DEPARTMENT OF

CHEMICAL ENGINEERING

GRADUATE PROGRAM & RESEARCH OVERVIEW

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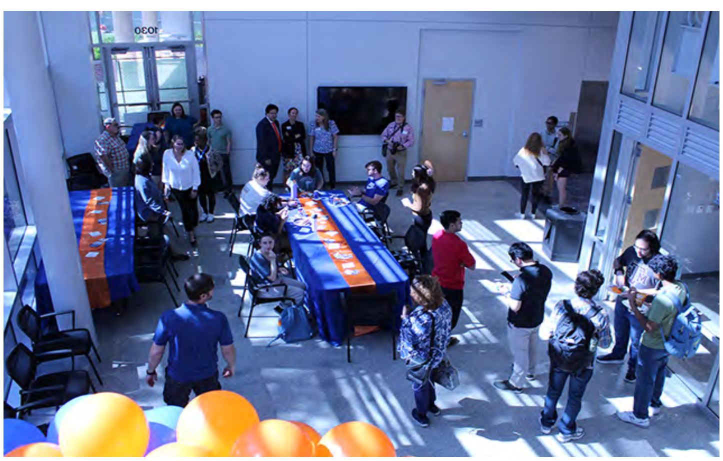


THE CHEMICAL ENGINEERING STUDENT CENTER reopened for student use in 2025 following repairs to the building's foundation. Faculty, students, and staff celebrated the return of this fully almuni-sponsored space in Spring 2025.

THE DEPARTMENT OF CHEMICAL ENGINEERING AT THE UNIVERSITY OF FLORIDA IS GRATEFUL TO DR. RICH DICKINSON FOR RETURNING TO THE ROLE OF DEPARTMENT CHAIR STARTING IN AUGUST 2025.

A MESSAGE FROM THE CHAIR:

We are delighted to share this brochure highlighting the exciting graduate programs in the Department of Chemical Engineering at the University of Florida. With a long-standing tradition of excellence, our department offers both Masters and Ph.D. degrees that prepare students to tackle today's grand challenges through cutting-edge research and rigorous training. Our graduate program continues to rank among the strongest in the region and the nation, and our faculty are internationally recognized for both their research contributions and their commitment to education.

Ph.D. students benefit from robust financial support packages and close mentorship by faculty actively engaged in high-impact research. Current research strengths include soft matter, biomolecular and genome engineering (including CRISPR technologies), catalysis and reaction engineering, electrochemical systems, and sustainable energy. Our faculty lead and collaborate in interdisciplinary initiatives taking advantage of UF's state-of-the-art facilities such as the Wertheim Laboratory for Engineering Excellence, Malachowsky Hall for Data Science & Information Technology, and UF's HiPerGator supercomputer. Our proximity to the UF College of Medicine, UF Health Shands Hospital, and the VA Hospital further strengthens opportunities for research partnerships in biomedical and translational science.

Graduate students also benefit from a strong community of scholars and professionals. Organizations like the Graduate Association of Chemical Engineers (GRACE) and AIChE-UF offer leadership, professional development, and social engagement opportunities. On-going infrastructure improvements are designed to improve the way our students learn and perform research.

Beyond campus, Gainesville offers a high quality of life in a vibrant, affordable community. Located in North Central Florida, it boasts a thriving cultural scene, access to natural springs and parks, and proximity to major cities like Orlando, Tampa, and Jacksonville—each within a two-hour drive. Whether you're enjoying an evening lecture series, kayaking at Ichetucknee Springs, or collaborating in a world-class laboratory, Gainesville offers an ideal setting for both academic and personal growth.

We invite you to visit us and experience firsthand what makes graduate study in chemical engineering at the University of Florida so rewarding.

Rich Dickinson
Professor and Chair
Department of Chemical Engineering

THE HERBERT WERTHEIM COLLEGE OF ENGINEERING HOUSES ONE OF THE LARGEST AND MOST DYNAMIC ENGINEERING PROGRAMS IN THE NATION.

- Curriculum offered across 10 departments, 15 degree programs, and more than 20 centers and institutes produces leaders and problem-solvers who take a multidisciplinary approach to innovative and human-centered solutions
- Engineering is the second largest college and one of the top three research units at UF
- The college produces inventions at twice the national average – and startups at three times the national average – for every research dollar spent
- A significant amount of interdisciplinary research is conducted through centers and shared instrumentation facilities, such as the Florida Institute for Cybersecurity Research (FICS), the Florida Semiconductor Institute (FSI), the UF Nanoscale Research Facility (NRF), the Nanoscience Institute for Medical and Engineering Technology (NIMET), and the Institute for Computational Engineering
- Students, faculty and alumni are hailed as New Engineers who aim to transform the way we live, work, and play

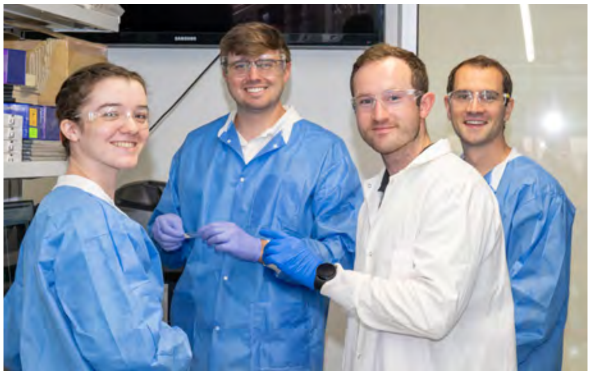
WITH OVER 55,000 STUDENTS, THE UNIVERSITY OF FLORIDA IS THE FIFTH LARGEST UNIVERSITY IN THE UNITED STATES.

- UF is ranked number 5 among the nation's top public research universities and is one of only 17 public land-grant universities that belong to the Association of American Universities
- The Graduate School coordinates more than 200 graduate programs
- UF supports over 100 interdisciplinary research centers, bureaus and institutes on campus
- As a land-grant university identified by the Morrill Act of 1862, UF has a special focus on engineering, as well as agriculture, with a mandate to deliver the practical benefits of university research throughout the state
- In addition to the 2,000-acre main Gainesville campus, UF has research centers, extension operations, clinics and other facilities and affiliates in every Florida county

THE HERBERT WERTHEIM LABORATORY FOR ENGINEERING EXCELLENCE is the college's flagship building with an 84,000-square-foot state-of-the-art research and

THE DEPARTMENT OF CHEMICAL ENGINEERING AT THE UNIVERSITY OF FLORIDA PROVIDES A WONDERFUL ACADEMIC ENVIRONMENT FOR GRADUATE SCHOOL, INCLUDING EXCEPTIONAL FACULTY, RESOURCES, AND A PICTURESQUE CAMPUS.

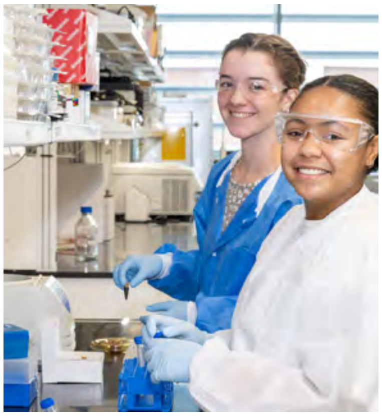
The department has 29 faculty members engaged in graduate research and teaching. Their interests span a wide range of topics including bioengineering, nanotechnology, complex fluids, catalysis, advanced materials processing, electrochemical engineering, semiconductor fabrication, and surface and interfacial phenomena. This diversity of interests is reflected in the types of graduate courses available at both the department and the college, allowing our students excellent opportunities to obtain a broad background in chemical engineering.



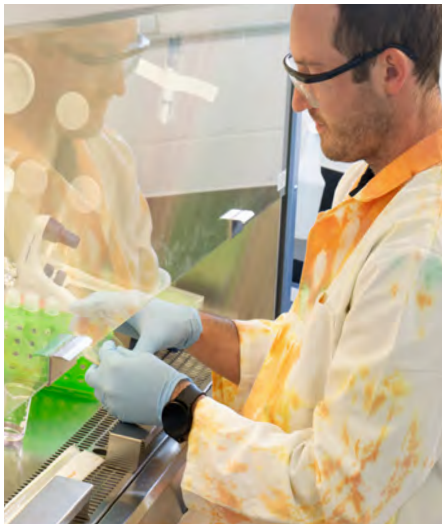
Support for our programs comes from federal agencies, such as National Science Foundation (NSF), the National Institutes of Health (NIH), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), the Department of Defense (DOD), and private nonprofit organizations, such as the American Chemical Society and the Gas Research Institute.

Research within our department is also often supported through industry partnerships, providing a way for students to apply fundamental academic work to everything from basic science, commercial development and manufacturing, and advancements in healthcare and medicine. Graduate students in the Department of Chemical Engineering can pursue a Doctorate of Philosophy (Ph.D.), Master of Science (M.S., thesis or non-thesis), or Master of Engineering (M.E.) degree.

GRADUATE STUDENTS ARE SURROUNDED BY OPPORTUNITIES TO GROW AND DEVELOP AS ENGINEERS AND SCIENTISTS



- State-of-the-art facilities with cutting edge research instrumentation
- Access to leading experts across the Herbert Wertheim College of Engineering and the 15 other colleges across campus
- Faculty mentors with awards for excellence in education and mentorship
- Cutting-edge technology, including exceptional supercomputing capacity for memory intensive computational efforts, data analysis, and database management
- Ph.D. students are often supported through competitive awards and fellowships, including external awards such as the NSF's Graduate Research Fellowship and internal awards, such as our annual UF ChE Excellence



GRADUATE STUDENTS ARE GIVEN EXTENSIVE OPPORTUNITIES TO ENGAGE IN PROFESSIONAL DEVELOPMENT

- First-class institutes and centers that foster entrepreneurship and interdisciplinary collaboration
- Certificate programs to foster skills development and competency
- Leadership opportunities in the chemical engineering graduate student association, GRACE (GRaduate Association of Chemical Engineers)
- Volunteering and community service opportunities
- Coursework opportunities to learn and practice skills in teaching, managing, and educating others

GRADUATE STUDENTS HAVE ACCESS TO AN ARRAY OF ACTIVITIES IN THE LOCAL COMMUNITY, WHICH PROVIDE OPPORTUNITES FOR STUDENTS TO MAINTAIN THEIR

- Alachua County and north Florida are known for their beautiful springs, nature trails, and opportunities for kayaking, canoeing, paddle boarding, and bird watching
- The Gainesville food scene has a variety of options from food trucks to fine dining, including over seven local breweries
- UF Health Shands Hospital provides excellent healthcare for any issue a student or their family may encounter
- Samuel P. Harn Museum of Art and the Phillips Center offer art installations, concerts, Broadway plays, and special events year-round
- Gainesville has its own airport, with quick access to major airline hubs, including Atlanta, Charlotte, Dallas, and Miami
- Proximity to large metropolitan areas including Orlando, Tampa, and Jacksonville

Pictured: Ruth B. Kirby Gilchrist Blue Springs State Park and Downtown Gainesville

PH.D. STUDENTS ARE SUPPORTED IN THEIR GROWTH AND DEVELOPMENT THROUGH A VARIETY OF DEPARTMENT AND COLLEGE SPONSORED ACTIVITIES

- All Ph.D. students making satisfactory progress receive guaranteed funding and incoming Fall 2025 Ph.D. students will receive an initial stipend of $34,000, tuition, and health insurance until the degree is awarded
- UF ChE offers competitive department and university fellowships and travel awards to support scientific communication and networking
- We encourage student participation in activities designed to promote professional development, leadership, and outreach to our community
- HWCOE and the ChE Department sponsor activities for students to interact with industry leaders and academic mentors in preparation for a variety of careers
- We are working to create a vibrant and diverse community to fulfill our students' intellectual and social needs while supporting their mental health and wellness
- The department sponsors monthly events and activities, such as the "First Friday" social event

GRADUATE ASSOCIATION OF CHEMICAL ENGINEERS

GRACE is a chemical engineering graduate student organization at UF that organizes programming focused on building a sense of community through events that focus on student well-being and professional development.

The annual **GRACE SYMPOSIUM** provides an opportunity for graduate students to share their recent scientific advancements with the community, including Ph.D. alumni.

ADVANCEMENT AND MENTORING COMMITTEE

The Advancement and Mentoring Committee in the Department of Chemical Engineering was founded by Dr. Helena Hagelin-Weaver. Since 2018, this group has grown and its mission is to empower, advance, and advocate for students and others in Chemical Engineering. Programming focuses on activities that advance professional development in a supportive and community-focused manner.

FIRST YEAR PH.D. STUDENT MENTORING PROGRAM

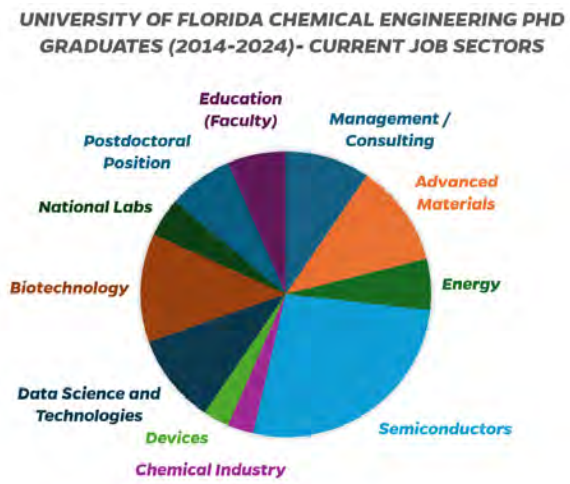
- Chemical engineering department-sponsored year long program for 1st year Ph.D. students that pairs new students with senior Ph.D. student mentors
- Improve Ph.D. student study habits and create a collaborative learning environment
- Encourage student social events and activities for students to make friends
- Promote and model healthy habits for maintaining Ph.D. student mental health
- Provide a near-peer mentor to reduce the propagation of "hidden curriculum" and ensure equal opportunities for student success

WE PRIDE OURSELVES ON TRAINING OUR STUDENTS IN AN INCLUSIVE ENVIRONMENT THAT SUPPORTS THEIR SCIENTIFIC AND PROFESSIONAL DEVELOPMENT.

PH.D. DEGREE

The Ph.D. degree plan is primarily a research program. Graduate students enrolled in the Ph.D. program have the opportunity to work closely with our dynamic, internationally recognized faculty. Ph.D. students will have the opportunity to work on innovative research problems through interdisciplinary collaborations in the colleges of engineering, liberal arts and sciences, and medicine, which are all co-located on the Gainesville campus. Ph.D. students observe a strong commitment to excellence in research and education in both the classroom and the laboratory, through outreach events, leadership opportunities, and educational training.

The granting of the degree is based on general proficiency and distinctive achievements of the Ph.D. candidate in their research field. Ph.D. students are expected to demonstrate the ability to conduct independent investigation of research problems and attain mastery of a field of knowledge. Ph.D. students will also have opportunities to gain valuable teaching and communication experience by assisting instructors in the classroom and supervising undergraduate and other graduate researchers in the laboratory. Ph.D. students will also have opportunities to grow in their professional development through trainings and graduate certificates in Engineering Leadership, Engineering Innovation, and Engineering Education.



Briefly, the requirements for the Ph.D. degree are:

1. Completion of at least 90 credits (minimum of 24 credits of coursework) beyond the B.S. degree while maintaining an overall and major GPA of 3.0 or higher. Specific coursework requirements include completion of Transport Phenomena, Molecular Thermodynamics, Advanced Mathematics, and Chemical Engineering Kinetics.
2. Successful completion of a written research proposal and oral qualifying examination based on the candidate's research plan to achieve the objectives for their doctoral dissertation and their general knowledge of chemical engineering fundamentals.
3. Successful completion of a written doctoral dissertation and final oral examination based on the candidate's original research.

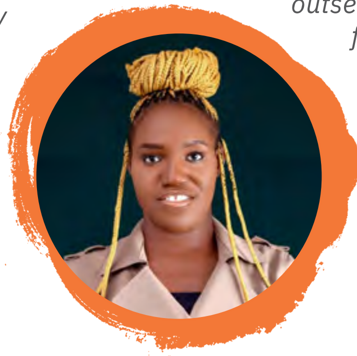
Final acceptance into the Ph.D. program requires successful completion of both the research proposal and the oral qualifying examination. Although the time to complete all Ph.D. degree requirements is dependent on the specific research program and student motivation, the minimum requirements for the Ph.D. program are typically met in three to five years following a B.S. degree.

All Ph.D. students that maintain good academic standing and make satisfactory progress receive competitive stipends, full tuition, and medical insurance for the duration of their Ph.D.

MARK ORAZEM
WILLIAM P AND TRACY CIRIOLI DISTINGUISHED PROFESSOR AND ASSOCIATE CHAIR FOR GRADUATE STUDIES

"At UF, collaborating with experimentalists and leveraging the power of UF's supercomputer for the computational design of soft materials has enriched my Ph.D. journey with invaluable interdisciplinary experience.."

Yinhao Jia
Ph.D. Candidate, Sampath Research Group



"I was immediately drawn to UF from the outset. The virtual information session for the UF Chemical Engineering PhD program deeply resonated with my career objectives. Being immersed in this environment now and engaging with the outstanding diversity among faculty, students, and graduate association is incredibly fulfilling."

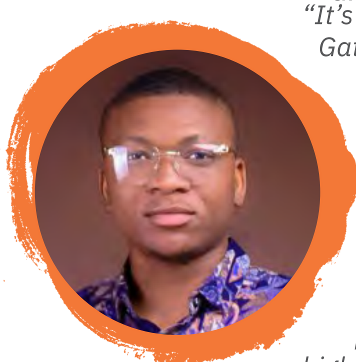
Shalom Iboh
Ph.D. Candidate, Restrepo-Florez Research Group

"Pursuing my PhD at the University of Florida has been a transformative experience. The supportive faculty and vibrant campus community have fostered innovation and intellectual growth. UF's commitment to excellence has equipped me with the skills and knowledge needed to excel in my career, making it an ideal place for aspiring scholars."

Hsiao-Hsuan (Renee) Wan
Ph.D. Candidate, Ren Research Group

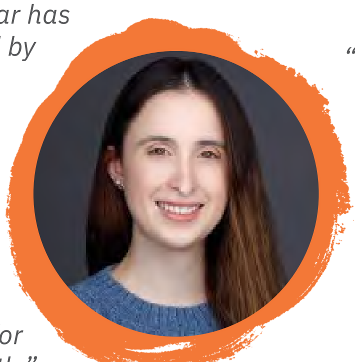
"UF's collaborative nature is exemplified by the sheer number of department and research centers on campus that make any research question approachable. With the diversity of students and events in Gainesville, I still have not run out of activities to do!"

Elizabeth Aikman
Ph.D. Candidate and NSF GRFP Research Fellow, Stoppel



"It's not just about the pride of being a Gator, but also the privilege of pursuing my PhD at one of the top public universities. My journey so far has been incredible, surrounded by brilliant minds, innovative research, and a supportive community that pushes me to excel. Every moment here has inspired me to push boundaries and aim higher. Given the choice, I would choose the University of Florida all over again for my academic journey. I am truly grateful for the opportunities and experiences shaping my path."

Israel David
Ph.D. Student, Choi Research Group



"Ever since I've been at UF, the campus has felt like a second home. The faculty and students here are bright and enthusiastic about their work. I'm proud to be a Florida gator and I could not have picked a better campus to pursue research at."

Danielle Loftis
Ph.D. Student, Moon Research Group

MASTERS OF SCIENCE

The Master of Science program provides an opportunity to develop an in-depth knowledge of chemical engineering fundamentals. M.S. students are also strongly encouraged to take advantage of courses that focus on valuable management, leadership, and entrepreneurial experiences in chemical engineering settings. Many students also acquire applied and fundamental skills through departmental research and/or industrial internships.

All new M.S. students are admitted to the non-thesis option at the time of admission. M.S. students enrolled in the thesis option are required to add a research component to the degree plan. Those M.S. students that desire to improve their research skills may convert to the thesis option upon approval of their research advisor and the Associate Chair for Graduate Studies.

M.S. students typically complete the degree requirements within 24 months. Briefly, the formal requirements for the M.S. degree are:

1. Completion of at least 30 credits of coursework beyond the B.S. degree, including Transport Phenomena, Advanced Mathematics, Chemical Engineering Kinetics and Advanced Chemical and Biological Processing Laboratory.
2. Successful completion of a written thesis or report on a research project, internship, or a contemporary chemical engineering topic.
3. Successful completion of a final oral examination based on the student's innovative research (thesis option).

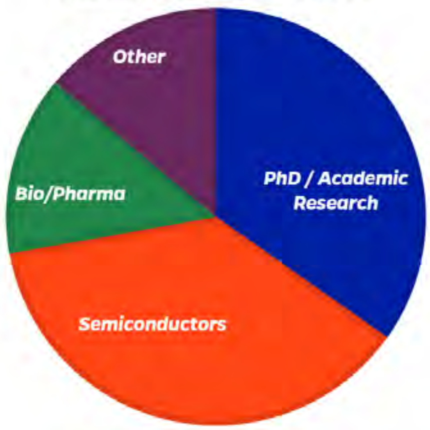
Upon graduation, our M.S. students obtain jobs in a variety of industrial sectors or pursue a Ph.D. degree or another advanced degree in medicine or law.

MASTERS OF ENGINEERING

The Master of Engineering program is designed for students that already hold a Bachelor of Science degree in biology, chemistry, physics, mathematics, or another branch of engineering who have not completed coursework in transport phenomena, kinetics of reactions, and/or thermodynamics.

The program provides an opportunity for M.E. students to develop an in-depth knowledge of chemical engineering fundamentals through both undergraduate and graduate coursework. Based on the background of the M.E. student, an individualized plan of one to three undergraduate courses are chosen to help the M.E. student gain the skills needed to be successful in the core Chemical Engineering graduate coursework. M.E. student requirements then follow those of the M.S. program. Many M.E. students are sought after in Chemical Engineering research laboratories due to their interdisciplinary training. M.E. students are also able to acquire experience in industrial practice and applied

JOBS BY SECTOR FOR 2019-2023 CHE M.S. AND M.E. GRADUATES



JOB SECTORS

Students successfully graduating with an M.S. or M.E. in Chemical Engineering have a wealth of opportunities available to them upon graduation. Over 35% of recent graduates have gotten a job in the semiconductor industry. Students looking for internships during the M.S. or M.E. degree are encouraged to talk to Dr. Patankar.

SUMANT PATANKAR
INSTRUCTIONAL ASSISTANT PROFESSOR & MASTERS PROGRAM COORDINATOR

"Becoming an MS student at UF has given me the opportunity to work alongside exceptional individuals and develop advanced research skills. The wide range of projects across various labs allowed me to explore different areas and ultimately select the one that best aligns with my interests. I learned to become a better team-player but also an independent researcher."

Hai Doan
MS Student, Stoppel Research Group

"What I appreciate most about UF is the vibrant academic environment and the plethora of opportunities available to students. The support from faculty and the availability of resources, like 24/7 libraries and advanced laboratory facilities, have greatly enriched my learning experience. Additionally, there are many fun activities and food joints at the Reitz Union for the students to step beyond academics and explore other interests."

Shivani Biskunda
MS Student, Denard Research Group

"Pursuing Masters at UF has been an incredible learning experience for me. The program seamlessly integrates theoretical foundations with practical applications. The department's commitment to research excellence is evident in its impressive facilities which have allowed me to explore diverse areas, from semiconductor manufacturing to biotechnology through intricately designed course modules and research volunteership opportunities. The supportive faculty have been invaluable mentors throughout my journey."

Joel V. John
MS Student, Weaver Research Group

"I truly appreciate the opportunity to come back to UF to pursue my master's degree in chemical engineering as part of the 4+1 combined degree program. The chemical engineering department has helped me reach my potential and provided me with support in my endeavors, both in terms of research and teaching opportunities. These experiences have built upon my practical skills as a chemical engineer in terms of problem-solving in technical fields, especially within semiconductors. Most importantly, having a strong support network of faculty members and fellow students really made my time at UF worthwhile."

Jasmeet Bhatt
MS Student

"My Master's experience has been transformative, allowing me to bridge theory and practice through detailed instruction and hands-on research. UF holds a special place in my journey, not only because of the academic opportunities but also because of the supportive mentors and peers who make it feel like a second home. The department is committed to ensuring student success in both coursework and professional opportunities and has aided my growth as a scientist tremendously."

Emma Thomas
ME Student, Jang Research Group

RESEARCH AREAS OF PRIMARY FACULTY

ADVANCED MATERIALS, DEVICES, AND NANOTECHNOLOGY

Travis Anderson
Won Tae Choi
Helena Hagelin-Weaver
Piyush Jain
Yeongseon Jang
Peng Jiang
Joshua Moon
Mark Orazem
Fan Ren
Carlos Rinaldi-Ramos
Janani Sampath
Whitney Stoppel

BIOMOLECULAR ENGINEERING, CELLULAR ENGINEERING, AND SYNTHETIC BIOLOGY

Carl Denard
Richard Dickinson
Piyush Jain
Yeongseon Jang
Mark Orazem
Fan Ren
Carlos Rinaldi-Ramos
Janani Sampath
Whitney Stoppel

COMPLEX AND MULTIPHASE FLOW DYNAMICS

Jason Butler
Anthony Ladd
Ranga Narayanan

ENERGY, ENVIRONMENT, AND SUSTAINABILITY

Won Tae Choi
Helena Hagelin-Weaver
Peng Jiang
Joshua Moon
Mark Orazem
Juan Restrepo-Flórez
Janani Sampath
Whitney Stoppel
Sergey Vasenkov
Jason Weaver
Kirk Ziegler

HETEROGENEOUS CATALYSIS AND SURFACE SCIENCE

Helena Hagelin-Weaver
Jason Weaver
Kirk Ziegler

MODELING, THEORY, AND SIMULATION

Anthony Ladd
Ranga Narayanan
Mark Orazem
Juan Restrepo-Flórez
Janani Sampath

TRANSPORT, MOLECULAR THERMODYNAMICS, AND ELECTROCHEMICAL ENGINEERING

Jason Butler
Won Tae Choi
Anthony Ladd
Joshua Moon
Ranga Narayanan
Mark Orazem
Juan Restrepo-Flórez
Carlos Rinaldi-Ramos
Sergey Vasenkov
Kirk Ziegler

TRAVIS J. ANDERSON, PROFESSOR & PHD RECRUITMENT COORDINATOR

Ph.D., 2008, University of Florida **tjanderson@che.ufl.edu**
Until Fall 2024, Head of the Power Electronics and Advanced Materials Branch, U.S. Naval

THE ANDERSON RESEARCH LAB ENCOMPASSES A STATE-OF-THE-ART SEMICONDUCTOR MATERIALS GROWTH, PROCESSING, AND TEST FACILITY TARGETED TOWARD ADDRESSING THE FABRICATION CHALLENGES ASSOCIATED WITH NEXT-GENERATION SEMICONDUCTORS.

Power conversion losses are pervasive in all areas of electricity consumption, including motion control, lighting, air conditioning, and computation technology. The fielding of high efficiency power switch technology using wide- and ultrawide-bandgap semiconductor devices in applications such as data centers, motor drives, solid-state lighting, hybrid/electric vehicle technology, wind turbines, and grid-scale power distribution has the potential to significantly mitigate climate change through the reduction of CO_2 emissions associated with inefficient electricity consumption. Semiconductor device fabrication represents a key application of core Chemical Engineering knowledge and training. The many steps involved in even a simple transistor process sequence include materials growth and film deposition, doping and etching, photolithography, thermal management, and steady-state operation of a foundry. In my group, we perform fundamental research addressing all of these topics.

NEXT GENERATION MICROELECTRONIC DEVICES

Wide-bandgap semiconductors (SiC, ZnO, GaN) and Ultrawide-bandgap semiconductors (Ga_2O_3, AlGaN, AlN, BN, and diamond) are key emerging materials for next-generation microelectronic device applications due to the high breakdown field and high mobility, enabling high switching speed and low switching losses. At the system level, this translates to improved size, weight, power consumption, cooling requirements, and system cost (SWaP-C2). In addition, materials are capable of operation in extreme environments such as high temperature (>500C) and radiation environments. In my group, we will evaluate device reliability and failure mechanisms, apply TCAD modeling and machine learning algorithms to device design, study heat transfer and novel thermal management technologies, understand operation in extreme environments, develop advanced processes for 2.5D and 3D heterogeneous integration, and collaborate with the Materials Science and Engineering Department on research topics associated with material growth by metal organic chemical vapor deposition.

JASON E. BUTLER, PROFESSOR

Ph.D., 1998, University of Texas at Austin **butler@che.ufl.edu**

MY RESEARCH GROUP GENERATES INSIGHTS AND SOLUTIONS to problems regarding the transport of complex fluids using experimental, computational, and theoretical methods. Complex fluids, which encompass suspensions of particulates, emulsions, polymer solutions, and more, serve important roles in a wide range of industries as well as emerging technologies. Efficient control and processing of these fluids requires predictive capabilities that, in most cases, are lacking, as they often demonstrate nonlinear dynamics that create unexpected and intriguing observations. Two major thrusts and examples within these spaces are described:

MACROMOLECULAR TRANSPORT IN MICROFLUIDICS

Microfluidic, or lab-on-chip, technologies have the potential to significantly improve medical diagnostic capabilities and accelerate advances in biological and biochemical research. Realizing this promise requires the ability to model and manipulate macromolecular motion within these small devices. As one effort, we have been examining transport dynamics of DNA, a polyelectrolyte, through electrodeless channels. The work has demonstrated new and unexpected methods that can be harnessed to control the cross-stream distribution of DNA using a combination of pressure gradients and electric fields. We are validating our model of this phenomenon through rigorous comparison of experimental results and simulations while simultaneously investigating technological applications such as the extraction of DNA from biological samples.

SUSPENSION RHEOLOGY AND DYNAMICS

Suspensions of particles in viscous fluids are found in everyday materials such as concrete, in industrial advanced technological applications, and even in natural processes. Consequently, advances in evaluation in the transport properties and predictive capabilities for the dynamics will have a widely distributed impact through improved ability to rationally design processes. Some recent work in our group is focused on assessing the precise origin of irreversibilities in non-colloidal suspensions of spheres; these irreversibilities can cause, as one example, suspensions to demix during rheological testing and create inaccurate estimates of viscosities. Much of our work examines suspensions of rod-like particles, where coupling of the orientational dynamics with the flow field and center-of-mass motion creates truly complex results.

WON TAE CHOI, ASSISTANT PROFESSOR

Ph.D., 2017, Georgia Institute of Technology **wontae.choi@ufl.edu**
Postdoctoral Scholar, 2017-2018, Georgia Institute of Technology
Postdoctoral Scholar, 2018-2021, University of Texas at Austin

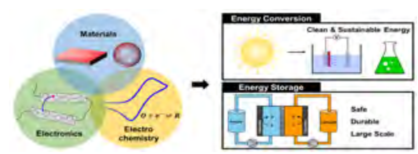
THE CHOI LAB RESEARCH IS AIMED AT RATIONAL DESIGN AND ENGINEERING OF NEXT-GENERATION ELECTROCHEMICAL SYSTEMS FOR ENERGY APPLICATIONS. We seek to address key questions related to electrochemical systems by leveraging electrochemistry, materials chemistry, and device engineering. Our interests include (1) synthesis of new materials for electrochemical devices, (2) combining electroanalytical chemistry, spectroscopy, and synchrotron characterizations to understand thermodynamics and kinetics of charge transfer processes, (3) perturbating chemistry and physics of materials to develop structure-property relationships, and (4) developing architectures for efficient energy conversion and storage devices.

IN-SITU ANALYSIS OF ELECTROCHEMICAL REACTIONS

Electrochemical processes provide sustainable pathways for producing fuels and chemicals from abundant feedstocks. A major thrust of our research is to establish fundamental design principles for electrocatalysts that drive industrially relevant reactions, including methane partial oxidation, carbon dioxide conversion, and water splitting. Our group develops advanced in-situ and operando methods, particularly scanning electrochemical microscopy (SECM), to probe the reactivity of catalytic intermediates during the reactions. By directly quantifying reaction dynamics, kinetics, and intermediate consumption, we seek to establish descriptors that link catalyst size, composition, structure, and electronic properties to activity and selectivity. This mechanistic understanding enables rational design of electrocatalysts and processes for electrochemical energy conversion.

IN-SITU ANALYSIS OF ELECTROCHEMICAL REACTIONS

We investigate photoactive semiconductors for solar-driven energy conversion, with emphasis on designing materials and elucidating charge carrier dynamics at photoelectrode–liquid interfaces. Our research combines electrochemical analysis and spectroscopy to reveal how interfacial energetics and photophysical processes govern light absorption, exciton separation, and charge transfer. A key focus is understanding these processes under intense light illumination to evaluate the operational limits of photoelectrochemical systems. Insights gained will guide the development of durable and efficient semiconductor materials for solar fuel production and integrated photoelectrochemical devices.



CARL A. DENARD, ASSISTANT PROFESSOR

Ph.D., 2014, University of Illinois at Urbana-Champaign **cdenard@ufl.edu**
Postdoctoral Scholar, 2015-2019, University of Texas at Austin

Our research is in molecular and cellular bioengineering. We apply our expertise in cellular and protein engineering to develop novel strategies to diagnose, target and fight disease.

UNDERSTANDING AND REPROGRAMMING THE SUBSTRATE SPECIFICITY OF POST-TRANSLATIONAL MODIFICATION ENZYMES FOR BIOMEDICINE, BIOTECHNOLOGY AND SYNTHETIC BIOLOGY

Enzymes that catalyze site-specific protein modifications play vital roles in regulating cellular processes. Understanding their substrate specificity not only provides insight into their physiological mechanisms but also enables their selective targeting to remediate disease states. Furthermore, leveraging and reprogramming the specificity of protein-modifying enzymes enables the development of novel therapeutics, diagnostic, and biotechnological tools.

Using methods of protein engineering and synthetic biology, my lab seeks to redefine and redesign the substrate specificity of protein-modifying enzymes to repurpose them as novel therapeutic and diagnostic modalities. In one area of focus, we are evolving the specificity of **proteases to target misfolded and aberrant proteins involved in neurodegenerative, autoimmune diseases and cancer**. We hypothesize that catalytic degradation of disease-related proteins can help fight diseases in ways that can be complementary to and mechanistically distinct from current therapeutic approaches. **In a second area of research, we are developing ML-guided technologies to reprogram proteases via novel functional protein-protein interactions**. In this area, we are uncovering fundamental mechanisms that govern protease distal regulation and designing enzyme and substrate-selective protease modulators based on macromolecules and natural products.

In a related area of research, we aim to **evolve enzymes for the site-specific labeling of proteins, cells and biomaterials to improve their therapeutic efficacy and disease targeting**. Specifically, we are investigating how these enzymes recognize their substrates, uncovering non-canonical substrates, and engineering new substrate specificities. One payoff to this research is the ability to generate highly functionalized therapeutic agents with multipronged and synergistic modes of action and to image protein and cellular targets in their physiological contexts.

A complementary research focus is to take advantage of site-specific protein modifications to build circuit-level logic functions that reprogram cellular behavior along rapid time scales. Highly programmable, responsive and predictable synthetic protein circuits will augment genetic engineering by introducing novel design principles that facilitate cellular engineering. In addition

RICHARD DICKINSON, PROFESSOR AND DEPARTMENT CHAIR

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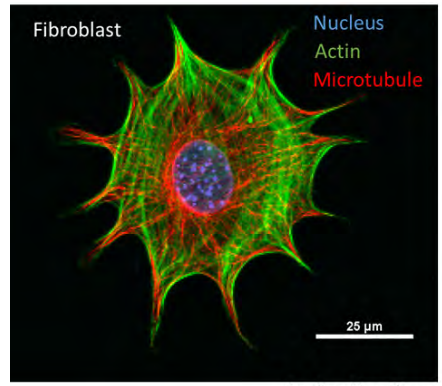
OUR RESEARCH IS IN THE AREA OF MOLECULAR/ CELLULAR bioengineering. We apply engineering principles to study the behavior of living cells or other small-scale biological systems. Using a combination of engineering modeling/analysis, quantitative experimentation, together with the tools of molecular cell biology, we seek to better understand the relationship between cell function and the physical and molecular properties of cells and their environment. Our projects are typically in collaboration with experts in microscopy and cell biology.

FORCE GENERATION BY INTRACELLULAR BIOPOLYMERS

Living cells have a cytoskeleton comprised of semi-flexible filaments (actin microfilaments, microtubules, and intermediate filaments), which determine the cell's mechanical properties and, through their interactions with molecular motors, are responsible for cell movements and intracellular force generation. In one area of focus, we study the reaction/diffusion processes involved with filament assembly that lead to cellular protrusions during cell crawling and propel intracellular pathogens such as Listeria monocytogenes. We are also investigating how the molecular motor protein complex dynein generating force on microtubules moves the nucleus and allows the cell to locate its center. Another area of interest is to understand the dynamics and mechanical properties of muscle-like actin filament bundles called stress fibers in non-muscle cells.

MECHANOBIOLOGY OF THE NUCLEUS

Cell behavior depends strongly on the chemical and mechanical properties of its environment. For example, stem cells cultured on compliant materials will differentiate to cells of the tissue type that has similar rigidity. Mechanical cues change gene expression in a process called



Credit: Qiao Zhang

HELENA HAGELIN-WEAVER, ASSOCIATE PROFESSOR

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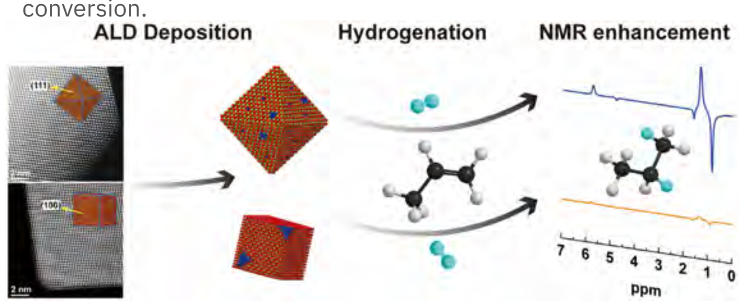
WE WORK ON HETEROGENEOUS CATALYST DEVELOPMENT in my laboratory and our ultimate goal is to obtain a fundamental understanding of these catalysts at the atomic level. Our approach is to synthesize well-defined heterogeneous catalysts using nanoparticle oxides with various shapes and sizes as supports and carefully control the deposition of active metal onto these supports using atomic layer deposition (ALD), or other more conventional catalyst synthesis methods, such as precipitation-deposition or incipient wetness impregnation. Since different shapes of nanoparticle oxides expose different surface facets, the use of these materials allows us to investigate how the active metal-support interactions vary with surface facets, and how this ultimately affects the catalytic activities and selectivities.

OUR RESEARCH INVOLVES CAREFUL CHARACTERIZATION OF the synthesized heterogeneous catalysts using a number of analytical techniques to determine important catalyst properties. We routinely perform surface area measurements, chemisorption of selected molecules to probe specific sites, temperature programmed reduction and oxidation (TPR and TPO) experiments to determine reduction-oxidation (redox) properties, X-ray diffraction (XRD) measurements to determine crystal structures and crystallite sizes, X-ray photoelectron spectroscopy (XPS) to determine electronic structure and surface chemical composition, high-resolution transmission electron microscopy (TEM) to determine particle sizes and shapes, and use the information to determine structure-activity relationships.

WE FOCUS MAINLY ON ENVIRONMENTALLY FRIENDLY, ENERGY-RELATED REACTIONS

Our projects include catalyst development for selective oxidation and hydrogenation reactions. Examples include low temperature activation of methane and conversion to higher value chemicals, selective hydrogenations for parahydrogen-induced polarization nuclear magnetic resonance applications, and algae to liquid fuels conversion.



PIYUSH JAIN, SHAH RISING STAR ASSOCIATE PROFESSOR

Ph.D., 2013, University of Missouri, Kansas City **jainp@ufl.edu**
Postdoctoral Scholar, 2014-2018, Massachusetts Institute of Technology

MY RESEARCH GROUP IS GENERATING INSIGHTS AND SOLUTIONS TO problems with genome engineering, specifically CRISPR/Cas systems. Over the past few years, the slow-progressing field of genome engineering has been transformed by the breakthrough of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) with astronomical applications in science, medicine, agriculture, biotechnology, and biomanufacturing. Originally derived from the bacterial immune system, the CRISPR/Cas technology works by introducing two components inside cells, a Cas nuclease that acts like molecular scissors and a guide RNA that binds with Cas and directs the complex to the target DNA to create double-stranded cuts in the DNA. Due to its ease of use, it is becoming a standard tool for genome engineering and the toolbox is exponentially increasing with hundreds of variants of CRISPR/Cas systems with applications in DNA and RNA manipulation. The biggest remaining challenges for CRISPR/Cas technology are safety, efficacy, and delivery. To address these pressing concerns, Jain lab is developing a multi-scale biomolecular engineering platform using nucleic acids chemistry, protein engineering, and nanoengineering.

Specific examples include:

RAPID CRISPR-BASED TESTS FOR DETECTING CORONAVIRUS

Jain lab recently discovered/engineered various CRISPR/Cas12 systems to turn them into fast cutters (Nat. Comms., 2020; Methods,2021; medRxiv, 2021). This helped us develop rapid and simple genomic tests for detecting SARS-CoV-2 virus (Comms. Med.-Nature-2022, eBioM-The Lancet, 2022) as well as other pathogens and diseases.

UNDERSTANDING AND IMPROVING SPECIFICITY OF CRISPR/ CAS SYSTEMS

CRISPR/Cas systems can tolerate several mutations in the DNA resulting into undesirable off-target cleavage. What if we chemically modify the guide RNA or the Cas? Using nucleic acids design and protein engineering, we employ an array of bioanalytical techniques with immediate applications for the detection and treatment of genetic disorders (Nat. Comms., 2020).

TARGETED DELIVERY OF CRISPR/CAS SYSTEMS

Despite the vast literature highlighting the delivery issues with CRISPR/Cas systems, it remains a major concern. The answer lies in developing safe and effective non-viral delivery methods. We aim to design multifunctional targeted nanoparticle systems that can protect CRISPR/Cas from degradation and target

YEONGSEON JANG, ASSISTANT PROFESSOR

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Postdoctoral Scholar, 2014-2015, University of Pennsylvania
Postdoctoral Scholar, 2015-2018, Georgia Institute of Technology

THE JANG LAB STUDIES HOW THE PRINCIPLES OF BIOLOGY CAN BE USED TO DESIGN NEW MATERIALS WITH LIFE-LIKE PROPERTIES. By engineering proteins and polymers that self-assemble into organized structures, we create systems that sense, adapt, and perform functions typically carried out by living cells. Our work connects fundamental science, understanding how biomacromolecules fold, interact, and organize, with practical innovation in medicine, sustainability, and energy.

SYNTHETIC PROTEIN VESICLES

We developed Globular Protein Vesicles (GPVs), a new class of compartments made entirely from engineered, folded proteins. Unlike lipid- or polymer-based vesicles, GPVs can stably host dense, functional proteins on their membranes. This enables synthetic systems that mimic key cell activities such as molecular sensing, protein synthesis, and enzymatic metabolism. Looking forward, we are building immunomodulatory GPVs as artificial antigen-presenting cells for cancer immunotherapy, in collaboration with the UF Health Cancer Center.

BIOMACROMOLECULE ASSEMBLY IN CROWDED ENVIRONMENTS

Living cells are densely packed with proteins and polymers, and this crowding strongly influences how molecules assemble and function. We study how macromolecular crowding drives protein self-assembly, phase separation, and transitions between different structural states. Combining experiments with molecular simulations, we map the rules that connect molecular features with large-scale organization.

BIOINSPIRED POLYMER SURFACES

We design polymer surfaces that prevent bacterial infection while supporting healthy cell growth. Inspired by insect wings, we created nanoscale patterns that physically rupture bacterial membranes, offering antibiotic-free protection. At the same time, these surfaces can be tuned to guide mammalian cell attachment and healing, with potential impact on medical implants, dental devices, and cardiovascular materials.

This interdisciplinary research provides exciting opportunities for graduate and undergraduate students to engage in cutting-edge science at the interface of chemical engineering, biomaterials, and synthetic biology.

PENG JIANG, PROFESSOR

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WE ARE BROADLY INTERESTED IN DEVELOPING new chemical, physical, engineering, and biological applications related to self-assembled nanostructured materials. Our current research is focused on the following four topics:

SELF-ASSEMBLED PHOTONIC & PLASMONIC CRYSTALS

Photonic crystals and plasmonic crystals offer unprecedented opportunities for the realization of all-optical integrated circuits and high-speed optical computation. Our group is developing a number of scalable colloidal self-assembly technologies to control, manipulate, and amplify light on the sub-wavelength scale. We are also involved in the fabrication, characterization, and modeling of a large variety of functional nanooptical and plasmonic devices enabled by the bottom-up approaches.

BIOMIMETIC BROADBAND ANTIREFLECTION COATINGS

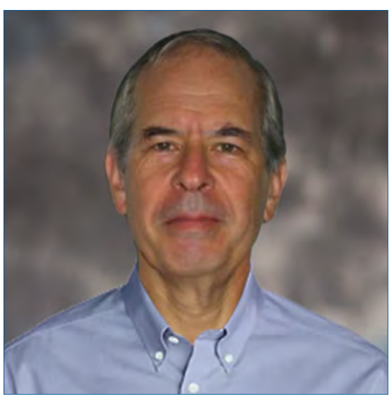
By mimicking the nanostructured antireflection layer on the cornea of a moth and the water-shedding coating on the wings of a cicada, we are developing self-cleaning broadband antireflection coatings for a wide spectrum of applications ranging from highly efficient solar cells and light emitting diodes to high-sensitivity spectroscopy for space exploration. Once again, we are interested in scalable nanomanufacturing technologies that can be inexpensively applied to large areas.

NOVEL STIMULI-RESPONSIVE SHAPE MEMORY POLYMERS

By integrating scientific principles drawn from two disparate fields—the fast-growing photonic crystal and shape memory polymer (SMP) technologies, we have developed a new type of shape memory polymer (SMP) that enables unusual "cold" programming and instantaneous shape recovery triggered by applying a large variety of unconventional stimuli (e.g., static pressure, vapors, and shear stress) at ambient conditions. These new stimuli-responsive SMPs differ greatly from currently available SMPs as they enable orders of magnitude faster response and room-temperature operations for the entire shape memory cycle. We are now exploring the broad applications of these smart materials in detecting Weapons of Mass Destruction (WMD) materials and aerospace morphing structures.

SMART WINDOW COATINGS FOR ENERGY-EFFICIENT BUILDINGS

Windows are typically regarded as a less energy efficient building component, and they contribute about 30 percent of overall building heating and cooling loads. We are developing a transformative dynamic window technology that enables dynamic and independent control of visible and near infrared light and eliminates expensive transparent conductors in the final devices. The innovative dynamic windows are inspired by the mature heat pipe and photonic crystal technologies, which



ANTHONY LADD, PROFESSOR

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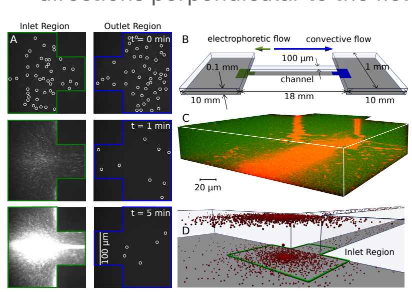
OUR RESEARCH FOCUSES ON DYNAMICS at scales that are small macroscopically (µm to mm), but are large compared to molecular sizes. The research combines statistical mechanics and fluid dynamics with advanced computing to elucidate the key physical processes that underlie laboratory observations and measurements. Current applications include:

REACTIVE TRANSPORT IN POROUS MEDIA

Flow and transport in porous media are usually modeled at the Darcy scale, where the system is described locally by average properties, such as porosity, permeability, dispersion coefficients, and reactive surface area. Although this allows large volumes to be simulated efficiently, there are serious difficulties in developing suitable models for the properties of the individual elements. Pore-scale modeling overcomes many of the limitations of Darcy-scale models, replacing unknown functions with well-defined parameters. Nevertheless, it is not yet clear that a single set of parameters – fluid viscosity, ion diffusion coefficients, and surface reaction rates – can consistently describe the dissolution of samples with different pore structures. The goal of our DOE sponsored project is to investigate the dissolution of idealized samples both numerically and experimentally to prove (or disprove) the correctness of the underlying equations.

MIGRATION OF DNA IN COMBINED FLOW AND ELECTRIC FIELDS

This project (in collaboration with Dr. Jason Butler) aims to investigate both the fundamental physics and potential biotechnological applications of the effect of a combination of hydrodynamic shear and electric field. From a fundamental point of view, the interest is to better understand the novel mechanism by which a charged polymer (like DNA) can be manipulated in directions perpendicular to the field lines. In a simple microfluidic device this can cause a rapid accumulation and trapping of the DNA, with implications for both biosensing and DNA extraction applications.



A. Epifluorescent images at the device inlet (green) and outlet (blue).
B. Schematic of the device showing the direction of flow (blue) and electrophoresis (green); the diagram is not entirely to scale.
C. A confocal scan showing the three-dimensional distribution of DNA within a 40 micron slab located on the lower wall of the inlet. DNA (orange) is concentrated on the wall of the device.
D. A perspective sketch of the inlet region, indicating the distribution of trapped DNA.

JOSHUA D. MOON, ASSISTANT PROFESSOR

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Postdoctoral Scholar, 2019-2022, University of California, Santa Barbara

OUR RESEARCH FOCUSES ON DESIGNING ADVANCED POLYMER MATERIALS for clean energy, clean water, and environmental sustainability. We combine modular polymer synthesis with experimental tools that probe both molecular-scale and macroscopic transport in polymers with the goal of informing predictive design of the next generation of materials for membrane-driven separations.

A few areas of interest to our group are:

Rational Design of Polymer Ionic Liquid Membranes through Uncovering Fundamental Gas Transport Mechanisms (NSF 2427603)

Facilitated Transport Membranes (FTMs) offer promise for energy-efficient carbon capture but often suffer from poor stability and a tradeoff between CO_2 permeability and selectivity. We aim to engineer new polymer membranes that minimize energy barriers for diffusion while increasing CO_2 affinity, thus driving up separation performance. In collaboration with the Vasenkov group (UF CHE), we aim to uncover transport and diffusion mechanisms of click-functionalized FTMs across a wide range of length and timescales enabled by advanced NMR spectroscopy.

Engineering molecularly precise, sub-nanometer gas transport pathways in robust macrocycle membranes (NSF 2343767)

An ideal gas separation membrane would contain ultra-thin nanopores that could perfectly separate different gases from each other while remaining extremely permeable. In collaboration with the Evans group (UF Chemistry), we are developing a new strategy for forming 2-dimensional polymer membranes with gas selective nanocavities built from aligned molecular rings called macrocycles. This project will uncover the underlying transport and mechanisms in these ordered ultrathin films.

Structure-dynamics-transport properties of Polymers of Intrinsic Microporosity (PIM) gas separation membranes (NSF CAREER)

PIMs are a promising solution for efficient gas and vapor separation membranes due to high permeabilities and selectivities imparted by their rigid backbones. However, many PIMs remain susceptible to plasticization and physical aging and a loss of separation efficiency when separating complex gas/vapor mixtures. We aim to develop an in-depth understanding of the interplay between free volume, polymer dynamics, and transport properties in novel click-functionalized PIMs to enable development of advanced plasticization- and aging-resistant membranes by direct molecular design.

RANGA NARAYANAN, CHARLES A. STOKES DISTINGUISHED PROFESSOR AND DISTINGUISHED TEACHER-SCHOLAR

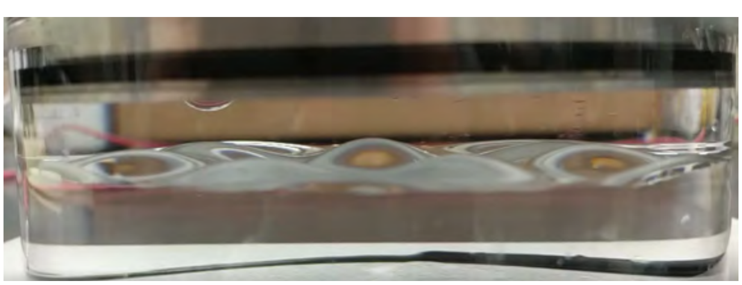
Ph.D., 1978, Illinois Institute of Technology **ranga@ufl.edu**

TRANSPORT OF HEAT, MASS, AND MOMENTUM ARE OFTEN accompanied by spatial and temporal pattern formation. Understanding the cause of pattern formation is pivotal as this research has application to the processing of materials on earth and under microgravity conditions. Such processes include additive manufacturing of metals, bulk crystal growth of semiconductors, thin film growth during evaporation, and electroplating.

IN THE AREA OF INSTABILITIES, IT IS THE GOAL of the present research to examine the physics of the spontaneous generation of spatial patterns in processes that involve flow resonance, solidification, electrodeposition, and free-surface convection. The pattern formation is associated with instabilities of a parent state as a control parameter is changed. Other processes of interest that involve instabilities are shearing flows with viscous dissipation of heat and oscillatory flows where flow reversal is the cause of non-rectilinear patterns.

THE MATHEMATICAL METHODS USED IN OUR RESEARCH are related to bifurcation theory, non-linear energy methods, and perturbation techniques.

THE EXPERIMENTAL METHODS involve electrostatic levitation and forcing, electrochemical deposition and flow sensing by infrared imaging and shadowgraphy.



Interfacial wave formation between layers of water (bottom) and silicone oil (top) when the fluids are subjected to an oscillatory electric field.

MARK ORAZEM, WILLIAM P AND TRACY CIRIOLI DISTINGUISHED PROFESSOR AND ASSOCIATE CHAIR FOR GRADUATE STUDIES

Ph.D., 1983, University of California, Berkeley **meo@che.ufl.edu**

ELECTROCHEMICAL ENGINEERING

The research performed in this group represents applications of electrochemical engineering to systems of practical importance. In recent work, electrokinetic phenomena were exploited to enhance continuous separation of water from dilute suspensions of clay associated with phosphate mining operations. The technology developed in this project is intended to greatly reduce the environmental impact of mining operations. Our group recently patented a sensor, based on indirect impedance measurements, that can detect corrosion of post-tensioned tendons in segmentally constructed bridges. We developed transient and impedance models for enzyme-based glucose sensors for diabetes management. In current work, we are developing models to predict corrosion of copper-clad cannisters Intended for storage of nuclear waste in underground repositories.

ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY

Electrochemical impedance spectroscopy is an experimental technique in which sinusoidal modulation of an input signal is used to obtain the transfer function for an electrochemical system. In its usual application, the modulated input is potential, the measured response is current, and the transfer function is represented as an impedance. The impedance is obtained at different modulation frequencies, thus invoking the term spectroscopy.

Through use of system-specific models, the impedance response can be interpreted in terms of kinetic and transport parameters. Work is underway to improve the understanding of how impedance can be interpreted to gain insight into the physics and chemistry of such diverse systems as batteries, fuel cells, corroding metals, and human skin. Current projects include a modelling and experimental study of electrodes used for stimulation of neurons and fundamental studies designed to enhance interpretation of impedance spectra. For example, in collaboration with French and Italian colleagues, our group developed a novel method to extract physically meaningful information from impedance data affected by frequency dispersion, a problem that had been unresolved since it was identified in the 1940s. Our power-law model, first published in 2010, has proven useful for oxides on metals, for human skin, and for water uptake in coatings. It is now implemented in industry to assess the quality of raw materials for electrochemical fabrication lines.

FAN REN, DISTINGUISHED PROFESSOR

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HEALTH SENSORS

We aim to develop a highly sensitive and low-cost heart attack sensor technology, which can be implemented in a wireless-capable, real-time and handheld sensor for personal and medical usages. Acute myocardial infraction (AMI) causes one of the highest mortality rates worldwide. The existing methods employed by first responders, hospitals and clinics are time consuming and require trained personnel to perform tests. The challenge is to develop a real-time, accurate, handheld and low cost heart attack sensor for both personal and medical applications. AlGaN/GaN high electron mobility transistor (HEMT) based wide-energy bandgap semiconductor sensors amplify tiny changes of the surface charges from 10_5 to 10_6 times larger (50-60 dB higher) than those results from simple conductive or resistive measurements for the conventional conductive or resistive based sensors.

WIDE ENERGY-BANDGAP DEVICES

b-phase of Gallium Oxide is a very promising monoclinic semiconductor with relevant applications for power electronics and also for solar blind photodetectors. β-Ga_2O_3 based devices are predicted to have a Baliga figure-of-merit at least 4 times higher than either SiC or GaN, as reflected in the higher breakdown field and lower on-state resistance. Several types of transistors, including MOSFETs and MESFETs, as well as power Schottky diodes and solar blind UV detectors have also been reported. Our group holds the records of highest forward current as well as highest reverse breakdown voltage. We are studying the effects of total dose proton, electron, gamma ray and neutron fluxes on Ga_2O_3, which has exceptionally high breakdown fields and great promise for high power, high temperature electronics.

CERAMIC COATINGS

Ceramic prostheses are important components of restorative dentistry because of their unrivalled aesthetics and biocompatibility. However, ceramic veneers are susceptible to chipping failures intraorally, compromising the integrity of the prostheses. The resulting roughened surfaces can lead to increased plaque accumulation and the replacement of these prostheses. The long-term goal of this research is to develop fracture-resistant and chemically stable (durable) dental ceramics for prostheses by applying protective coatings. The overall objective is to critically evaluate the corrosion resistance and the strength of these dental ceramic coatings as a function of a simulated environment with constant changes in pH and intermittent abrasion.

JUAN MANUEL RESTREPO-FLÓREZ, ASSISTANT PROFESSOR

Ph.D., 2019, Georgia Institute of Technology **restrepoflorezj@ufl.edu**
Postdoctoral Scholar, 2019-2022, University of Wisconsin-Madison

In my group, we leverage our expertise in optimization and multhyphysics simulations to formulate mathematical models enabling the identification of new, sustainable, and innovative processes, and materials. We are motivated by the grand-challenges in sustainability: (1) the need to develop carbon-neutral processes to produce energy and chemicals, (2) the need to minimize waste generation, and (3) the urgency to find mitigation strategies to alleviate the damage already done. We focus our efforts into two research thrusts: (1) the design of tools and the formulation of models to support the synthesis, analysis, and optimization of sustainable energy systems and processes that use waste materials as feedstock, and (2) the development of methods for analyzing and enabling new separation technologies.

AT THE ENERGY SYSTEMS LEVEL, we are interested in the synthesis of biorefineries, their integration with electro/photo-catalytic processes that produce fuels and chemicals from CO2, and the incorporation of renewable energy sources into these processes.

AT THE WASTE MANAGEMENT LEVEL, we are concerned with designing and analyzing facilities to process/upgrade plastic waste. Our efforts are devoted to addressing four questions instrumental for the deployment of these technologies: What pathways should we use to upgrade biomass or plastics into fuels and chemicals? How can we identify them considering economic and environmental criteria? How can we tailor them to obtain products with similar or better properties than those currently available? And how can we design their supply chains? To address these questions, we leverage the use of optimization tools (e.g., mixed-integer non-linear programming (MINLP), superstructure-based optimization, stochastic programming), life cycle analysis (LCA), and techno-economic analysis (TEA).

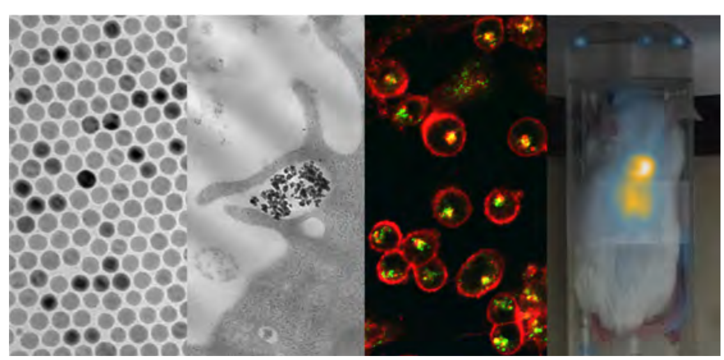
AT THE SEPARATIONS LEVEL, we focus on developing tools for the synthesis and analysis of membranes and adsorption processes and on the design of new materials for the precise control of mass diffusion. Designing energy-efficient separations is fundamental to mitigate the environmental impact of industrial processes. Both membranes and adsorption appear as energy-efficient alternatives. The understanding of these technologies from the material to the process scale enables their widespread implementation. In this field, my research addresses the following questions: How can we use multiphysics simulations to inform the design of adsorption and membrane processes? How can we automate the synthesis of membrane separation cascades? How can we exploit recent advances in diffusion theory to design new materials and devices? To tackle these questions, we will rely on tools such as multiphysics simulations, data-driven surrogate models, and superstructure-based optimization.

CARLOS M. RINALDI-RAMOS, DEAN'S LEADERSHIP PROFESSOR

Ph.D., 2002, Massachusetts Institute of Technology **carlos.rinaldi@ufl.edu**

MY GROUP STUDIES THE BEHAVIOR AND BIOMEDICAL APPLICATIONS OF MAGNETIC NANOPARTICLES. We combine expertise in synthesis and surface modification of magnetic nanoparticles, physical, chemical, and magnetic characterization, and modelling to understand the colloidal behavior of magnetic nanoparticles, their interaction with biological entities, and to advance their biomedical applications. We are actively investigating novel methods of synthesizing nanoparticles with tailored magnetic properties, evaluating nanoparticle stability and mobility in biological environments, and advancing applications of magnetic nanoparticles in cancer therapy and magnetic particle imaging.

Magnetic particle imaging (MPI) is a new biomedical imaging modality that enables unambiguous, tomographic, and quantitative evaluation of the distribution of magnetic nanoparticles in living subjects. We engineer biocompatible nanoparticle tracers for MPI that offer unprecedented resolution and sensitivity and can be used to track immune cells or image the distribution of biomarkers in pre-clinical models of cancer. We also engineer the surface of tracers to label cells of the innate and adaptive immune system for sensitive and quantitative tracking of their biodistribution. We collaborate with clinicians and other scientists to evaluate the application of MPI for tracking adoptive cell transfer immunotherapies. Students in my group become experts in nanoparticle synthesis, characterization, and evaluation for biomedical applications through highly collaborative, interdisciplinary research projects.



JANANI SAMPATH, ASSISTANT PROFESSOR

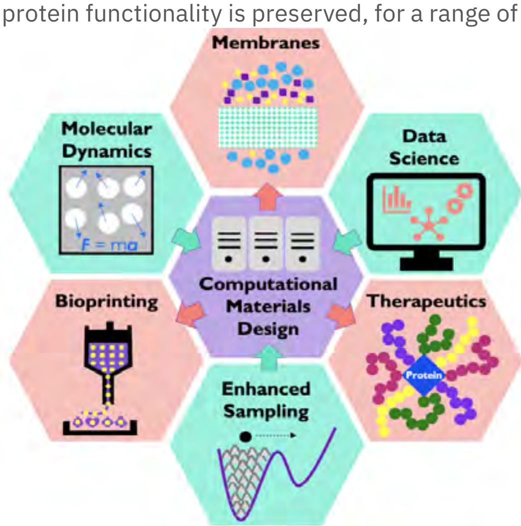
Ph.D., 2018, The Ohio State University **jsampath@ufl.edu**

WE STUDY POLYMERS, PROTEINS, AND THEIR HYBRIDS TO DESIGN THE NEXT GENERATION OF SOFT MATERIALS using molecular dynamics simulations, high throughout computations, and enhanced sampling methods. To sustain materials discovery in the future given the limited resources at our disposal, predictive engineering techniques must be employed to allow for efficient design and optimization of materials. Specific applications that interest us are:

1) Engineering polymer membranes for gas separation and water purification: Polymer membranes are widely used for separations due to their energy efficiency and relative ease of production. Using precisely controlled models of polymer membranes, we will describe the effect of membrane chemistries, polymer crosslinking, free volume density, and feed conditions on the membrane's separation ability.

2) Developing Bio-ink for 3D Printing: Materials used for 3D bioprinting are known as 'bio-ink', and primarily consist of a mixture of polymers and proteins. A clear understanding of the ordering of polymer-protein conjugates in solution will lead to greater structural control of the final 3D printed object, and we will provide general design guidelines for material selection of bio-inks.

3) Designing Polymer-Protein Conjugates for Therapeutics: Polymer-protein conjugates display a host of advantageous properties, as they combine the functionality and structure of proteins, along with the stability and processability of polymers. Using simulations, we will characterize polymer chain conformation when it is conjugated to therapeutically relevant proteins like insulin, to understand polymer length scales over which protein functionality is preserved, for a range of polymer



WHITNEY L. STOPPEL, DR. AND MRS. FREDERICK C. EDIE TERM ASSOCIATE PROFESSOR

Ph.D., 2014, University of Massachusetts Amherst **whitney.stoppel@ufl.edu**
Postdoctoral Scholar, 2014-2018, Tufts University

The Stoppel Lab is focused on the design and optimization of natural biomaterials for a variety of applications in healthcare and medicine. We explore and then leverage biopolymers produced by other species, such as insects, and work to understand and engineer complex structures and materials, using nature as our inspiration. We aim to link mechanical and structural properties to transport and kinetics within these materials, understanding and predicting bioactive molecule delivery. We utilize these materials to harness the power of the immune system in tissue regeneration to alter the way that these materials integrate following implantation or to develop 3D material platforms to investigate disease progression. Work in the Stoppel Lab is in collaboration with engineers, clinicians, and scientists. We value educating and training a diverse workforce and welcome anyone interested in applications of chemical engineering to advancing technologies for human health.

TAKING INSPIRATION FROM NATURE TO ENGINEER NEW MATERIALS

Insects in the Lepidopteran order produce silk fibroin proteins to form their cocoons, aid in food storage, and for transportation. Traditionally, silk-based healthcare materials come from cocoons of the domesticated silkworm (*Bombyx mori*), and we aim to expand use to other species, like *Plodia interpunctella.* We use rheological and microscopy techniques to quantify mechanical and structure properties in new materials. We use genetic engineering techniques, such as CRISPR, to alter protein sequences. We explore environmental changes, such as those anticipated with climate change, on wild type silk protein sequence and structures. We take inspiration from these insects to engineer biomaterials to meet current and future challenges in healthcare and medicine.

MATERIAL DESIGN AND *IN VITRO* CHARACTERIZATION

Natural biopolymers such as silk fibroin, alginate, or decellularized extracellular matrix can be combined to form biomaterials. The biomaterial's composition has significant impact on cell function and biological processes. We determine specific material properties and compositions that consistently alter or direct cell function through time-dependent analysis of cell-material interactions.

QUANTIFYING BIOMATERIAL PERFORMANCE *IN VIVO*

Understanding complex interactions between the immune system, local stromal cell populations, and implanted biomaterials necessitates spatiotemporal analysis of biomaterial degradation and histogenesis. We quantify how biomaterial composition and structure alter the rate of degradation and the composition and strength of new tissue that replaces the material. On-going efforts aim to understand how genetic engineering can be leveraged to develop materials with improved interactions *in vivo*.

SERGEY VASENKOV, PROFESSOR

Ph.D., 1994, Russian Academy of Science **svasenkov@che.ufl.edu**

MY RESEARCH PROGRAM FOCUSES ON DEVELOPING FUNDAMENTAL UNDERSTANDING OF TRANSPORT of molecules and ions in membranes, sorbents, catalysts and related materials on a broad range of microscopic length scales between around 100 nm and tens of microns. Such materials usually exhibit complex and, in some cases, even hierarchical structure that results in different transport properties on different microscopic length scales. Understanding the complexity of microscale transport in these materials on a fundamental level is required for optimizing their performance in separations and catalysis. For such studies, we develop and apply nuclear magnetic resonance (NMR) techniques that benefit from combining advantages of high magnetic field and high magnetic field gradients.

MICROSCOPIC GAS TRANSPORT IN GAS-SEPARATION MEMBRANES AND CATALYSTS

An application of a unique diffusion NMR technique, pulsed field gradient (PFG) NMR at high magnetic field and large magnetic field gradients resulted in the first direct measurements of microscale transport of gas molecules in mixed matrix membranes (MMMs) and carbon molecular sieve (CMS) membranes as well as in aerogel and nanoporous gold catalysts. In particular, for MMMs, which are formed by dispersing fillers, such as metal-organic frameworks (MOFs) in polymeric matrices, it was possible to resolve diffusion inside MOF particles from diffusion in the polymer phase between the particles. My group has proposed and validated experimentally an analytical expression for the long-range diffusivity in MMMs.

TRANSPORT-STRUCTURE RELATIONSHIP IN MEMBRANES WITH IONIC PROPERTIES

Polymer membranes with ionic properties such as the commercially available Nafion® are among the most promising materials in a wide variety of applications including fuel cells, water desalination, chemical sensing, and selective capture of chemical warfare agents (CWA). Molecular and ion diffusion plays an important role in these applications. My group applies advanced NMR techniques to quantify intramembrane transport of liquid sorbates on all relevant microscopic length scales leading to fundamental understanding of transport-structure relationship in this class of materials.

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The Weaver Group focuses on advancing the molecular-level understanding of surface chemical reactions that are important in applications of heterogeneous catalysis. We investigate chemical reactions on solid surfaces using many analysis methods based on ultrahigh vacuum (UHV) surface chemistry and physics, including methods that provide information about surface reaction kinetics, adsorbed intermediates, atomic scale surface structure and the chemical states of adsorbed molecules and atoms of the solid. We make rigorous comparisons between our experimental data and predictions of molecular simulations, and find that this approach is a powerful way to identify elementary steps in surface reaction networks. We investigate the catalytic behavior of well-defined surfaces using kinetic measurements combined with operando surface spectroscopy to enable comparisons between the results of our model UHV studies and the behavior of working catalysts.

GROWTH AND SURFACE CHEMISTRY OF OXIDE THIN FILMS

We investigate the growth and chemical properties of oxide thin films that develop on the surfaces of late transition metals during oxidation catalysis. This work is motivated by findings that metal oxide layers form on metallic catalysts in oxygen-rich environments, and that such oxide layers can play a decisive role in determining catalytic performance. We produce oxide thin films for characterization in UHV by oxidizing metallic surfaces using atomic oxygen beams or through controlled exposure to O_2 in an isolated reaction cell. This approach allows us to investigate oxide films under well-controlled conditions, and gain insights about the growth and surface chemical properties of oxides that are central to several catalytic applications, such as the catalytic combustion of natural gas, exhaust gas remediation in automobiles and selective oxidation processes. Key topics of focus include the oxidation mechanisms of late transition-metal surfaces and the chemistry of small molecules on metal oxide surfaces, particularly the oxidation of light alkanes. Our work continues to advance the molecular-level understanding of catalytic reaction mechanisms on late transition-metal oxides.

CATALYSIS ON MULTIFUNCTIONAL SURFACES

We study chemistry on dilute alloys, mixed-metal oxides and metal-oxide nanostructures. These types of materials feature different types of surface sites and domains separated by interfacial regions at which the constituents make atomic contact. Such multifunctional surfaces can exhibit unique catalytic properties as a result of cooperativity among the coexisting surface domains as well as distinct chemical properties of the interfacial regions and isolated sites. Our main goals are to determine how coexisting sites and domains influence catalytic reaction processes and develop structure-reactivity relationships that may be used to design multifunctional surfaces that promote selective catalysis. We are particularly interested in understanding how to modify these surfaces to achieve high selectivity and activity for converting light alkanes to value-added products such as olefins and organic oxygenates.

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NEARLY ALL NANOMATERIAL APPLICATIONS REQUIRE an interface with other materials, including, for example, polymers in composites, electrodes in devices, pharmaceuticals in drug delivery, body fluids and cells in bioimaging and biosensors, or analytes in chemical sensors. Our group focuses on developing a fundamental understanding of interfaces in nanoscale systems, which can have far-reaching implications to various fields of nanotechnology. The goal is to manipulate interfaces to dictate the nanostructures that are fabricated and to control reactions and transport at the surface of the nanostructures. Once these interfaces can be controlled and manipulated, it is possible to fabricate nanomaterials with novel functionality, improving their integration and performance in several applications.

MANIPULATING INTERFACES

The ultimate objective is to create new functionality by manipulating the interface. The manipulation of nanoscale interfaces can alter the wettability, interaction of nanomaterials with matrices, and their stability to environmental effects. We aim to control these interfaces to alter the dispersion and sensing properties of the nanoparticles. These factors also limit the organization and dimensions of nanostructures that are fabricated. For example, we have exploited the natural sensing capabilities of single walled carbon nanotubes (SWCNTs) to help us characterize the localized environment surrounding them. The ability to characterize the surface of SWCNTs has enabled the development of processes to alter the surfactant structure surrounding the nanotube, providing more stable suspensions, better fluorescence intensities, selective adsorption onto surfaces, and reduced toxicity.

CONTROLLING REACTIONS AND TRANSPORT AT SURFACES

Nanotechnology offers significant promise to improving the performance of solar cells, batteries, and supercapacitors because of the large surface area and unique properties of nanomaterials. However, designing these devices requires exceptional control of the chemical and electronic processes that occur at interfaces. Since many of the atoms in nanostructures exist on the surface, their reaction and transport properties depend strongly on the interface. Our group develops processes that control reactions and transport at the surface to synthesize porous materials suitable for gas phase separations. These nanomaterial interfaces can also be used to help control

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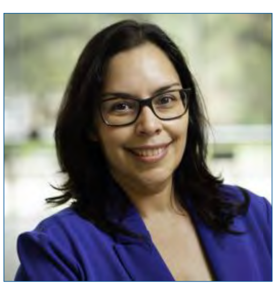

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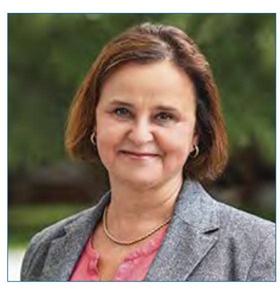

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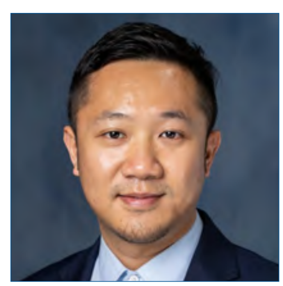

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