TECO Clean Energy Research Center

AT THE UNIVERSITY OF SOUTH FLORIDA

CLEAN ENERGY NEWS

AT THE UNIVERSITY OF SOUTH FLORIDA / FALL '24 – SPRING '25

Dr. D. Yogi Goswami President-Elect of ASEMFL

Distinguished Professor Dr. D. Yogi Goswami

By Stephanie Washington

In 2024, Dr. D. Yogi Goswami was named President-Elect of the Academy of Science Engineering and Medicine of Florida (ASEMFL). Dr. Goswami is a Distinguished University Professor and Director of the TECO Clean Energy Research Center at the University of South Florida. ASEMFL was founded at the University of Central Florida at the direction of Provost Dale Whittaker in 2017.

In his new role with ASEMFL Dr. Goswami will work with the Board and members to provide advice to the State of Florida on science, technology, and health issues.

"As a researcher and educator, I consider it both a duty and a privilege to gather and analyze information on issues of importance to the State, providing objective and informed insights to the people and leaders of Florida. I am truly honored by the trust placed in me by the members of the ASEMFL in electing me to this position." Dr. Goswami said.

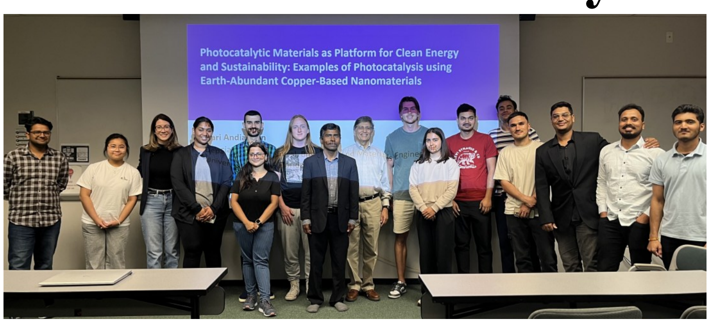
Paul R. Sanberg, PhD. Distinguished University Professor at USF, former board member at ASEMFL, and President of the National Academy of Inventors spoke highly of Dr. Goswami and his appointment. "[Dr. Goswami] is an incredible active Fellow, [Board] Member, and partner and his support and dedication to the Academy's mission has been a shining example to our members…We are excited to continue to work with Dr. Goswami in his new role as President[-elect] of ASEMFL."

This latest appointment adds to the many accomplishments Dr. Goswami has had over his career and his time at USF.

Inside this issue:

Goswami & Earth Day Celebration	**1**
Abhinav Sobti's Research	**2-4**
CERC News	**5**
New CERC Affiliate Staff	**6**
SES at USF	**7**
About CERC	**8**

Earth Day Celebration 2025



Dr. Marimuthu Andiappan, and SES at USF student attendees at the Earth Day celebration

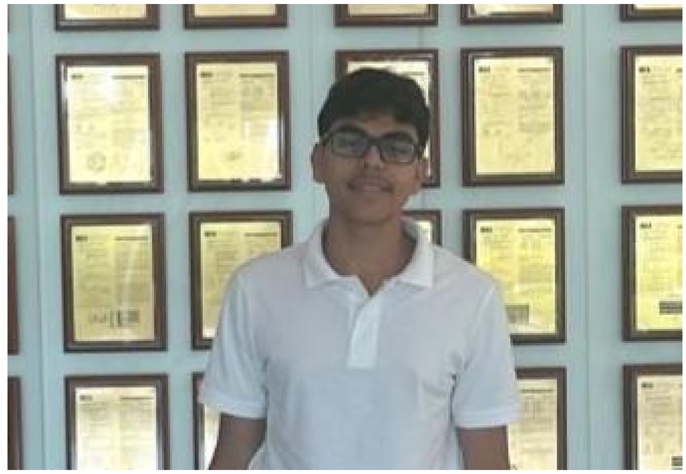
By Dr. Marimuthu Andiappan, edited by Stephanie Washington

On Earth Day 2025, USF Associate Professor, Dr. Marimuthu Andiappan delivered a keynote talk titled: *Photocatalytic Materials as Platform for Clean Energy and Sustainability: Examples of Photocatalysis using Earth-Abundant Copper-Based Nanomaterials*.

Dr. Andiappan presented his group's recent work on photocatalysis for clean energy and sustainability. Specifically, Dr. Andiappan's research group focuses on the development of earth-abundant metal oxide nanomaterials-based photocatalytic processes. Dr. Andiappan showed that photocatalytic processes will play a key role especially in three major areas: (1) conversion and storage of solar energy in the form of chemical fuels, (2) decarbonization of the chemical industry, and (3) carbon dioxide (CO_2) conversion and valorization into valuable chemicals and fuel-precursors. Dr. Andiappan presented example photocatalytic reactions using plasmonic copper (Cu) nanostructures and dielectric Mie resonant nanostructures built on earth-abundant materials, such as Cu_2O, and CuO. He showed the plasmonic and dielectric Mie resonance-enhanced photocatalysis using probe reactions, such as reverse water-gas shift reaction ($CO_2 + H_2 \rightarrow CO + H_2O$) and carbon-carbon (C-C) coupling reactions. These probe reactions are important examples for demonstrating the potential role of photocatalytic materials in addressing climate and clean energy objectives, in meeting the net-zero carbon emissions goal.

Development and Testing of a Paint for Passive Cooling of Buildings

USF CERC hosts bright High School students to conduct research on topics of global sustainability along with the graduate students and Post Doctoral Fellows. The summer research experience prepares the young researchers for a life in which they would contribute to the society at large with their innovations. Mr. Abhinav Sobti worked one such research project during Summer 2024 and wrote a paper based on the work. This paper by Abhinav Sobti is reproduced below.



Abhinav Sobti author *of Development and Testing of a Paint for Passive Cooling of Buildings*

Introduction

The rising global temperatures and increasing energy consumption for cooling purposes highlight the need for innovative and sustainable cooling solutions. Passive cooling techniques, which reduce energy consumption and dependence on mechanical cooling systems, have garnered significant attention. Among these techniques, the use of materials with high reflectance of solar radiation in the wavelength range of 0.3 to 3 microns and high emittance in the infra-red wavelength range of 8 to 13 microns has shown promising results (Goswami, 2022). Our atmosphere is transparent to the wavelength range of 8 to 13 microns, which is known as the Atmospheric Window. Therefore, a material that emits radiation in the Atmospheric Window exchanges heat with deep space, which is at the absolute zero temperature. A material or a combination of materials that possess such characteristics can actually cool itself without the aid of mechanical cooling. Researchers at Stanford University (Rafaeli et.al. 2013, Raman et. al. 2014) created multi-layered structures of materials that actually achieved cooling of 4.90C to 70C below the ambient temperature while facing the Sun during the daytime. Their research proved the concept; however, it would not be practical for application to buildings. The concept that would be practical for cooling of buildings would use one or more materials that could be applied as a paint on the buildings (Wijewardane and Goswami, 2012). My research as a member of the research group at the Clean Energy Research Center at the University of South Florida was focused on one such material, which is Barium Sulfate ($BaSO_4$). Barium sulfate, seems to have excellent radiative cooling properties. This report explores the production and application of barium sulfate paint for passive cooling of buildings.

Properties of Barium Sulfate

Barium sulfate possesses several key properties that make it an ideal candidate for passive cooling applications:

- High Solar Reflectance: Barium sulfate reflects a significant portion of solar radiation, thereby reducing heat absorption. The material has a reflectance ranging from 93.0% to 98.5% depending on the wavelength of light. This high reflectance is crucial in minimizing the amount of heat that penetrates building surfaces.

- Non-Toxic: Barium sulfate is safe for use in various environments due to its non-toxic nature, making it suitable for widespread application in residential and commercial buildings.

- High Emissivity: The high emissivity of barium sulfate allows it to radiate most of the absorbed heat in the atmospheric window, potentially to deep space, thus not contributing to local or global warming. The material has an emissivity of 98.1%, indicating its excellent capability to radiate heat.

Methodology

Producing Barium Sulfate: Varying Drops per Minute

The production process of barium sulfate involved several steps to ensure the purity and optimal particle size of the final product.

The chemical reaction used is:

$BaCl_2 \cdot 2H_2O + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl + 2H_2O$

Barium Sulphate was produced in the lab using the above reaction. To create the paint, a binder was used, which

Development and Testing of a Paint for Passive Cooling of Buildings, continued from page 2

produced a liquid paint. A spray gun was then used to coat aluminum plates with the paint.

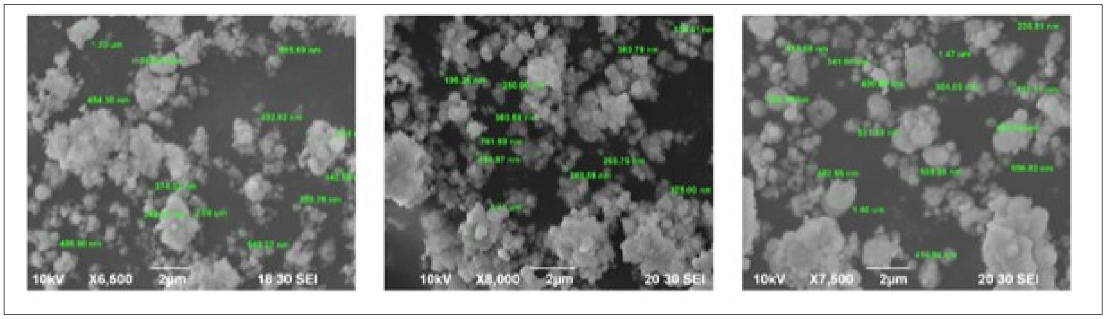


Figure 1: *SEM images of the barium sulfate molecules formed in the experiment.*

Observations

Under an electron microscope with a magnification of 18,000x, the particles of Barium Sulfate were observed to be clumped together, making accurate measurement of individual particle diameters challenging. Further, it was noted that the drop rate did not significantly affect the particle size, as the mean particle size was broadly similar across all samples.

Testing the Samples

To test the effectiveness of the barium sulfate paint, an outdoor setup was put in place. Several sample aluminum panels were prepared, with one sample coated with the Barium Sulphate paint, and other samples coated with different types of commercial white paints, known as “Cool Roof” paints. Each panel was placed on a stand 2 meters high to minimize ground influence on temperature measurements. Ambient temperature was measured using a Stevenson screen, which protected sensors from direct sunlight and wind while allowing adequate ventilation. This setup ensured accurate temperature assessments of the paint's cooling capabilities. A thermocouple was connected to each panel to measure its temperature over a period of 3 hours. These readings were compared with the ambient temperature to evaluate the cooling ability of each panel.

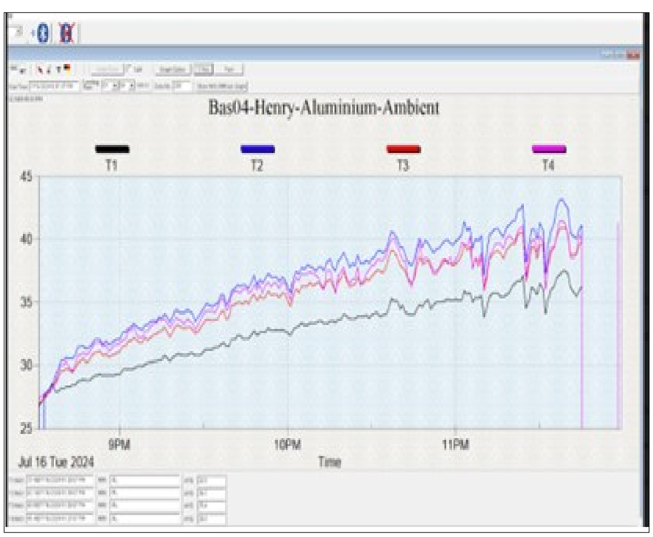


Figure 2: *Thermocouple readings of the barium sulfate sample (t1), compared to commercial paint (t2, 3, 4).*

Figure 3: *Thermocouple readings of the barium sulfate sample (t1), compared to commercial paint (t2), aluminum plate (t3), and ambient*

Development and Testing of a Paint for Passive Cooling of Buildings, continued from page 3

Results

The barium sulfate paint exhibited superior cooling performance compared to commercial "Cool Roof" paint samples. Surface temperature measurements showed that $BaSO_4$-coated surfaces maintained significantly lower temperatures than those coated with commercial paints. In direct sunlight, $BaSO_4$-coated surfaces consistently measured several degrees cooler. Compared to ambient temperature, the $BaSO_4$ sample was very similar, indicating that barium sulfate paint provides a substantial improvement over traditional paints in passive cooling applications, offering an efficient and environmentally friendly solution to reduce heat buildup on surfaces.

Conclusion

This research demonstrates the potential of barium sulfate ($BaSO_4$) paint as an effective passive cooling solution for buildings. Barium sulfate's high solar reflectance and thermal emittance properties enable it to maintain significantly lower surface temperatures compared to conventional paints. The experiments confirmed that optimal particle size and purity are crucial for maximizing these cooling properties. Despite some challenges in the production process, particularly regarding particle size and separation techniques, the final $BaSO_4$ paint formulation showed excellent performance in real-world conditions. By reducing the heat absorbed by building surfaces, $BaSO_4$ paint offers a sustainable and energy-efficient alternative to traditional cooling methods, contributing to the fight against rising global temperatures. This innovation holds promise for broader applications and further development in the field of sustainable building technologies.

References:

1. Goswami, D.Y., (2022), "Principles of Solar Engineering" 4th Edition, CRC Press/Taylor and Francis Publishers, Boca Raton, FL.

2. E. Rephaeli, A. Raman, S. Fan, Ultrabroadband photonic structures to achieve high performance daytime radiative cooling, Nano Lett. 13 (2013) 1457–1461. http://dx.doi.org/10.1021/nl4004283"http://dx.doi.org/10.1021/nl4004283.

3. A.P. Raman, M.A. Anoma, L. Zhu, E. Rephaeli, S. Fan, Passive radiative cooling below ambient air temperature under direct sunlight, Nature 515 (2014) 540–544. http://dx.doi.org/10.1038/nature13883"http://dx.doi.org/10.1038/nature13883.

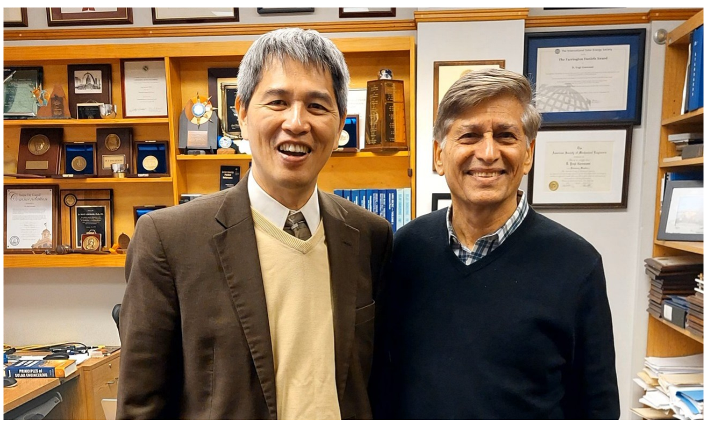
4. S. Wijewardane, D.Y. Goswami, A review on surface control of thermal radiation by paints and coatings for new energy applications, Renew. Sustain. Energy Rev. 16 (2012) 1863–1873. http://dx.doi.org/10.1016/j.rser.2012.01.046.

CERC News

Left: Brady Pitts, Krishnendu Maity, and Tim Mead; Right: Brad Pitts and Dr. D. Yogi Goswami, Both images at CERC Lab

MOF 2024 Carbon Capture Innovation

In July of 2024, CERC was recognized for their participation in the MOF 2024 Carbon Capture Innovation Prize awarded by Surface Managements systems. Although CERC's entry was not selected as the ultimate winner, they were recognized for their cutting-edge research and awarded a reward voucher worth $20,000. Surface Managements systems Sales Manager Brady Pitts visited CERC to hand deliver the awards voucher.



Dr. Chang-Yu Wu with Dr. D. Yogi Goswami at his office in Engineering Building II

Dr. Chang-Yu Wu at USF

Dr. Goswami met with Dr. Chang-Yu Wu, Professor and Department Chair, Chemical, Environmental and Materials Engineering at the University of Miami, after his seminar on Dec. 4th, 2024, *Just Add Water - Water-based Condensational Particle Growth for Super-Efficient Collection of NanoAerosol.* Dr. Goswami and Dr. Wu were colleagues at the University of Florida during his tenure there before coming to USF in 2005. Dr. Wu is a co-author for several of Dr. Goswami's published research papers.

USF Commencement (stock photo)

CERC Graduates

CERC is proud to announce the following graduates for Spring and Fall 2024: Sudhansh Pramod Harkut graduated with a Masters of Science in Chemical Engineering. His thesis is titled, "*Development of a Coating for Radiative Cooling of Buildings*"

Sree Amrutha Varshini Rangaraju graduated with a Masters of Science in Material Science Engineering in Spring 2024

CERC is proud to announce the following graduate for Spring 2025: Shreyash Bhadirke. Shreyash was selected for "Outstanding MS Thesis" from the Department of Chemical Biological and Materials Engineering for 2024-2025. His thesis is entitled "*Removal of CO_2 from Indoor Air and Its Recovery for Reuse by Absorption and Desorption Processes Optimized for Indoor Environment* "

CERC Affiliate Faculty

CERC is proud to introduce new affiliate faculty

Dr. Arman Sargolzaei

Assistant Professor, Mechanical Engineering.

Dr. Sargolzaei is an expert in control methods, machine learning, and AI for networked control systems, aiming to enhance quality of life through safety, security, and privacy. He holds doctorates in Mechanical and Electrical Engineering and is currently an assistant professor at the University of South Florida.

Dr. Ahmad Vasel-Be-Hagh

Associate Professor, Mechanical Engineering

Dr. Ahmad Vasel-Be-Hagh joined the University of South Florida in 2024 as an Associate Professor of Mechanical Engineering to establish the Thermofluids Discovery Laboratory. He holds a Ph.D. from the University of Windsor. Notable projects include studying solar farms' atmospheric effects, optimizing wind farms, developing de-icing technology for nuclear plants, and modeling condensation trails for hydrogen-powered airplanes.

Marimuthu Andiappan

Associate Professor, Chemical, Biological and Materials Engineering

Dr. Marimuthu Andiappan is an Associate Professor in the department of Chemical, Biological and Materials Engineering at the University of South Florida. His research focuses on plasmonic nanomaterials and high-dielectric metal oxide nanomaterials-based photocatalytic processes, solar energy conversion and storage, sustainable production of fuels, chemicals, and pharmaceuticals, and carbon dioxide (CO_2) conversion

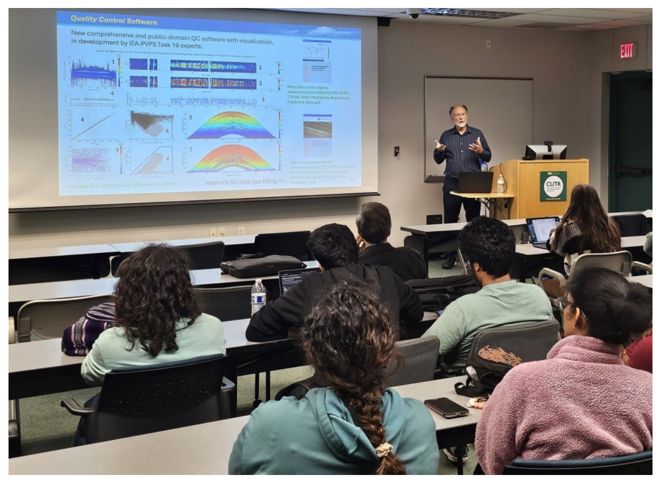
Solar Energy Society at USF

On Monday, December 2, 2024, the USF Solar Energy Society held a lecture featuring Dr. John Khun Professor of chemical, biological, and materials engineering, & associate chair of graduate studies. His lecture Synthetic Sustainable Aviation Fuel (SAF) R&D focused on the transformative process of converting carbon dioxide into sustainable aviation fuel. The use of SAFs can have significant benefits such as reducing greenhouse gas emissions, using waste materials like used cooking oil and improving air quality. Dr. Khun's lecture shined a spotlight on the importance of sustainable fuels in the future of aviation.

USF Solar Energy Society with Dr. John Khun guest lecturer

The Solar Energy Society at USF hosted Dr. Chris Gueymard on February 25, 2025. Dr. Gueymard is a prominent expert in the field of solar energy, solar radiation modeling, radiometry, and atmospheric physics. He delivered a presentation titled "*Solar Resource Assessments and the Challenge of Bifacial PV*," offering his perspectives on the potential of bifacial photovoltaics. His presentation identified key factors that affect how well solar energy works and the challenges in improving new solar technologies.

Dr. D. Yogi Goswami, advisor to the Solar Energy Society and distinguished University Professor here at USF, provided an introduction for Dr. Gueymard and spoke about the importance of continued research and innovation in renewable energy.



Dr. Chris Gueymard giving a presentation for Solar Energy Society of USF in CUTR, Feb. 25, 2025

Fernanda Silva Pimenta is a third-year Ph.D. candidate in Chemical Engineering at the University of South Florida and president of the Solar Energy Society at USF, a student chapter of the American Solar Energy Society. Ms. Pimenta was selected to receive the John and Barbara Yellott award for Graduate students from the American Solar Energy Society.

Her research is driven by a strong commitment to developing Net Zero Carbon solutions for the transportation sector, with a particular focus on aviation—a field currently reliant on fossil fuels. She has centered her doctoral research on the direct capture of atmospheric CO_2 and its conversion into sustainable aviation fuel using solar energy. Her work specifically explores the Fischer-Tropsch Synthesis (FTS) process, a thermochemical catalytic method that transforms CO_2 into syngas using solar heat. This syngas is then converted into liquid hydrocarbons such as green diesel and gasoline.

Fernanda Pimenta president of the Solar Energy Society at USF

CLEAN ENERGY IS GREEN ENERGY

Florida has no sustainable indigenous supply of fossil fuels but we do have solar and biomass resources. The Clean Energy Research Center (CERC) at the University of South Florida pursues research and development of new and environmentally clean energy systems. See our website for a complete listing of our research, patents, and publications: cerc.eng.usf.edu

KEY RESEARCH PROJECTS

- Environmentally clean energy systems
- Solar thermal power
- Photovoltaics
- Concentrating solar power
- Energy storage (phase change materials, thermal storage, batteries, supercapacitors)
- Photocatalytic detoxification/disinfection technologies
- Smart materials (Thermochromics and electrochromics)
- New efficient thermodynamics cycles
- Solar energy conversation via rectifying antennae
- Biomass conversion/biofuels
- Solar water desalination and distillation
- Design of solar plants on reclaimed land

CERC DIRECTOR

Dr. Yogi Goswami is a Distinguished University Professor and Director of the Clean Energy Research at USF, as well as Editor-in-Chief Emeritus of the *Solar Energy* journal and Editor-in-Chief of *Solar Compass.* A member of the Florida Inventors Hall of Fame, he has more than 40 years of experience in education, research, entrepreneurship, leadership and policy development.
Contact: goswasmi@usf.edu

CERC Founder

Dr. Elias K. Stefanakos, is a USF professor emeritus and former CERC Director. His focus was on research and development related to renewable energy sources and systems, such as concentrated solar power systems, Smart materials (thermochromics and electrochromics) and photovoltaic energy.

CERC Staff

Tim Mead, Lab Manager and Engineer, timead@usf.edu
Stephanie Washington, Publications Designer, CERC Newsletter writer, snwashington@usf.edu

TECO Clean Energy Research Center
AT THE UNIVERSITY OF SOUTH FLORIDA

UNIVERSITY of SOUTH FLORIDA

CERC AFFILIATE FACULTY

Ahmadreza Vasel-Be-Hagh, Ph.D., Associate Professor, Mechanical Engineering
Ajit Mujumdar, Ph.D., Professor of Instruction, Mechanical Engineering
Andrew Hoff, Ph.D., Professor, Electrical Engineering
Arash Takshi, Ph.D., Professor, Electrical Engineering
Arman Sargolzaei, Ph.D., Assistant Professor, Mechanical Engineering
Ashok Kumar, Ph.D., Professor, Mechanical Engineering
Babu Joseph, Ph.D., Professor Emeritus, Chemical, Biological and Materials Engineering
Chris Ferekides, Ph.D., Professor, Electrical Engineering
George Nolas, Ph.D., Distinguished University Professor, Physics
George P. Philippidis, Ph.D., Associate Dean for Research, Patel College of Global Sustainability; Associate Professor, Patel College of Global Sustainability and Department of Integrative Biology
Humberto Rodriguez Gutierrez, Ph.D., Associate Professor, Physics
Jamie Chilton, Ph.D., Associate Professor of Instruction, Industrial and Management Systems Engineering
Jeffrey Cunningham, Ph.D., Professor, Civil and Environmental Engineering
John Kuhn, Ph.D., Professor, Chemical and Biomedical Engineering
Krishnendu Maity, Ph.D., Post Doctoral Fellow, Chemical Biological and Materials Engineering
Lingling Fan, Ph.D., Professor, Electrical Engineering
Mia Naeini, Ph.D., Associate Professor, Electrical Engineering
Marimuthu Andiappan, Ph.D., Associate Professor, Chemical, Biological and Materials Engineering
Mark Stewart, Ph.D., Professor Emeritus, Geosciences
Prasanta Kumar Biswas, Ph.D., Courtesy Professor, Electrical Engineering
Robert E. Hooker, Ph.D., Associate Professor, Supply Chain Management
Samantha Wijewardane, Ph.D., Post Doctoral Fellow, Chemical Biological and Materials Engineering
Sarina Ergas, Ph.D., Professor, Civil and Environmental Engineering
Stanley Russell, Ph.D., Associate Professor, Architecture
Tapas Das, Ph.D., Department Chair, Industrial and Management Systems Engineering
Venkat Bhethanabotla, Ph.D., Professor, Chemical, Biological and Materials Engineering
Wilfrido Moreno, Ph.D., Professor, Electrical Engineering
Yasin Yilmaz, Ph.D., Associate Professor, Electrical Engineering
Zhixin Miao, Ph.D., Professor, Electrical Engineering
Zhuo Lu, Ph.D., Associate Professor, Electrical Engineering