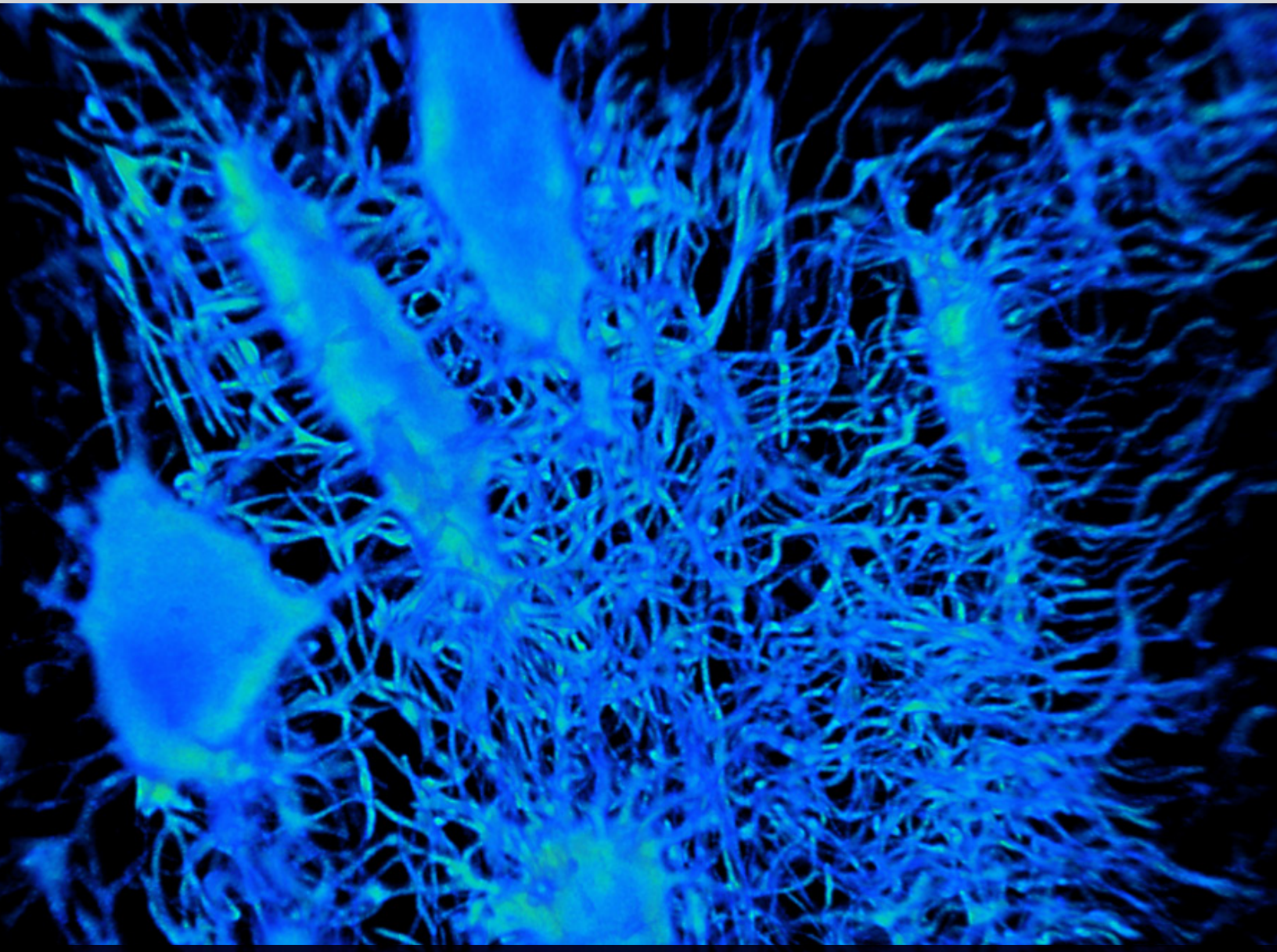
Department of
MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

newsletter



FOSTERING INNOVATION

2022

CHAIR'S MESSAGE

Dear Friends of Mechanical Engineering,

Greetings from the Mechanical Engineering Department. We are grateful to be able to send this from the MEK rather than our home offices. The last two semesters back in person have been excellent, despite some of the challenges of the pandemic still raging.

We just had graduation for the class of 2022 and it was wonderful to personally send off a talented group of students. I am not sure if there has been a better time to be a mechanical engineering graduate. Opportunities are plentiful and the need for quality engineers to face the challenges in the world is growing. Our students had many successes this year, some of which are highlighted in this newsletter.

The department has continued to grow. We added six new faculty this past year and they have made an amazing difference. We now have a high-quality Systems Engineering program up and going; we are expanding the program online and into the area of Engineering Management. We have expanded our faculty in the robotics, aerospace, and heat transfer areas, and are now teaching new classes related to these fields as well as data science.

Looking to the future, construction is almost complete on the addition to the Rio Tinto Kennecott building, home of the Department of Mechanical Engineering. Currently we are expecting to move into the building in July 2022. We are excited to move our senior design program into the new space starting this Fall. In addition, we will move most of our lab classes into MEK this year, meaning hundreds more students a day will be in the building. We hope to make this a community space for most of our ME activities. Plan to take a tour this fall (and we will include this in our Alumni Social in October)!

The legislature recently provided some money to expand our robotics and automation efforts. We expect to be adding degrees and graduates in this area soon. Let us know if you are interested in collaborating on these efforts. We are especially interested in working with companies in this field.

Our most recent freshman class was 20% larger than the previous year (which was 10% larger than before the pandemic), and this year's group is looking even bigger. We are excited to welcome so many enthusiastic students and look forward to helping them progress through our program and to changing the world. Come and join us in this effort!

Best regards,
BRUCE K. GALE, Ph.D.
Professor and Chair

NEURONS OF BONE

ABOUT THE COVER: 3D confocal microscopy image of osteocyte cells (10-20 um length) connected to each other with their dendritic processes. These cells, as called the "neurons of bone", compose 90% of bone cells and live almost a lifetime. Osteocytes, thought for a long time to be dormant, might actually play a key role in bone health. They can sense loading and damage around them and communicate with other cells and distant organs to maintain bone health.

Photo courtesy of professor Claire Acevedo. Learn more at https://acevedo.mech.utah.edu/

Tossed in Space


The "Fred" Orbot from Rogue Space Systems

Rogue Space Systems, a New Hampshire-based company that produces orbital robots (Orbots™) for satellite servicing, will apply new research from U mechanical engineering professor Jake J. Abbott and U School of Computing associate professor Tucker Hermans on manipulating certain metal objects using magnetic eddy currents. The U technology — dubbed "Omnimagnet" — will be developed for use with Orbots, robotic spacecraft designed to move satellites in and out of different orbits as well as to monitor and inspect satellites.

"When [Rogue Space Systems CEO Jeromy Grimmett] showed me Rogue's vision of their Orbots equipped with our Omnimagnets, it was like my sci-fi fantasies were coming to life," says Abbott. "It's amazing to think that Rogue will be able to put the research results from my lab into practical use in space so quickly. My team and I are looking forward to working with Rogue to continue to advance our capabilities, and we're grateful for the financial support of U.S. Space Force."

With Abbott's and Herman's technology, Rogue's robots will be able to gently detumble uncontrolled space scrap or crippled spacecraft without actually touching it, and allow them to safely capture and repair malfunctioning objects to extend their life.

The concept involves moving metallic, non-magnetized objects in space with spinning magnets. When the metal, which could be space debris or a satellite spinning out of control, is subjected to a changing magnetic field, electrons circulate within the metal in circular loops, "like when you swirl your cup of coffee and it goes around and around," says Abbott.

The process turns the metal into essentially an electromagnet that creates torque and force, which can allow you to control where the debris goes without physically grabbing it.

The use of this technology will have great impact on being able to control an object so that it can safely be touched, fixed, moved to another orbit, or deorbited, according to Rogue Systems. Satellites that are out of control pose a high risk of colliding with other objects in space and creating more space debris, so Rogue hopes this new technology can help the company operate in space in a safer manner and by mitigating the creation of more "space junk."

HIGHLIGHTED GRANTS

25 new projects, more than $4 million since last September!

Edoardo Battaglia – NSF, 2 yrs, $128,684, "NRI: FND: Customizable Haptic Co-Robots For Training Emergency Surgical Procedures"

Marc Calaf & Steven Naleway – Army Research Office, 1 yr, $78,500, "Thermal Infrared Imagery: Products for characterizing the near surface conditions"

Brittany Coats & Ken Monson – NSF, 3 yrs, $619,534, "Tissue Damage Progression in Repeated Mild Traumatic Brain Injury"

Todd Easton – California Energy Commission, 3 yrs, $79,999, "OLIT: Outdoor Lighting Integrated with Technology"

Mathieu Francoeur – Research Incentive Seed Grant, 1 yr, $38,000 "Engineering the Thermal Conductivity of Dielectric Nanostructures Via Coupled Surface Phonon-Polaritons"

Mathieu Francoeur & Bart Raeymaekers – NSF, 3 yrs, $498,661, "An Integrated Approach to Designing and Fabricating Engineered Dielectric Metamaterials for Energy Harvesting Applications"

Bruce Gale – Viome Life Sciences, Inc, 6 mos, $397,502, "Viome Phase I: Microfluidic Sample Processing"

Electronic Bioscience Ink, 1 yr, $40,000, "Rapid, Multiplexed, Idealized Antiepileptic Drug Monitoring"

Todd Harman – R-Zero Systems, 4 mos, $50,000, "CFD Simulations of Airborne Viral Transport in the Presence of UV-C Light"

Jacob Hochhalter – AirForce Research Lab, 7 mos, $53,741, "Human-Interpretable Machine Learning for Certification and Sustainment of Fatigue-Critical Additively Manufactured Components"

DOE Sandia, Inc, 1 yr, $45,000, "Surface Patterning Method to Enable Simultaneous Microscale Full-Field Strain Measurement and HR-EBSD Analysis Over a Single Domain

Jungkyu Kim – U Pivot, 1 yr, $65,000, "PIVOT Ascender Grant: A Dynamic Cell Culture Platform for Combinatorial and Biomechanical Stimulation"

NCATS-NIH, 1 yr, $30,000, "A Biometric Cornea Chip For Studying Fuchs' Dystrophy"

Owen Kingstedt – DOE Sandia, Inc, 8 mos, $45,499, "Understanding the Coupling Between Heat Generation and Mechanical Work in Large Deformation Plasticity - Round Robin Testing"

Pania Newell – DOE Oakridge ONRL, 6 mos, $32,911, "Thermo-Mechanical Characterization of High Entropy Alloys Using Nanoindentation"

Rob Parker – Schaeffler Technologies AG & Co.KG, 3 yrs, $493,192, "Dynamic Modeling and Software Simulation Module For Wave Gears"

Sameer Rao & Mathieu Francoeur – Semnai Family Foundation, 1 yr, $92,189, "Solar-Driven Multi-Cycle Atmospheric Water Harvesting"

Ashley Spear – NSF, 4 yrs, $622,222, "Physics-Informed Artificial Intelligence For Parallel Design of Metal Matrix Composites and Their Additive Manufacturing"

Collaborating in India

Over the course of several years, mechanical engineering professor and department chair Bruce Gale has been collaborating with professor L. Sujatha, from Rajalakshmi Engineering College in India, to help them establish a microfluidics lab using microfabrication and silicon processing. That collaboration led to a Fulbright Specialist Award for Gale to spend two weeks in India continuing to help develop their microfluidics research program with a series of lectures and discussions and hands-on feedback.

This collaboration started over email when Sujatha reached out to Gale. They had started building out their microfluidics lab, found some of his papers, and tried to implement them. Gale helped them work through some issues, as well as helping answer questions on manufacturing processes. Eventually, they put in for a Fulbright to bring Gale out to further the collaboration.

As with so many things, the initial plans were delayed due to the pandemic. Finally in March, Gale was able to travel to India along with his wife and three of his children. Over the course of his visit, Gale delivered 32 lectures. Each of the eight main working days started with a professional development lecture for the local faculty on topics like how to write a paper, mentoring, collaboration, getting students accepted to U.S. universities, and more. The second and third lectures were focused on microfluidics and based on the microfluidics course that Gale offers at the U. After lunch each day, Gale gave lectures based on his research in microfluidics. In addition to the time spent at the engineering college, Gale also spent a day at the sister institution, Rajalakshmi Institute of Technology.

"It was great getting to interact with the students and faculty," said Bruce Gale. "Outside of the lectures, I had the opportunity to work one-on-one with both faculty and students to help solve problems related to research projects on which they were working, helped them understand how their work fits into the wider world of microfluidics, or shared feedback on proposals for new medical devices. Everyone treated me so well, my wife worried it would go to my head."

Gale is also looking forward to future collaborations. The group in India is more focused on simulations, whereas Gale's lab does a lot more actual design and manufacturing. This opens opportunities to share resources to widen the impact of research, as well as doing work at the U that they don't have the tools for in India. It's also another great avenue to recruit good students from India for a graduate degree at the U.

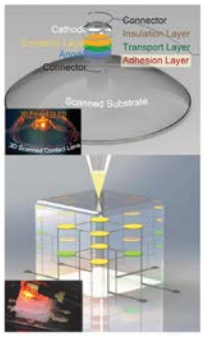
"Everyone was super friendly," said Gale. "We never had any issues and I really enjoyed the opportunity to see the sights in addition to working with students and faculty. I'm looking forward to continuing to grow this collaboration and finding future opportunities to visit as well as bringing students to the U."

You can learn more about Prof. Gale's work through the State of Utah Center of Excellence for Biomedical Microfluidics: https://mems.utah.edu/

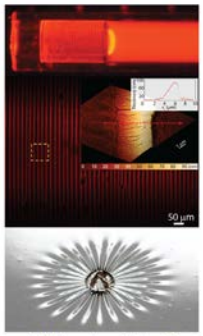
Additive Manufacturing of Nanomaterials-based Devices

3D printing, also known as additive manufacturing, has enabled exciting advancements in a broad range of areas. Assistant professor Yong Lin Kong is pushing the boundary of 3D printing to develop fundamentally transformative technologies that can overcome geometrical, mechanical, and material dichotomies between conventional manufacturing techniques and a broad range of three-dimensional systems. These advancements enable the creation of 3D functional devices and architecture with a wide range of applications including remote manufacturing of electronics and advancing soft robotics to address unmet clinical needs.

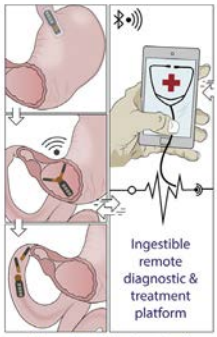
Kong's work allows seamless integration of active electronics and devices (including but not limited to optoelectronics, transistors, etc.) onto a wide range of three-dimensional constructs. Some examples of what this can help create include the integration of active electronics into existing biomedical devices such as implants and prostheses and the creation of multifunctional constructs seamlessly incorporated with active electronics via a multi-material 3D printing approach.



3D printed nanomaterials-based electronics



Multi-scale printing & soft matter physics



Biomedical electronics & ingestible robots

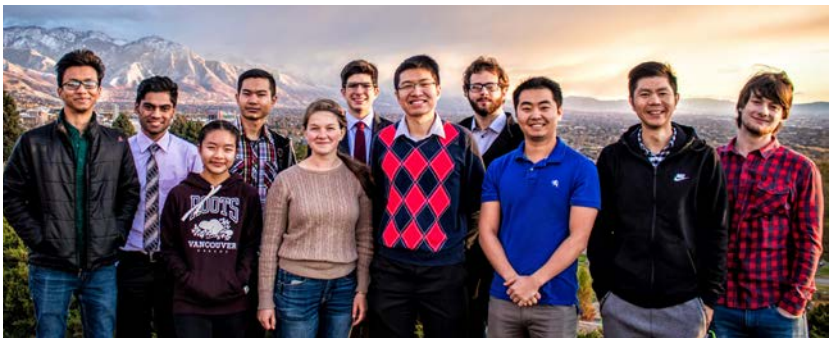
One area Kong's group is currently studying is 3D printing electronics into FDA-approved medical implants in collaboration with clinical collaborators. Kong recently received an NIH Trailblazer Award to establish this work with orthopedic surgeons and researchers, developing advanced sensing electronics that can be printed into existing total joint replacement implants.

"We envision that the ability to seamlessly integrate sensing electronics into implants will enable the acquisition of previously unavailable longitudinal data," said Kong. "This data will help us to better understand both biomechanics and implant failure, providing important data to improve future implants."

Another area Kong is working in is the integration of nanomaterials with an extrusion-based 3D printing process to create a wide range of transformable mesoscale (structures that can reach up to centimeters in overall size but retain micro- or nano-features) architecture. This can potentially help create biomedical devices that can address unmet clinical needs. One example of that work is Kong's invention "gastric resident electronics (GRE)." This is a 3D printed electronic that can be folded into the shape of a capsule. Once ingested and exposed to gastric fluid in the gastric space, the device can expand into a robust mechanical configuration that helps it stay longer in those spaces. This, for the first time, enables a surgery-free delivery of long residence electronics to a dynamic and hostile gastric environment, allowing treatments that leverage the stomach's immune-privileged property.

Kong's team is also studying the integration of ferromagnetic nanomaterials with a magnetic 3d printing process that will allow them to create magnetoactive mesoscale soft robots. The multi-materials extrusion printing approach would also enable seamless integration with other functional sensing electronics and actuators. This could allow for the ability to telemanipulate soft robots that can transverse in the human body, allowing for surgery-free or minimally invasive medical operations for biopsy, drug delivery, or even tumor removal.

"We are extremely excited for the opportunity to establish a fundamentally new multiscale 3D printing approach that can overcome the long-standing challenges in the integration of electronics with three-dimensional systems to functionalize an otherwise passive construct," Kong said. "Once established, the fundamentally new research direction can address a broad range of unmet clinical needs."



You can learn more about Kong's work through the Additive Manufacturing Laboratory website: https://kong.mech.utah.edu/

Alum of the Year 2021 – Chris Hirschi

The U's Department of Mechanical Engineering and its External Advisory Board are proud to recognize Chris Hirschi as this year's Alum of the Year. Hirschi is a Senior Mechanical Engineer at Sarcos Robotics working on electromechanical systems where he designs mobile robots, exoskeletons, and more. He also is dedicated to promoting STEM activities for kids and is a longtime mentor with the FIRST Robotics program.

Hirschi was always interested in mechanical things, making engineering a natural pursuit. "I started college without any electrical engineering background and felt way behind in my first electrical engineering class," said Hirschi, "but when I got to mechatronics, a light went on."

With that interest kindled, Hirschi went on to focus a fair amount of his education on electrical engineering and controls. He received both his Bachelor of Science and Master's degrees in mechanical engineering from the University of Utah. After graduation, Hirschi joined Sarcos Robotics, where he has helped design their MDMR Snake Robot for DARPA, a project for reliably traversing challenging terrain for surveillance, eventually serving as the primary driver for the robot and serving as the technical lead on the project for over 10 years.

Now, Hirschi is the most senior mechanical engineer at Sarcos, in terms of both tenure and years of experience. He currently co-leads mechanical efforts of an exoskeleton project while mentoring young engineers and newcomers to the company.

In addition to his impressive work in robotics, Hirschi is also an avid mentor and advocate for STEM activities for kids, particularly within the FIRST organization. He coached multiple FIRST Lego League teams for 11 years and has served in the FIRST Robotics Competition (FRC) in various capacities for 14 years. He was a judge for many Utah regionals and has mentored several Utah teams, mostly at the Academy of Math, Engineering, and Science, where his three sons participate. He continually recruits those around him as volunteers, including his family and Sarcos colleagues. For the past four years, Hirschi has focused his FIRST volunteering efforts on coaching the FRC team at Cottonwood High, which is populated mostly by immigrants and refugees.

Senior Design Project Highlight

A team of students (Abigail Anderson, Meisha Jensen, Alejandra Real, Alexia Savas, and Camryn Thompson) collaborated with Office of Naval Research and professor Eric Pardyjak on a portable calibration wind tunnel.

This device will be used to calibrate a liquid water content probe during a 2022 field experiment. The wind tunnel will needed to be light-weight, have variable wind speeds, variable temperatures, and a high humidity range. The device will be used in remote testing sites, therefore a small wind tunnel is needed to be able to travel safely along with other field-testing equipment.

The team used SOLIDWORKS Flow Simulation for computational fluid dynamics (CFD) simulations for an open-loop wind tunnel design to begin the project. They then completed a CAD model and prototype assembly with 3D-printed and aluminum parts. The correct voltages were found to create the desired wind speeds using a pressure transducer and pitot tube.

The team also collected wind speed data for 2-10 m/s, then added in humidity and temperature variables for a closed-loop design. They also incorporated a low-cost environmental measurement station (LEMS) as a simple data collection interface.

Senior Design Project Highlight

A team of students (Aaron Bruderer, Landon Malo, Alex Query, and Zilong Wang) collaborated with AutoLiv and associate professor Mathieu Francoeur to create an airbag inflator testing device.

Airbag inflators are responsible for inflating airbags when a car accident occurs. They are capable of inflating an airbag in as little as 55 milliseconds. They accomplish this feat by igniting an explosive referred to as "generant". The gases from the reaction are filtered before entering the airbag. Due to the extreme heat and pressure required to accurately simulate inflator ignition, current testing methods rely on building and testing a full inflator in order to test the performance of the filter. This testing process is expensive, time consuming, and does not allow for reuse of the filter

The device the team created successfully met the mass flow requirements of the project, however the heating system still needs additional work to fully meet the requirements. This is still an improvement upon previous testing methods and is able to measure the temperature drop across the airbag inflator filter. With improvements to the heating system the device should be able to perform according to Autoliv's specifications and be a better test-bed moving forward for these inflators

Katie Bezdjian Receives Fulbright Award

Mechanical engineering student Katie Bezdjian has received a Fulbright Award. As part of the award, she will spend a year abroad where she will be studying thermophotovoltaics alongside researchers at the Solar Energy Institute at the Technical University of Madrid in Spain.

The Fulbright program is an international educational exchange program designed to build relationships between people in the U.S. and around the world with the aim of solving global challenges. The program is funded through the U.S. Department of State and grant recipients are selected based on academic and professional achievement as well as a record of service and demonstrated leadership in their respective fields.

Bezdjian just completed her M.S. thesis, which focused on characterizing a high-temperature paint called Pyromark 2500, which is often used as a receiver coating in concentrated solar power systems. The paint can maximize the amount of solar energy absorbed by the receiver, which improves the efficiency of the entire solar power system. Her research involved both physical experiments and computer modeling to study the evolution of Pyromark's radiative properties due to high-temperature exposure.

"I view renewable energy engineering as the perfect integration of my academic and personal interests," said Bezdjian. "I've always gravitated toward thermal sciences, and I'm deeply passionate about nature conservation."

Bezdjian's Fulbright grant is focused on thermophotovoltaics (TPV), a type of solar energy technology. TPV devices include a heat source that emits thermal radiation toward photovoltaic cells, and then the photovoltaic cells generate electricity. TPV cells have the potential to reach high efficiencies—researchers at the National Renewable Energy Laboratory and Massachusetts Institute of Technology recently developed TPV cells with efficiencies higher than 40%. Bezdjian will study a novel TPV device fabricated from germanium alongside researchers in Spain. Specifically, she will focus on modeling the TPV device and measuring the thermal conductivity of the device's components. This is one piece of a larger three-year grant. Researchers in Spain have already begun work on aspects of the project and will continue to work after Bezdjian completes her time.

"I'm very excited about the collaboration aspect," said Bezdjian, "as well as expanding my knowledge of solar energy technologies."

Bezdjian is graduating this spring and will leave for Spain later this year.

"I want to thank all of the professors I've had the privilege of learning from during my time at the U," said Bezdjian. "I wouldn't have the knowledge or the capabilities to pursue this opportunity if it weren't for them. I'd especially like to thank my master's thesis advisor, Dr. Mathieu Francoeur, for introducing me to the PI I'll be working with while in Spain and Dr. Sameer Rao for his support in my application. I feel fortunate to have such a wealth of support in this department."

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ME Undergrad Kian Ben-Jacob Receives AIAA Professional Society Service and Leadership Scholarship

The American Institute of Aeronautics and Astronautics (AIAA) Utah Section has awarded their 2022 Professional Society Service and Leadership Scholarship to Kian Ben-Jacob, an undergrad in the Department of Mechanical Engineering at the U.

Kian was recognized for his meaningful and consistent contributions in the academic setting and within his community. In addition to his undergraduate work, Kian is the President of the AIAA Student Chapter and Aerospace Club at the University of Utah, a member of Tau Beta Pi Honor Society, a licensed amateur radio operator, and a certified private pilot. He is also leading an effort to compete in the Spaceport America Cup.

"My interest in Aeronautics stems from my curiosity to explore the unknown," said Kian "as well as the respect I have towards the engineering aspects involved. Aeronautics has really helped me appreciate just how capable humans are and has inspired me to contribute to our progression."

Kian has channeled that interest and passion into helping build up the Aerospace Club, partnering it more closely with the Mechanical Engineering department, and working to recruit more members. He has led the design of the rocket the club is now in the process of building, as well as helps other club members learn the basic and advanced parts of high-power rocketry.

"By the time I graduate, I hope the club will grow to have more projects other than rocketry, such as flying and building competitions for drones and RC planes, and much more," said Kian. "I think the key to this will be getting my peers as excited as they can about aerospace."

Kian plans to finish his undergraduate degree in mechanical engineering, and then pursue a graduate degree, with the aim of working in the field of aerospace.

"I am very optimistic about the potential of humanity and believe our generation will play an important role for our future. I hope my peers will share my ambitions to learn from the universe and help our wonderful world become more wonderful," said Kian.

Kian is also an Undergraduate Research Opportunity Program Scholar with the U's Office of Undergraduate Research.