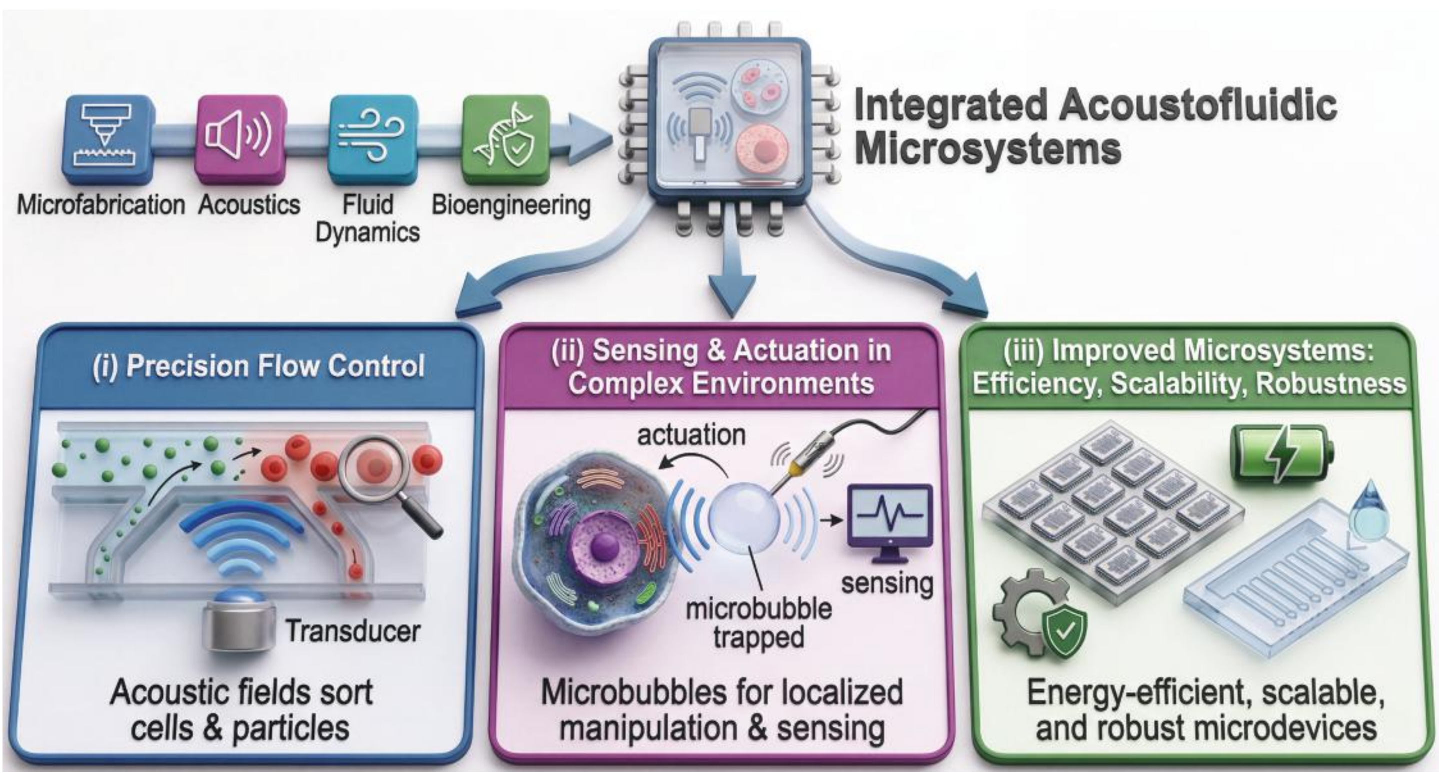
Current research focuses on the use of acoustic fields, microbubbles and microstructured materials to advance



three key areas. First, these technologies enable highly precise control of fluid flow, allowing researchers to guide particles and cells with exceptional accuracy.

Second, they support the development of new sensing and actuation methods that can function effectively in complex biological and soft-matter environments. Third, the team is working to improve the energy efficiency, scalability and overall robustness of microsystems, making them more viable for real-world applications.

By enabling this level of control over microenvironments, the Microfluidic Laboratory is helping to deepen mechanistic understanding of biological processes while accelerating innovation in disease diagnostics and therapeutic testing. The work positions the lab at the intersection of engineering and medicine, where precision technologies can drive meaningful advances in human health.

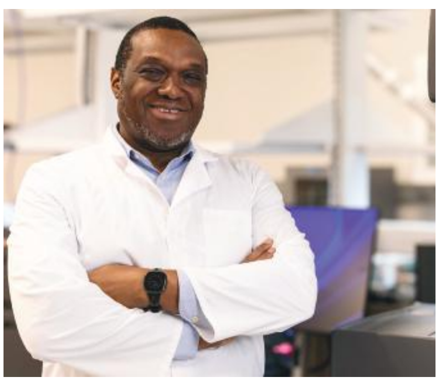


Advancing Materials for Extreme Environments and Next-Generation Systems

From next-generation aircraft to advanced energy systems, the need for materials that can perform under extreme conditions is rapidly growing. At the University of Memphis, Dr. Okenwa Okoli and his research group are meeting this challenge through the Advanced Engineered Materials Lab, where innovative materials are being developed to power the future of aerospace and clean energy.

The lab focuses on the design, development, and testing of advanced engineered materials for applications in clean energy and aerospace. This work emphasizes lightweight, durable, and multifunctional materials capable of withstanding extreme temperatures, mechanical stress and other demanding operating conditions.

Research efforts span a wide range of critical areas, including aerospace structures, hypersonic flight systems and space exploration technologies. In parallel, the lab is contributing to clean energy innovation through the development of materials that support energy generation, energy harvesting, and improved structural performance in energy systems.



A key component of the lab's work is advancing how these materials are created and applied.

Researchers are exploring new approaches to material design, manufacturing processes, and testing methods to ensure performance and reliability in real-world conditions. This integrated approach helps bridge the gap between fundamental research and practical engineering solutions.

In addition to its research impact, the lab plays an important role in student development. Through hands-on experience in cutting-edge materials research, students gain the technical knowledge and practical skills needed to contribute to industries such as aerospace, energy and advanced manufacturing.

By combining innovation in materials science with workforce development, the Advanced Engineered Materials Lab is helping prepare the next generation of engineers while supporting advancements in technologies that operate at the frontiers of performance.

RESEARCH SPOTLIGHT · MATERIALS SCIENCE AND ENGINEERING

Advanced Engineered Materials Lab

Designing next-generation materials that perform under extreme conditions — powering the future of aerospace and clean energy.

Dr. Okenwa Okoli
Lab Director

APPLICATION AREAS

- **Aerospace Structures** — Lightweight, durable materials for next-gen aircraft
- **Hypersonic Flight** — Extreme heat and mechanical stress resistance
- **Space Exploration** — Advanced systems for demanding space environments
- **Clean Energy** — Energy generation, harvesting and structural performance

RESEARCH FOCUS

- **Lightweight and Multifunctional Design** — Materials engineered for multiple performance roles
- **Extreme Temperature Resistance** — Stable under severe thermal and mechanical loads
- **Advanced Manufacturing Methods** — New approaches to creation, processing and testing
- **Real-World Reliability** — Bridging fundamental research to engineering solutions

STUDENT DEVELOPMENT

- **Hands-On Lab Experience** — Cutting-edge research from day one
- **Technical Skill Building** — Knowledge for aerospace, energy and manufacturing
- **Workforce Readiness** — Preparing next-gen materials engineers

Global Energy Experience Broadens Student Opportunities

Drs. Alexander Headley (back row left) and Yong Hoon Lee (back row right) are pictured with students who were chosen for InteGRATE: (from left) David Thomas Braese, Jayce Fiene, Jennifer Farler and Madison Galloway.

Students in the University of Memphis engineering programs are gaining international research experience through the InteGRATE program, a summer initiative focused on energy systems and global collaboration.

Through a partnership with the Technical University of Munich (TUM), participants travel abroad to engage in hands-on, interdisciplinary research. Students are able to select their research focus and faculty mentors, creating a customized experience aligned with their academic and career goals.

The program is led by Dr. Alexander Headley, who brings a global perspective shaped by his own academic experiences abroad.

"During my graduate studies, I had the opportunity to work with researchers across Europe, which gave me a clearer understanding of how regional challenges shape energy solutions," Headley said. "What works in Germany may not work in the U.S. Exposing our students to these differences helps them develop a broader perspective and consider a wider range of solutions."

Beyond technical skill development, InteGRATE introduces students to the global complexity of energy systems, emphasizing how geography, policy and infrastructure influence innovation. The experience also strengthens international research connections and enhances the department's global engagement.

Each summer, a cohort of five students participates in the program, returning with expanded knowledge and a deeper understanding of how to apply energy solutions across local, national and global contexts.

SUMMER RESEARCH INITIATIVE · GLOBAL ENERGY STUDIES

InteGRATE

Solving Tomorrow's Energy Challenges — Abroad

UofM students gain hands-on experience in energy systems through international summer research at the Technical University of Munich.

PARTNERSHIP | **University of Memphis** Memphis, Tennessee, USA → **Technical University of Munich** Munich, Germany

THE STUDENT JOURNEY

01 **Choose Research & Mentor** Tailor to your interests

02 **Travel to Munich** International immersion

03 **Research with Global Experts** Hands-on discovery

04 **Return & Apply Locally** Broader perspective

Technical Skills Advanced energy research beyond the classroom

Global Network Connections with international researchers and institutions

Regional Perspective How energy challenges vary across the globe

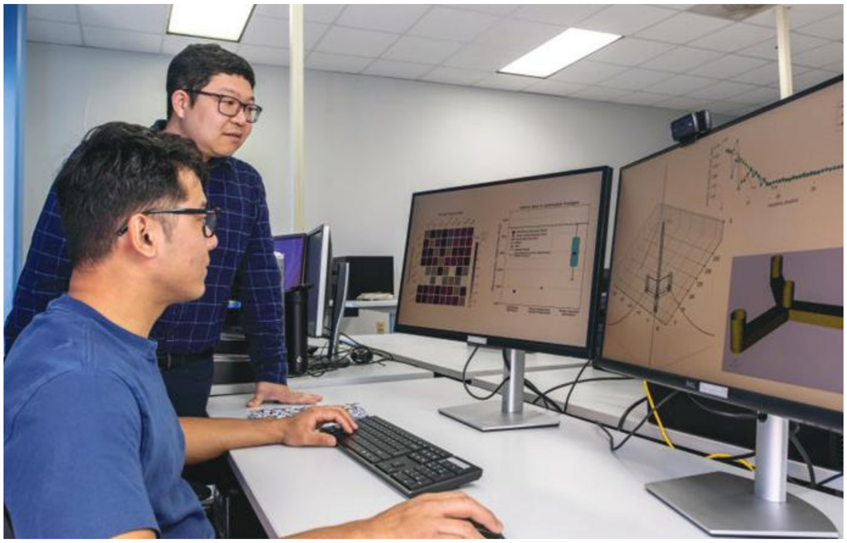
STEM Leadership Next-generation sustainable energy leaders

5 SUMMER FELLOWS

2 PARTNER UNIVERSITIES

∞ CAREER IMPACT

Building Smarter, More Sustainable Energy Systems Through Integrated Design



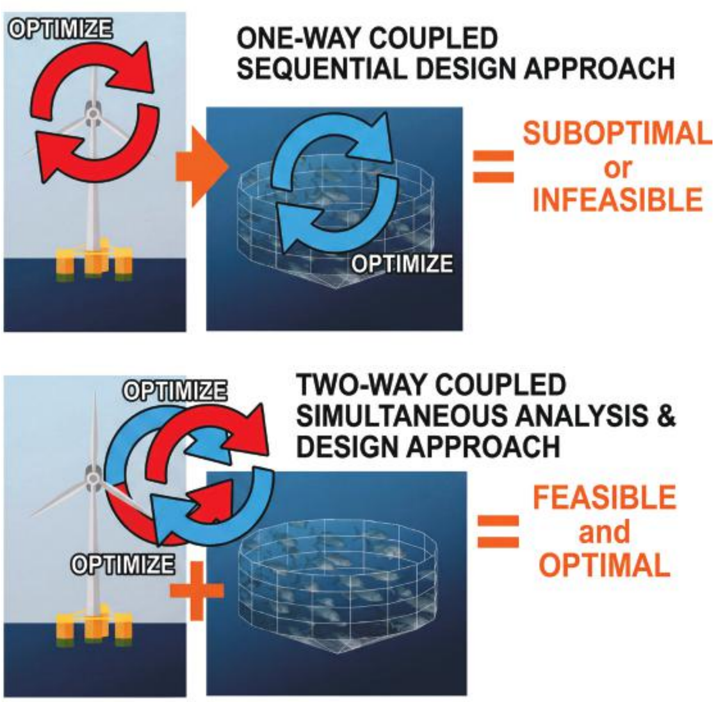
Modern energy systems are becoming more complex, requiring new approaches to design, modeling and optimization. Researchers in the Lee Research Group are advancing sustainable energy systems through innovative modeling, design and optimization approaches that address the growing complexity of modern energy infrastructure.

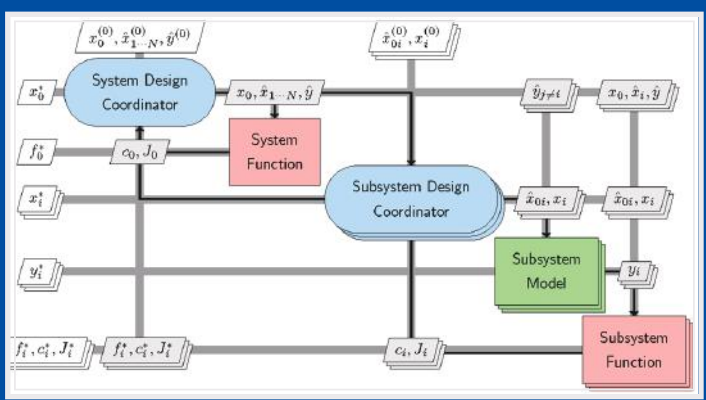
Dr. Yong Hoon Lee leads research focused on the interactions between fluid, structural and control systems in large-scale energy environments, including offshore and marine applications. His group develops multidisciplinary design strategies that incorporate control co-design, hydro-structural analysis and mission-oriented energy optimization to improve overall system performance.

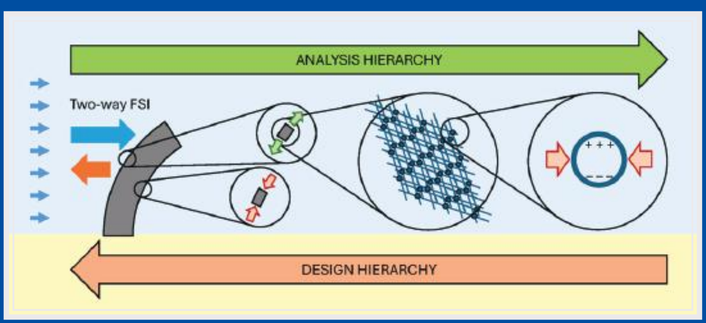
By combining physics-based models with reduced-order simulations and advanced optimization frameworks, the team is able to capture the complex, coupled dynamics that govern energy systems. These approaches enable more efficient design processes, allowing researchers to evaluate performance, feasibility and scalability with greater speed and accuracy.

In parallel, the Lee Research Group is exploring innovative energy system configurations that maximize the use of space and resources. This includes concepts such as co-located energy generation and aquaculture operations in marine environments, where integrated systems can deliver multiple benefits within a single footprint.

Through system-level analysis and integrated design methodologies, this work is helping to identify solutions that improve operational efficiency while supporting environmental sustainability. Complementing these efforts, Dr. Alexander Headley contributes expertise in renewable energy integration and optimization, further strengthening the department's focus on scalable, future-ready energy solutions.







Leveraging Advanced Modeling to Optimize Energy System Performance

Reducing computational cost without sacrificing accuracy is a major challenge in modern engineering design. The Lee Research Group, led by Dr. Yong Hoon Lee, is developing advanced computational tools to improve the design and performance of complex energy and thermal systems.

The team's work centers on physics-informed modeling frameworks that capture key interactions between fluid flow and heat transfer. A reduced-order modeling approach predicts wake-induced convective heat transfer while preserving essential physical behavior across laminar and turbulent regimes—significantly lowering computational demands compared to traditional simulations.

This enables faster evaluation of design concepts, improved performance screening and more efficient optimization in complex flow environments. The group is also advancing an integrated framework for design coupling analysis, combining surrogate-based optimization with control co-design to better understand how variables interact across disciplines.

Together, these efforts support more informed decision-making and accelerate innovation in energy systems and other applications where fluid, thermal and control dynamics are closely linked.

Advancing Naval Performance Through Cavitation Research

Multi-institutional research is improving durability, efficiency and design of critical marine systems.

AI-generated conceptual illustration of cavitation on a marine propeller. Image is for illustrative purposes only and does not represent experimental data.

Hidden beneath the surface of naval operations is a persistent threat to performance and durability: cavitation erosion. Researchers in the Department of Mechanical Engineering are leading a multi-year effort to better understand this complex phenomenon and its impact on naval vessel performance and longevity.

Led by Dr. Daniel Foti and funded by the Office of Naval Research, the project examines how collapsing vapor bubbles generate highly concentrated forces that cause surface damage to marine components such as propulsors and control systems. These repeated impacts can lead to performance loss, increased maintenance costs and reduced operational lifespan.

Simulation prediction of turbulent, cavitating flow over the hydrofoil based on the LCC experiment conditions

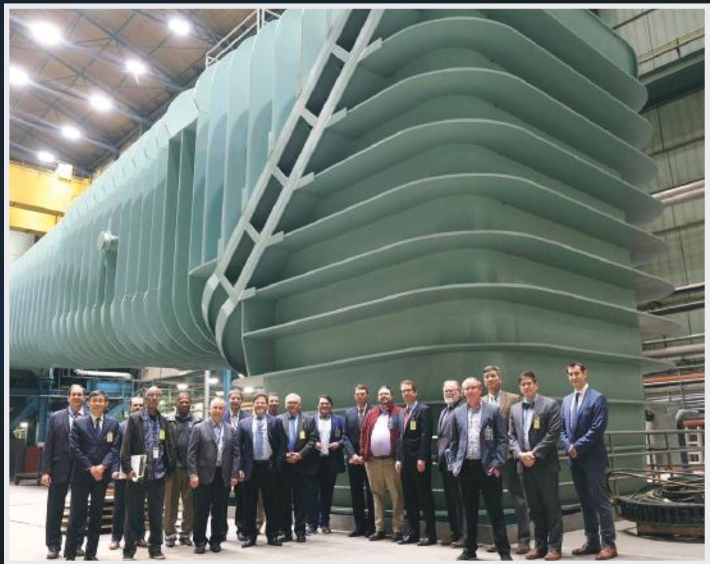
A central challenge in cavitation research is the gap between small-scale laboratory testing and real-world conditions. Traditional model-scale experiments often fail to fully capture the complex behavior observed in full-scale naval environments. This project addresses that gap by combining computational modeling, material characterization and large-scale experimental testing.

A key component of the research is work conducted at the U.S. Navy's Large Cavitation Channel (LCC) in Memphis—one of the world's most advanced high-speed, variable-pressure water tunnel facilities. There, researchers are performing full-scale experiments to better understand the relationship between cavitation dynamics and material response under realistic operating conditions.

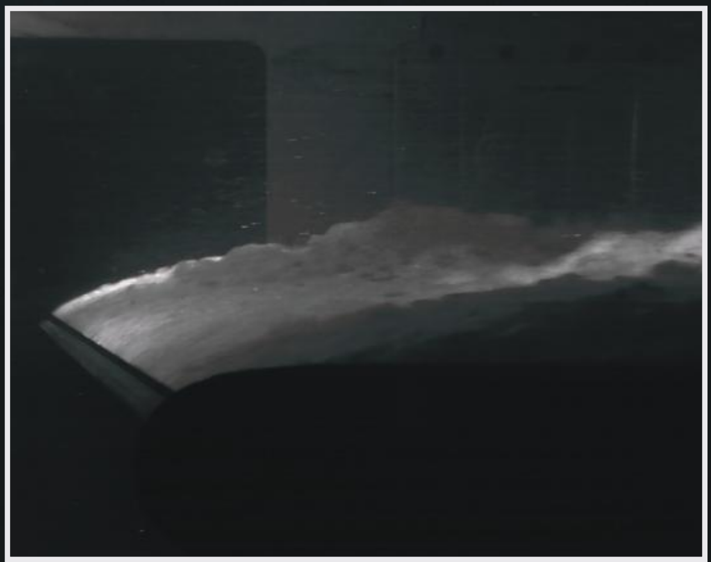
The project brings together a multidisciplinary team of collaborators from the University of Memphis, the University of Michigan and the Naval Surface Warfare Center Carderock Division. At the University of Memphis, Dr. Amir Hadadzadeh leads efforts to characterize material response under erosive conditions, while Dr. Yuan Gao investigates cavitation formation through microfluidic experiments. Dr. Foti directs numerical simulations that model cavity dynamics across multiple scales and inform experimental design.

Initial project phases established the experimental framework and capabilities for full-scale testing, while ongoing work expands testing conditions and simulation accuracy. Together, these efforts are providing new insight into how cavitation forms, evolves and interacts with material surfaces.

The long-term goal of this research is to improve the design, durability and efficiency of naval components while reducing maintenance and lifecycle costs. By advancing understanding of both the fluid dynamics and material behavior associated with cavitation, the project is contributing to more resilient and high-performing marine systems.



Group from the University of Memphis and Naval Surface Warfare Center Carderock Division in front of the LCC



Cavitation sheet forming over a 10 ft span hydrofoil in the LCC

Unlocking Additive Manufacturing Potential Through Data

Additive manufacturing is reshaping how products are designed, produced and qualified across industries. The Metal Additive Manufacturing Lab (MAM Lab) is expanding its impact in advanced manufacturing through a combination of workforce development and data-driven research.

Led by Dr. Seyed M. Hojjatzadeh, the lab has significantly enhanced its training initiatives over the past year by hosting EOS Additive Minds–certified programs for both graduate and undergraduate students. These hands-on experiences provide training on industrial metal additive manufacturing systems and prepare students to operate equipment safely and efficiently using industry-standard workflows.

Real-time data and digital twin technologies are redefining precision and reliability in manufacturing.

As an official Additive Minds partner, the MAM Lab is now positioned to deliver advanced training for industry professionals, including master-class–level instruction. This designation establishes the lab as a regional hub for workforce development in metal additive manufacturing, strengthening connections between academic research and industry needs.

At the same time, the lab is advancing digital twin technologies that are transforming how additive manufacturing processes are monitored and controlled. Digital twins enable real-time connections between process conditions and part quality, performance and reliability—critical factors in modern manufacturing environments.

Central to this work is in-situ monitoring, where sensors collect data during the build process to detect anomalies, improve process control and reduce the time and cost associated with part qualification. To support these efforts, the MAM Lab has implemented multiple sensing systems, including optical tomography and long-wave infrared thermal imaging, enabling comprehensive, multi-modal monitoring of manufacturing processes.

Building on collaborations with Oak Ridge National Laboratory, this research is positioning the lab to support data-driven qualification methods for both industrial and biomedical applications, advancing the reliability and scalability of additive manufacturing technologies.

Members of MAM Lab from left: Yusef Qazzaz, graduate student; Craig Bowlin, graduate student amd EPS Tech; Morteza Pakniat graduate student and Adeel Khawaja. undergraduate student

Metal Additive Manufacturing Lab (MAM Lab)

Additive manufacturing is reshaping how products are designed, produced and qualified across industries.

Workforce Development

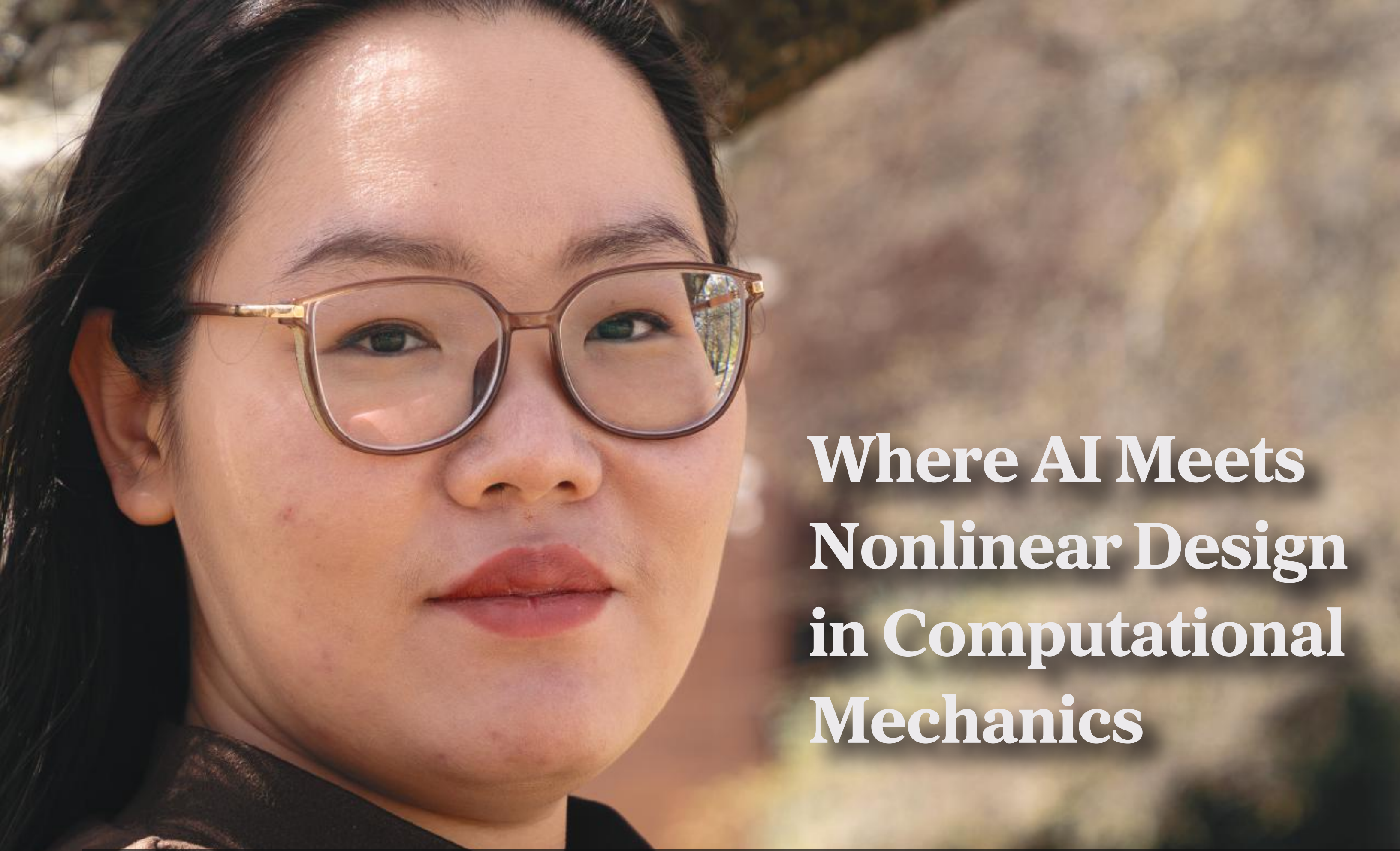
- EOS Additive Minds–certified training (grad & undergrad)
- Hands-on with industrial metal AM systems
- Safe, efficient operation, industry-standard workflows
- Regional hub for master-class-level training

Digital Twins & In-Situ Monitoring

Process conditions → Real-time data → Part quality / performance / reliability

- In-situ sensing anomaly detection — Optical tomography; Long-wave IR thermal imaging
- Improved control
- Reduced time & cost

Collaboration with Ook Ridge National Laboratory, industrial and biomedical applications.



Where AI Meets Nonlinear Design in Computational Mechanics

Innovative modeling and machine learning are expanding the boundaries of structural analysis and engineering design.

Simulating complex structural behavior requires tools that go beyond traditional modeling approaches. Researchers in the Department of Mechanical Engineering are developing advanced computational methods to better understand and predict the behavior of complex engineering systems.

Dr. Yue Guan leads research focused on high-dimensional, higher-order mechanics problems, using AI-aided approaches to simulate systems that are difficult to capture through traditional methods. This work addresses emerging challenges across engineering and society by enabling more accurate and efficient analysis of complex structures.

> *AI-driven modeling is unlocking new possibilities for predicting and designing complex structural behavior.*

A key innovation from the lab is a hybrid machine learning framework known as STABLE, which predicts the buckling load of cylindrical shells using nondestructive testing data. This capability has important implications for structural health monitoring and post-disaster assessment, where rapid and reliable evaluation of damaged infrastructure is critical.

To support experimental validation and real-world application, the Tunable Nonlinearity and Stability Lab has added a 3D digital image correlation system. This technology enables precise measurement of deformation and strain, helping bridge the gap between computational models and physical systems.

Beyond modeling, the lab is also advancing the development of novel materials and design strategies by tuning simulated mechanical behavior. This includes work on prestressed metamaterials and sub-millimeter force sensors, expanding the possibilities for engineering design in strongly nonlinear regimes.

Together, these efforts are extending the frontiers of computational mechanics and enabling new approaches to designing, monitoring and optimizing complex systems.

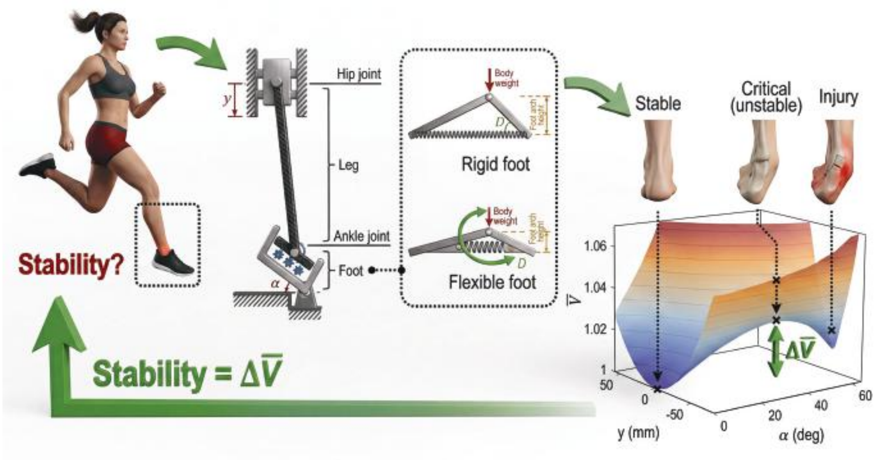
Reimagining Fall Prevention Through Nonlinear Dynamics

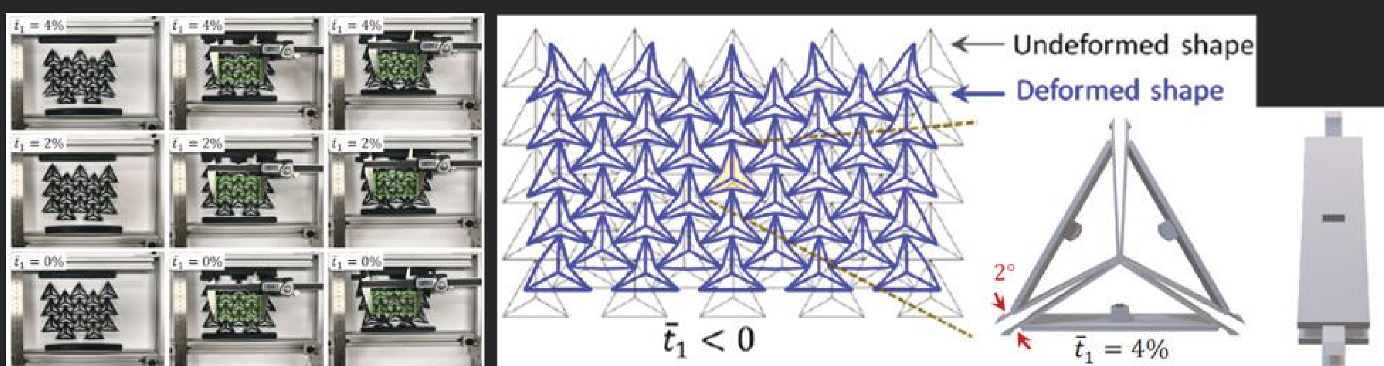
As the U.S. population ages, fall-related injuries have become an increasingly urgent public health concern. Researchers in the Department of Mechanical Engineering are working to address this challenge through advanced modeling and analysis of human motion and stability.

Dr. Yue Guan's research focuses on simulating full fall dynamics and evaluating nonlinear human postural stability to better understand how and why falls occur. By moving beyond traditional linear and empirical approaches, the work introduces a more precise, quantitative framework for assessing stability and injury risk.

The research integrates multibody dynamic models, nonlinear analysis techniques and human motion experiments, conducted in collaboration with the Biomechanics and Musculoskeletal Analysis Laboratory. This multidisciplinary approach allows for a more comprehensive understanding of how the human body responds under varying conditions, including imbalance and external disturbances.

Through this work, Dr. Guan's group is evaluating the effectiveness of existing fall-prevention tools while also informing the development of next-generation strategies. The goal is to enable more targeted stability assessments and personalized recommendations that can reduce fall risk and improve quality of life, particularly for older adults.





Expanding Research and Student Impact in Plasma Science

P3ARL

Plasma, Particles, Powders & Aerosol Research Laboratory

Led by Dr. Ranganathan Gopalakrishnan

Funding

Army Research Office

Department of Energy

Army Education Outreach

Federal sponsors supporting fundamental and applied plasma research across energy, defense, and manufacturing.

Research focus

Plasma systems

Aerosols & powders

Materials synthesis

Off-site experiments

Cutting-edge experimental systems probing complex plasma interactions with direct applications to next-gen materials and processes.

People and training

Doctoral researchers

Undergraduates

High school students

Hands-on plasma research experience for students at all levels, including doctoral work at Auburn's Magnetized Plasma Research Lab.

Outcomes

Peer-reviewed publications

National security

New research capabilities

Workforce development

Expanding UofM's research infrastructure while generating outputs that advance industry, defense, and emerging technologies.

The P3ARL lab is advancing discovery while preparing the next generation of engineers and scientists.

The Plasma, Particles, Powders, and Aerosol Research Laboratory (P3ARL) continues to expand its role as a hub for advanced plasma research within the Department of Mechanical Engineering. Led by Dr. Ranganathan Gopalakrishnan, the lab is equipped with cutting-edge experimental systems that support both fundamental investigation and applied research across energy, national defense, manufacturing and environmental technologies.

Supported by the Army Research Office and the U.S. Department of Energy, P3ARL is focused on exploring complex interactions in plasma systems involving aerosols and powders—work that has the potential to influence next-generation materials and processes across multiple industries.

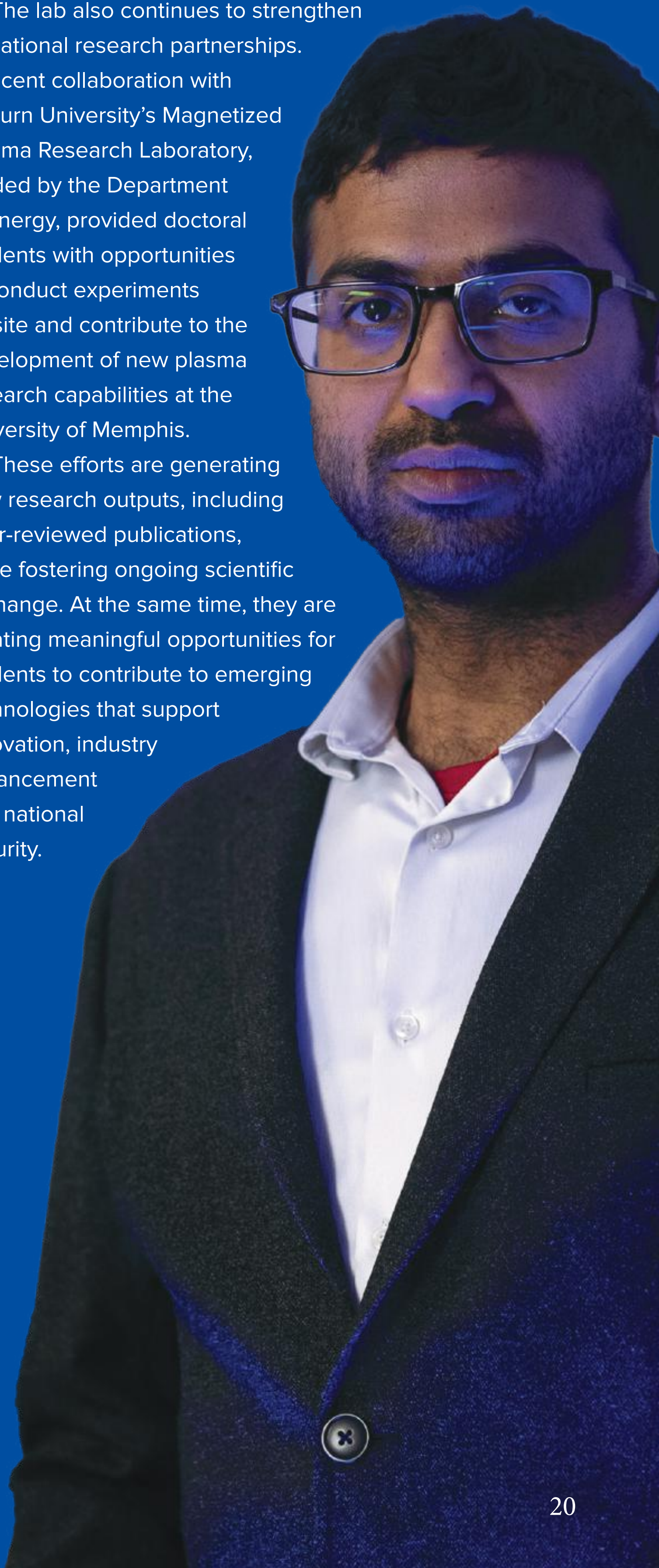
> *Our research is opening new pathways in plasma science while preparing students to lead in emerging technologies.*

"At P3ARL, our research pushes the boundaries of plasma science, exploring complex interactions in aerosols and powders that have the potential to transform energy, manufacturing and materials technology," said Gopalakrishnan.

A central component of the lab's mission is student engagement and workforce development. Through the Army Educational Outreach Program, undergraduate and high school students participated in hands-on research this year, gaining direct experience with plasma-based materials synthesis and experimental techniques.

The lab also continues to strengthen its national research partnerships. A recent collaboration with Auburn University's Magnetized Plasma Research Laboratory, funded by the Department of Energy, provided doctoral students with opportunities to conduct experiments off-site and contribute to the development of new plasma research capabilities at the University of Memphis.

These efforts are generating new research outputs, including peer-reviewed publications, while fostering ongoing scientific exchange. At the same time, they are creating meaningful opportunities for students to contribute to emerging technologies that support innovation, industry advancement and national security.



At a Glance

- Advanced plasma research lab in Mechanical Engineering
- Focus areas: plasma, particles, powders and aerosols
- Supported by the Army Research Office and U.S. Department of Energy
- Hands-on research opportunities for undergraduate and high school students
- Active collaboration with Auburn University
- Research applications in energy, manufacturing, national defense and environmental systems

Engineering the Future of Space Exploration

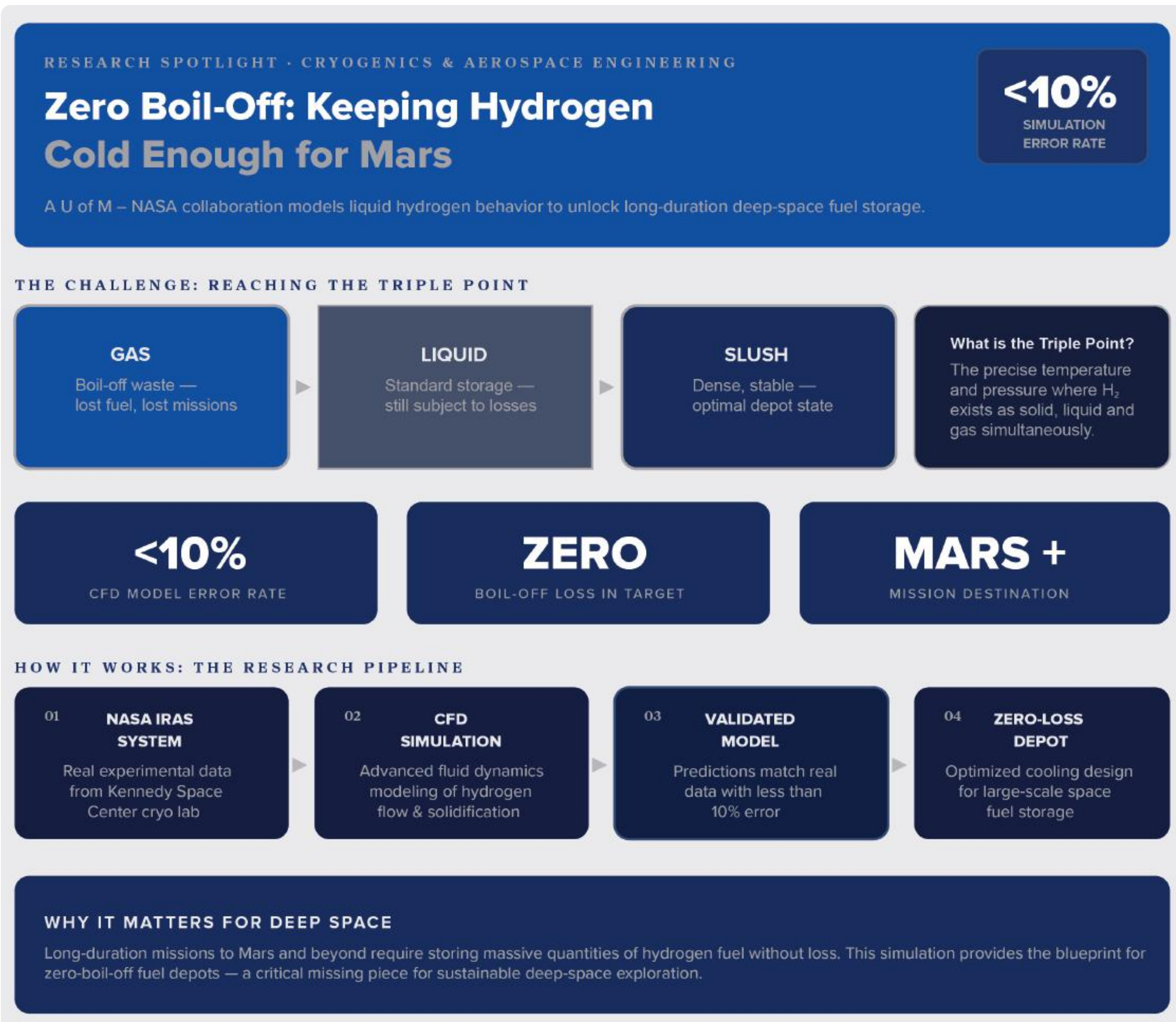
Long-duration space missions depend on solving one critical challenge: how to store cryogenic fuel efficiently without loss. Researchers in the Department of Mechanical Engineering are working to address this challenge through advanced simulation and modeling of liquid hydrogen systems.

Dr. Colin P. Mahony and Dr. Jeffrey G. Marchetta from the University of Memphis, alongside Adam M. Swanger of NASA's Kennedy Space Center Cryogenics Test Laboratory, have developed a high-fidelity simulation to predict the complex behavior of liquid hydrogen, including its solidification, to eliminate boil-off losses in large storage tanks.

Published in Results in Engineering, the study uses advanced computational fluid dynamics validated with experimental data from NASA's Integrated Refrigeration and Storage system. The model predicts flow fields and solidification zones with less than 10% error, providing a highly accurate representation of system behavior.

By modeling the IRAS system, the research demonstrates how cooling strategies can be optimized to maintain hydrogen at the "triple point," where it forms a dense slush. This state allows for more efficient storage and reduced fuel loss, addressing a major barrier in long-duration spaceflight.

These findings have significant implications for the design of large-scale, zero-loss fuel depots—an essential component for sustained missions to Mars and beyond. By improving how cryogenic fuels are stored and managed, this work is helping lay the foundation for the next generation of space exploration systems.



Energy Innovation Drives Manufacturing Efficiency

More than $1 million in potential annual energy savings is being identified through applied research and industry collaboration led by the University of Memphis Industrial Training and Assessment Center (ITAC). Through targeted assessments and data-driven recommendations, the center is helping manufacturers improve efficiency, reduce costs and strengthen long-term sustainability.

Energy assessments conducted in 2025 across five manufacturing facilities in the region revealed a combined potential for more than $1,017,000 in annual energy savings. Collectively, the recommended measures represent an estimated $2.2 million investment, with an average payback period of less than 10 months.

Across these sites, several key opportunities for efficiency improvements consistently emerged. Some of the most immediate returns were associated with compressed air system optimization, where repairing leaks and correcting pressure settings resulted in payback periods often under one month.

The team also identified significant opportunities in waste heat recovery, capturing energy from industrial processes such as compressors and ovens to preheat air or water. These improvements typically achieved payback within a few months.

For longer-term impact, the assessment team recommended strategic upgrades, including solar energy installations and the integration of variable frequency drives on motors, pumps and hoists. The team also highlighted existing best practices within facilities and identified federal and utility incentive programs that can help offset implementation costs.

The ITAC team collaborates with the Tennessee Department of Economic Development (TDEC) on waste and sustainability initiatives and works with the Tennessee Valley Authority to connect manufacturers with incentives and rebates that support energy efficiency improvements.

The photo shows the ITAC Team from left to right: Crystal Warren (TDEC); Wahib Ibrahim (UofM); Jayce Fiene (UofM); Wyatt Walorinta (UofM); Isaiah Triplett (UofM); Molly Rachlin (UofM); Ansar Ali (UofM); William Surbrook (UofM); Jeff Marchetta, director (UofM); Jennifer Farler, student team leader (UofM); and Vaughn Cassidy (TDEC)

Engineering Stronger Materials Through Advanced Manufacturing

At the intersection of materials science and advanced manufacturing, researchers in the Department of Mechanical Engineering are developing new approaches to design high-performance metals for demanding applications.

Led by Dr. Amir Hadadzadeh, the Processing-Microstructure-Properties (PMP) Lab focuses on understanding how manufacturing processes influence the internal structure of metals and, ultimately, their performance. By studying the relationship between processing, microstructure and material properties, the lab is working to engineer next-generation alloys with enhanced strength, durability and reliability.

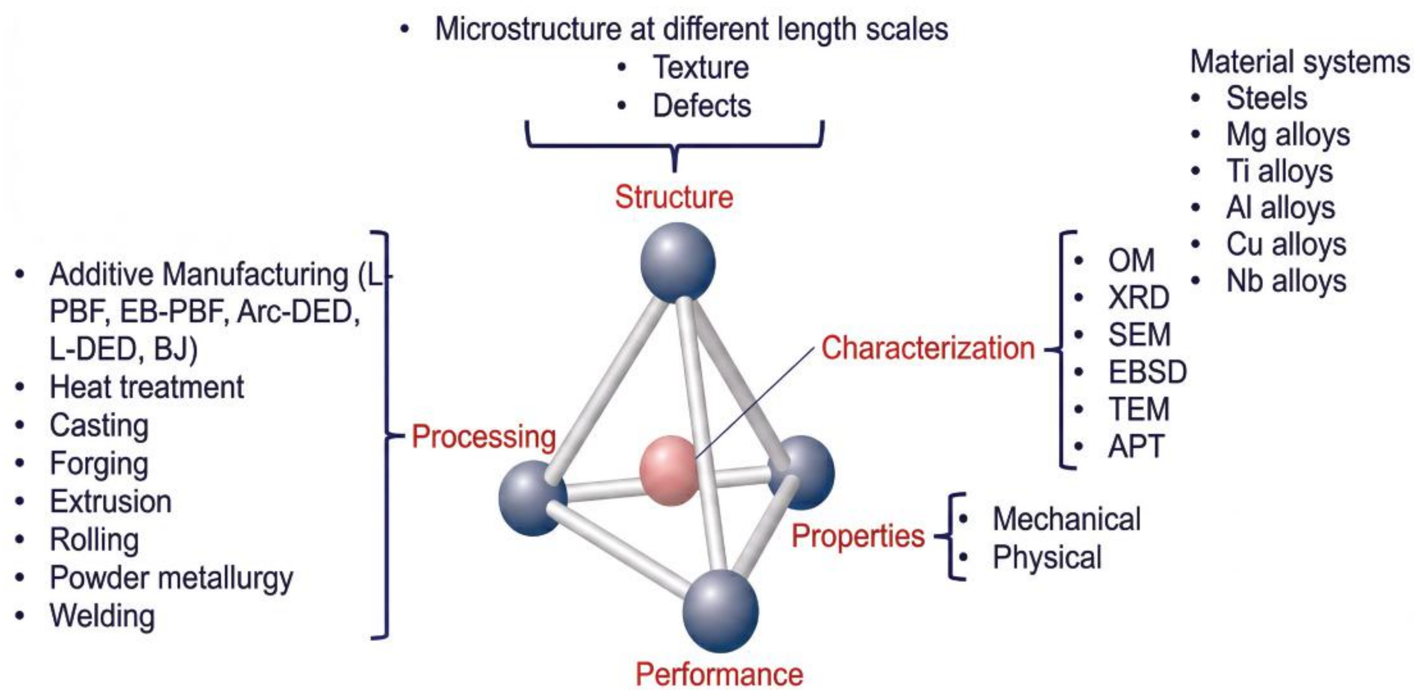
A central component of this research is the use of advanced manufacturing techniques, including additive manufacturing methods such as laser powder bed fusion, directed energy deposition and binder jetting. These approaches allow researchers to precisely control how materials are formed, enabling the development of complex microstructures across multiple length scales.

Through this level of control, the lab is able to tailor key material characteristics, including phase transformations and strengthening mechanisms, to achieve improved performance. The work emphasizes a balance between strength and ductility, a critical factor in designing materials that can withstand extreme conditions without failure.

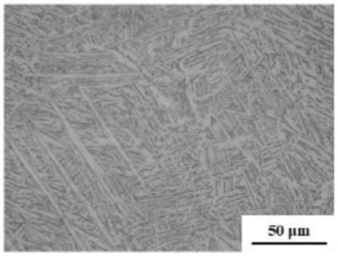
To support this effort, the PMP Lab uses advanced characterization tools to analyze materials at the micro and nanoscale, providing deeper insight into how structure influences behavior. This integrated approach—combining processing, analysis and design—is helping to accelerate the development of materials for use in aerospace, energy, defense and biomedical applications.

By advancing the science of materials design, the lab is contributing to technologies that require higher performance, greater reliability and improved efficiency, while also preparing students to work at the forefront of modern manufacturing and materials engineering.

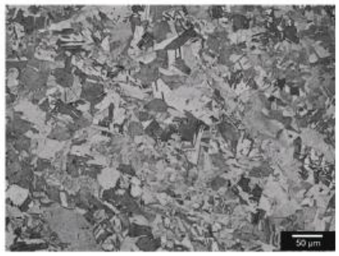
Research Philosophy - Materials Science Paradigm



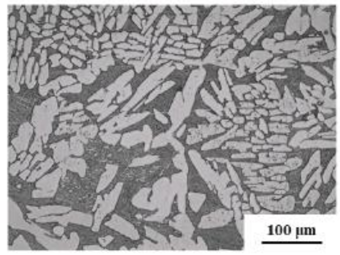
Microstructure Gallery



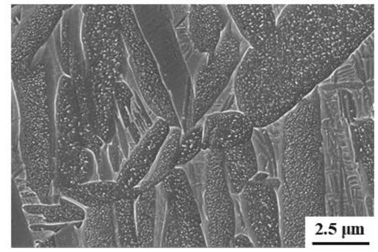
OM micrograph of HIP L-PBF-Ti64



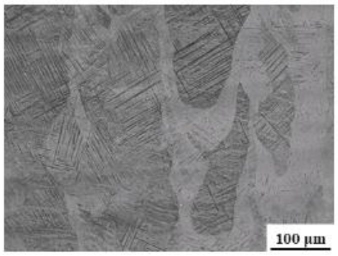
OM micrograph of pure copper



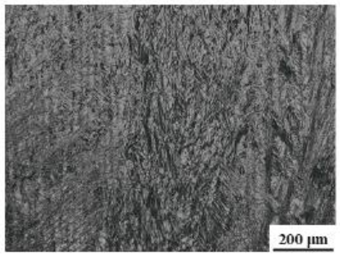
OM micrograph of heat-treated L-PBF-Ti64



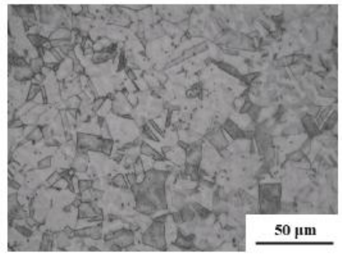
SEM micrograph of heat-treated L-PBF-Ti64



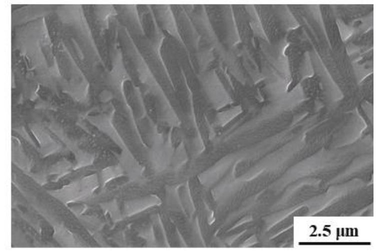
OM micrograph of as-fabricated L-PBF-Ti6242



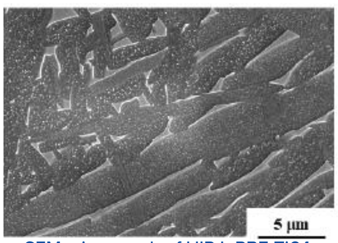
OM micrograph of as-fabricated WAAM-PH13-8Mo Steel



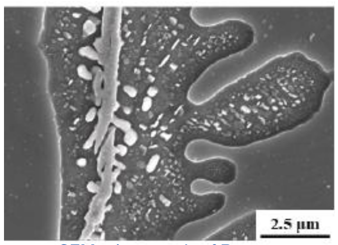
OM micrograph of annealed 316L Stainless Steel



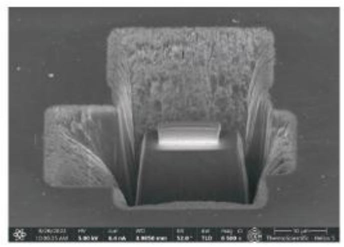
SEM micrograph of heat-treated L-PBF-Ti6242



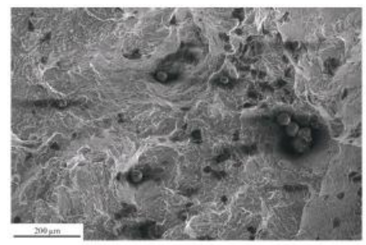
SEM micrograph of HIP L-PBF-Ti64



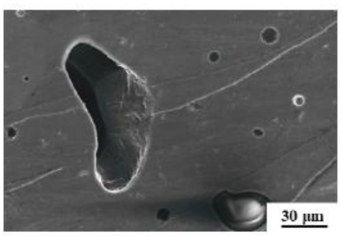
SEM micrograph of Bronze



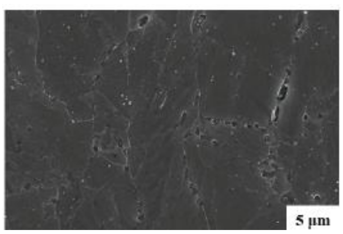
Ion-milled trenches around a FIB sample



Fracture Surface of L-PBF-Ti6242

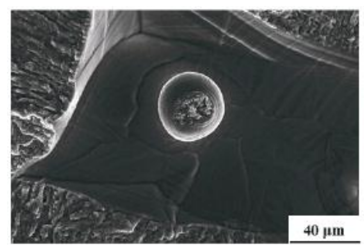


SEM micrograph of as-fabricated BJ-PH17-4 Stainless Steel

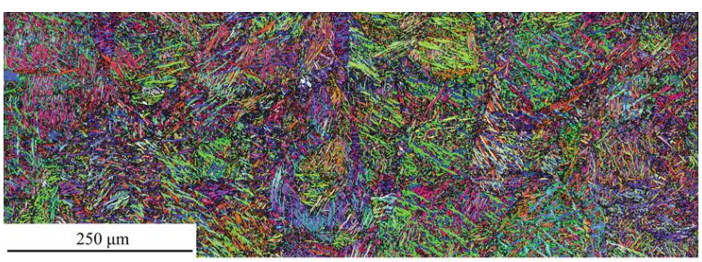


SEM micrograph of as-fabricated L-PBF-PH17-4 Stainless Steel

SEM micrograph of C103 powder particles

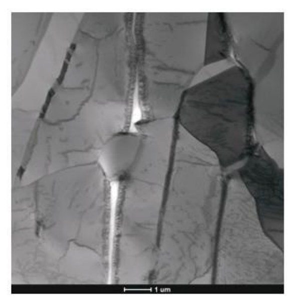


Fracture Surface of L-PBF-Ti64

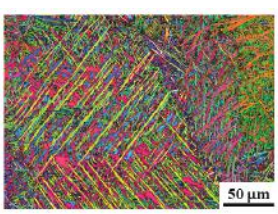


EBSD of L-PBF-Ti6242

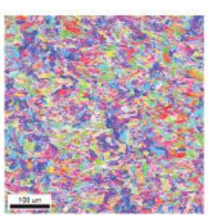
TEM of as-fabricated L-PBF-Ti64



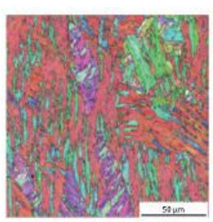
TEM of heat-treated L-PBF-Ti64



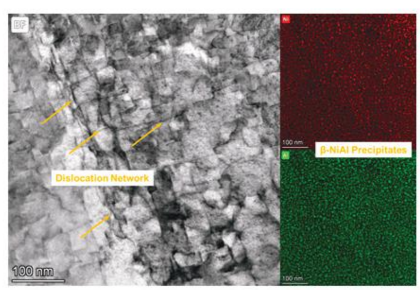
EBSD of L-PBF-Ti64



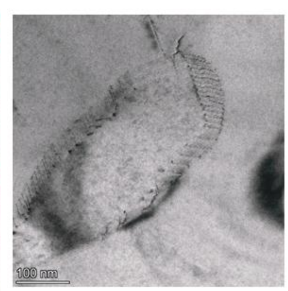
EBSD of L-PBF-PH13-8Mo



EBSD of Arc-DED-PH13-8Mo



STEM-BF micrograph and EDS elemental maps of L-PBF-PH13-8Mo stainless steel



TEM micrograph of heat-treated L-PBF-Ti6242

Mechanical Engineering Senior Design

Senior Design in the Department of Mechanical Engineering is driven by long-standing partnerships with industry leaders across manufacturing, medical devices, automation and advanced systems. Through this two-semester capstone experience, students collaborate directly with company sponsors to solve real-world engineering challenges—gaining hands-on experience in design, analysis, fabrication and testing.

Projects span a wide range of applications, from biomedical device development with partners like Medtronic to industrial systems with companies such as ABB and Vanguard Soap, as well as nationally competitive builds through programs like Baja SAE and AIAA design competitions. These collaborations often extend beyond the classroom, resulting in award-winning work, competition placements and even patent development.

This year, The Suspension is Killing me tied for first place in the Oral Presentation category with their project 'Tiger Baja Suspension and Steering System." They placed second in Overall Senior Design. Pictured from left is David Maybee, Olivia Ganavazos, Caleb May and Isabella Selvera.

School Guardians tied for third place in Overall Senior Design with their project "Privacy Screen Kit." Pictured from left is Flavie Dubé, Derian Williams, Tanya Prahalathan and Juan Guerrero.

Herff College of Engineering Design Expo

Senior Design Project Highlights

Project	Year	Sponsor	Remarks
2024 AIAA Design/Build Fly Competition	2023-2024	AIAA	The team was qualified for the final competition
Fill'er UP	2024-2025	Vanguard Soap	Received the department senior design award
Axial Force Sensing Adapter	2024-2025	Medtronic Inc.	Resulted in a patent
Depth Stop for Cervical Instruments	2025-2026	Medtronic Inc.	Joint project with BIOMED
Pipe ID Painting System	2025-2026	ABB	Joint project with TECH
TigerBaja 2026 Frame and Cockpit Integration and TigerBaja 2026 Front Suspension and Steering	2025-2026	Baja SAE	Will attend the 2026 competition

Student Spotlights:
Outstanding Mechanical Engineering Undergraduates

Sophie Nieder

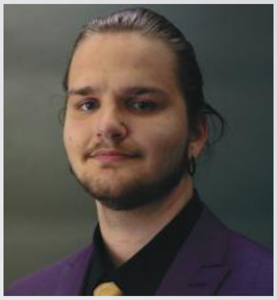
Sophie Nieder serves as the president of the Society for Women Engineers at the Herff College of Engineering. In 2026, through her studies and networking, she began an internship with FarmChem Corporation. Sophie said she looks forward to applying the knowledge she's acquired at Herff to her new professional setting. After graduating, she plans to continue her involvement with the Society of Women Engineers. While she takes an array of skills with her into the workforce, Sophie said she gained much more than that at the Herff College of Engineering.

Michael Dumas

Michael Dumas won the Herff College of Engineering Dean's Award for Outstanding Undergraduate Student. As a senior, Dumas serves the college as an Engineering Ambassador while working as a Quality Engineering Intern at Smith & Nephew. He's already on track to move up in the company, stepping into a Manufacutring Engineering position at Smith & Nephew after graduating in May. Dumas plans on continuing his work-and-school balance while earning a part-time Master's degree in Materials Science and Engineering as a full-time Smith & Nephew employee.

Tanya Prahalathan

The Herff College of Engineering proudly recognized Tanya K. Prahalathan as its Mechanical Engineering Outstanding Senior. As a freshman, she got involved on campus upon joining the Herff College of Engineering She lived in the Engineering Living Learning Complex located on the fifth floor of the Shirley C. Raines Centennial Place and joined student organizations, two activities she credits with strengthening her community and bolstering her academic success. She encouraged younger students to follow the same path and take advantage of every opportunity presented to them.



Shaun Bowlin

Shaun Michael Bowlin received the Mechanical Engineering Outstanding Junior. Shaun spent his junior year working alongside Dr. Agarwal in the Dynamics, Systems, and Controls lab. His work centers on a Kresling origami-inspired robotic arm made from rigid materials, utilizing a new class of materials called Polycatenated Architected Materials. Shaun hopes to finish his project by manufacturing a unit from metal via addictive manufacturing and plans to complete the first of his designs over the summer. Shaun credited his fellow students at the Herff College of Engineering with giving him the support he needed to succeed, whether that looked like all-night studying sessions or pick-up soccer games.

Marc Cicalla

Marc Cicalla works with Dr. Daniel Foti, Associate Professor at Graduate Program Coordinator at the Herff College of Engineering. Marc assists Dr. Foti on the wind wall project and assists students in the Verticall Integrated Projects program with their research. He also works alongside other faculty and fellow students to study how rain drops form. After graduating, Marc plans to either enroll in the EiT program at Siemens or continue his research in pursuit of a PhD with Dr. Foti. Marc said some of his favorite memories at the Herff College of Engineering include figuring out how to heat orphanages, trips with the AIAA VIP and DBF teams and visiting the Kennedy Space Center. Before graduating, he looks forward to seeing how Hondajet planes are put together and how engineers improve the planes.

THE UNIVERSITY OF MEMPHIS

Department of
Mechanical Engineering