GW | Engineering

DEPARTMENT OF BIOMEDICAL ENGINEERING

Capitalizing on the Heart of the Action

THE GEORGE WASHINGTON UNIVERSITY

WASHINGTON, DC

LETTER FROM THE DEPARTMENT CHAIR

The Department of Biomedical Engineering at The George Washington University offers unique and exciting opportunities for our students allowing them to take advantage of our location in the heart of the Nation's capital and near numerous federal agencies and research labs involved in biomedical and health-related research. The students also get a chance to get engaged in various cutting-edge research efforts that are happening within the Department and are funded by the National Institutes of Health, National Science Foundation, Department of Defense, American Heart Association, private foundations, and industry. These research efforts include novel methods to analyze medical images and present additional information to physicians, new technologies to understand electrical conduction abnormalities in the heart to better respond to heart attacks and arrhythmias, new approaches to provide selective delivery of drugs, such as chemotherapy agents, to areas of interest in the body without damaging healthy tissues, and development of next-generation soft, lightweight, and bio-compatible recording and stimulation devices, among many other exciting projects.

Our department offers small classroom sizes, core faculty committed to teaching, and collaborative and never competitive student atmosphere where students can freely learn from a diverse group of peers and faculty. Further, our department is located right next to the GW School of Medicine and Health Sciences and GW Hospital allowing for a great collaborative and cross-disciplinary teaching and research environment. Our overall welcoming and supportive environment is critical in achieving our goal of successfully training the next generation of biomedical engineers. Our students become well-rounded engineers aware of contemporary issues and challenges both as related to the biomedical field and society as a whole. They go on to make a difference in various important areas including basic research, device development, patent law, regulatory field, and medicine.

Our overall goal is not just solving engineering challenges but solving global health challenges with a constant commitment to making a positive societal impact!

Vesna Zderic, Ph.D.
Professor and Chair
Department of Biomedical Engineering
School of Engineering and Applied Science
The George Washington University

FACULTY PROFILE

PROF. HYUNGSOK "NATHAN" CHOE'S JOURNEY IN BIOMEDICAL ENGINEERING

Professor HyungSok "Nathan" Choe's academic journey began in Electrical Engineering. However, during graduate school, he joined a medical image processing lab that opened his eyes to the transformative potential of applying engineering principles to healthcare. He then transitioned to biomedical engineering because it resonates with humanity's innate desire for better health and extended lifespans; being part of the effort to achieve those goals greatly appealed to him. Ultimately, Prof. Choe says his choice was driven by the opportunity to merge his engineering skills with a profound sense of purpose.

Prof. Choe illustrates this drive by designing each research project to contribute significantly to the betterment of the public. His work focuses on three pillars: Engineering for the Public Good, Medical Image Innovation, and Sustainable Development Goals (SDGs) for Engineering. A notable aspect of Engineering for the Public Good involves Senior capstone projects sourced by non-profit organizations; for example, their recent collaboration with QL Plus focused on aiding members of the paraplegic Olympic bobsled team in accessing their rental van. They focused on designing a user-friendly device that is resilient, portable, safe, and adjustable to accommodate the entire team.

Aiding members of the paraplegic Olympic bobsled team in accessing their rental van.

The SDGs in Engineering initiative centers around objectives such as integrating sustainable engineering concepts into GW's existing biomedical engineering curriculum and establishing meaningful collaborations with local and international organizations. A crucial facet involves comprehensive research evaluating students' experiential learning journeys and the assimilation of their knowledge concerning sustainable engineering production concepts. Experiential learning is a value Prof. Choe holds dearly, and GW's emphasis on it is one of many reasons he was drawn to GW. Additional reasons include the university's reputation for nurturing an inclusive and innovative academic environment and access to impactful partnerships with key government agencies due to its strategic location.

GRADUATE HELPING AMPUTEES THRIVE

GW alumna Sarah Malinowski co-started her own company, Seamless Transition, LLC, to build a prosthetic so amputees, especially veterans and active duty military members, could resume their active lifestyles.

Many of us take for granted the countless daily activities we use our legs and arms for. Sarah Malinowski, M.S. '23, will never do so again after meeting a United States military veteran who had lost his leg during active duty while she worked at a prosthetic clinic during her undergraduate days. He shared the difficulties he suddenly faced with what we typically perceive as routine activities due to the limitations of current prosthetic limbs. As an engineer, Malinowski has been asking herself one question ever since: How can I solve this?

Malinowski has always wanted to create prosthetics, and after earning her bachelor's in mechanical engineering from St. Cloud State University, she decided to pursue her master's degree in biomedical engineering at GW Engineering. Here, she could continue developing her prosthetic knee prototype with advice from faculty such as her thesis advisor, Dr. Chung Hyuk Park. Dr. Park guided her in testing the small-scale prototype she named Rugged Redemption. She now holds a provisional patent for Rugged Redemption and has started her own company, Seamless Transition, LLC.

Ultimately, Seamless Transition, LLC, aims to empower amputees to regain and maintain their active lifestyles, including enabling service members to meet retention standards to regain Active Duty status for deployment. Malinowski wants the company's prosthetics to move with the user seamlessly and remove the need for another prosthetic for a different activity or manually adjust it into a different setting. Her next step with Rugged Redemption is to complete the full-scale design using recent studies to conclude its overall design and begin full-scale prototype testing. Once it moves to full-scale prototyping, Seamless Transition, LLC, will also begin the FDA approval process for Rugged Redemption. The knowledge Malinowski gained from Dr. Victor Krauthamer will be helpful in this process as he provided great insight into the FDA's testing and design requirements for these types of medical devices. In the meantime, Rugged Redemption will already be helping veterans in one of the places that need it most right now, hospitals in Ukraine, as they will be the ones to test the full-scale prototypes.

DESIGNING BIOCOMPATIBLE DEVICES TO ADVANCE PERSONALIZED MEDICINE

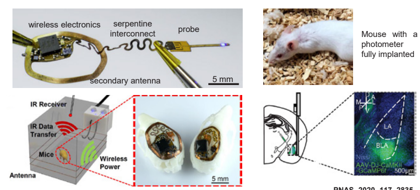
In Professor Luyao Lu's Advanced Bio-integrated Electronics Laboratory, he and his team conduct highly multidisciplinary research that integrates emerging materials, microfabrication devices, circuit designs, biology, animal studies, and more. Their goal is to provide advanced healthcare platforms that seamlessly integrate with biological systems to facilitate personalized medicine design and accurate disease diagnosis. To accomplish this, Prof. Lu's team focuses on the following research areas:

1. Studying, understanding, and exploiting interesting, unusual soft materials, such as nanomaterials and organic/inorganic semiconductors;
2. Developing new fabrication and engineering approaches for patterning those materials and controlling their electrical, mechanical, and optical properties;
3. Creating advanced electronic and optoelectronic systems with an emphasis on bio-inspired and bio-integrated technologies.

The lab's research, supported by NIH, NSF, and GW, has critical applications in many basic and translational research programs. For example, in a recent *Science Advances* paper, the lab reported the first transparent and dissolvable heart implant that can perform complicated monitoring and control of the heart without needing secondary surgery for removal. The device is an advanced soft electronics system that uses an array of sensors and actuators to perform more complicated investigations of the heart than traditional devices like a pacemaker has been able to do in the past. It's made of materials approved by the U.S. Food and Drug Administration that are compatible with the human body and can fully dissolve after a clinically relevant period. As the first of its kind, their device serves as the basis for bioresorbable cardiac technologies for postsurgical monitoring and treating many temporary patients in specific clinical scenarios.

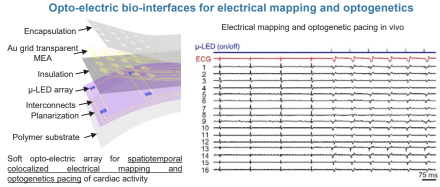
Fellow researchers may adopt the materials, fabrication, and device design strategies from their results to build advanced bio-integrated systems that improve fidelity, simplify the operation, expand the experimental options, and support mechanistic research in many biomedical engineering programs, such as elucidating disease mechanisms, personalized medicine, drug testing, and organs-on-chip. By participating in Prof. Lu's lab, students are educated on how to solve real-world problems in biotechnology development and improve human health. They receive systematic training in experimental design, fabrication, measurements, data analysis, writing papers, and preparing presentations throughout the research process.

Battery-free subdermally implantable wireless photometers for neuroscience



PNAS, 2020, 117, 2835.

Opto-electric bio-interfaces for electrical mapping and optogenetics



Soft opto-electric array for spatiotemporal colocalized electrical mapping and optogenetics pacing of cardiac activity

Advanced Functional Materials, 2020, 30, 1910027; Advanced Optical Materials, 2022, 10, 2201331.

Flexible and stretchable transparent MEAs for biointerfacing

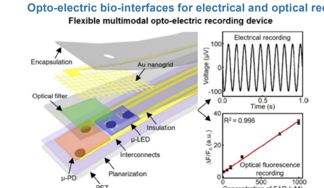
Scalable fabrication process to generate large-area, wafer-scale transparent MEA

A MEA laminated on the curved heart surface

Advanced Materials Technologies, 2020, 5, 2000322.
Advanced Materials Technologies, 2021, 6, 202100225.
Advanced Materials Technologies, 2023, 2201716.
ACS Applied Bio Materials, 2023, 6, 1701-1719.
Science Advances, 2023, 9, eadi0757.

Opto-electric bio-interfaces for electrical and optical recording

Flexible multimodal opto-electric recording device

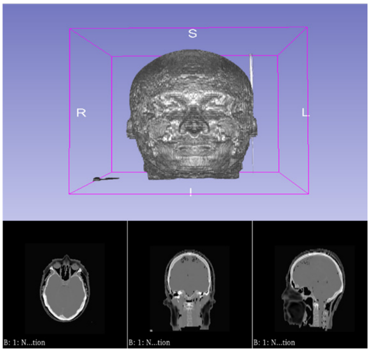


Soft opto-electric device for colocalized electrical recording and optical monitoring of green fluorescent reporters.

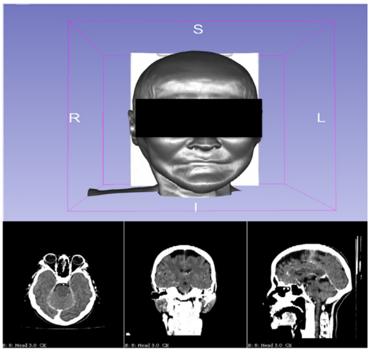
ACS Applied Electronic Materials, 2023, 5, 1688.

IMPROVING IMAGE ANALYSIS AND THE RECOGNITION OF ANOMALIES

Atrial fibrillation (AF) remains the most commonly occurring arrhythmia, with the primary treatment option being to the ablation of abnormal sources of electrical activity using percutaneous radiofrequency (RF) catheters. While RF ablation procedures do halt abnormal electrical activity from spreading, there are limited means for real-time monitoring of tissue injury during this process. In the Medical Imaging and Image Analysis Laboratory, Professor Murray Loew is collaborating, under an NIH grant, with Nocturnal Product Development, LLC, and the GW School of Medicine and Health Sciences to create a new generation of imaging catheters based on spectral changes in tissue autofluorescence by thermal damage. This technology will pave the way for easier, faster, safer, more cost-effective, more reliable, and minimally invasive RF ablation procedures.

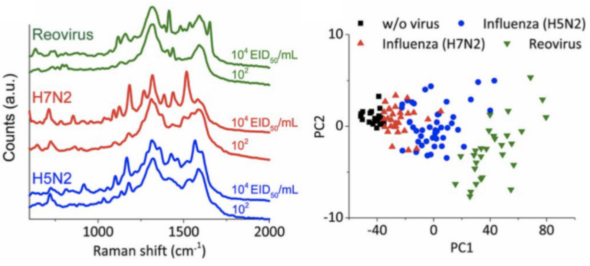


Renderings showing anonymization of faces in MRI brain studies.



Hyperspectral imaging for the treatment of AF is only one area of research Professor Loew is currently conducting. Other areas include imaging, registration, mosaicking, and analysis of images of paintings, developing measures of spatial and temporal salience to guide detection and recognition algorithms for physical anomalies, and infrared imaging for early cancer detection in the breast. In the latter project, their algorithms will incorporate thermal and deformation models to establish criteria for defining regions of suspected abnormality. The lab's research focuses on the analysis of medical images of many modalities, principally for clinical applications.

Prof. Loew's methods are applied in other areas as well. For example, the lab has, under an NEH grant, collaborated recently with the Catholic University of America and the Library of Congress on an interdisciplinary project dedicated to developing an "identification tree" that uses ultraviolet light tools as a first-level examination step that will lead to the methodical application of other non-invasive techniques to allow the identification of unstable and deteriorating types of glass in cultural heritage collections. The "identification tree" will aid caretakers of cultural heritage by providing a simple sorting mechanism that identifies at-risk cultural heritage, even when deterioration is not yet evident. The examination protocol and methodology will also be simple, low-cost, and tailored to end-users who are not first-level scientists but will expand to include progressively sophisticated techniques for detailed study and higher degrees of confidence by the museum professional.



Machine learning for virus detection in Raman spectroscopy

A TALE OF TWO TOPICS: INNOVATING MEDICAL IMAGING AND BROADENING ACCESS TO RESEARCH

Professor Jason Zara exemplifies the diverse research interests of GW Engineering faculty through his two vastly different research thrusts. In the Laboratory for Optical and Acoustic Imaging, he investigates the application of novel instrumentation and computing techniques to medical imaging applications. Prof. Zara's laboratory research focuses on a wide range of optical and acoustic imaging technologies and image analysis in optical coherence tomography and MRI and studies the diagnosis and therapy of multiple health conditions, including oral and bladder cancers and epilepsy. Much of this work is conducted in conjunction with collaborators at the Food and Drug Administration (FDA).

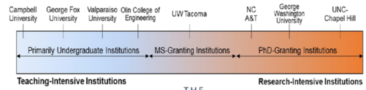
When Prof. Zara is not innovating medical imaging, he leads a multi-institutional effort to develop tools that improve the access and quality of undergraduate research experiences. This effort is part of a project supported by a $2.024 million grant from the Kern Family Foundation titled "Research for All (R4A)," for which GW is the lead institution and Prof. Zara is the Principal Investigator. Its goal is to broaden participation in undergraduate research with three complementary and interrelated tasks to develop entrepreneurially minded (EM)-focused undergraduate research frameworks and tools, including i) EM-focused course-based engineering research experiences (URCurious), ii) EM-focused training modules that bolster student and faculty skills for improved quality and impact of these research projects (URSkilled), and iii) an online platform that connects students, faculty, and industry partners to enable and scale-up internal and external research collaborations (URConnected). The project aims to substantially increase access to meaningful and impactful research opportunities for undergraduate students at GW and our partner institutions.

Both of Prof. Zara's research thrusts are inherently interdisciplinary. His laboratory research has involved collaborations with faculty from the Mechanical and Aerospace Engineering Department, Civil and Environmental Engineering Department, GW Medical School, and GW Hospital, in addition to a Children's National Medical Center. Research for the R4A project involves GW and seven other universities, including George Fox University, North Carolina Agricultural and Technical State University, Olin College of Engineering, University of Washington-Tacoma, The University of North Carolina-Chapel Hill, Campbell University, and Valparaiso University. Such interdisciplinarity will drive significant results that positively impact society in and outside the classroom.

1. Research for All (R4A)

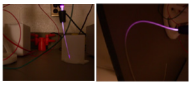
The overall goals of this effort are to:

1) expose ALL engineering students to real research problems.
2) better prepare them to contribute to research laboratories.
3) make more effective matches between students and research opportunities.

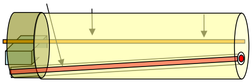


THE KERN FAMILY FOUNDATION

2. Imaging and treatment of epithelial cancers with OCT and cold plasmas – with Keidar Lab from MAE



Delivery of the plasma through a 2 mm diameter flexible plastic tube.



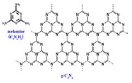
Potential Probe Design

ARCS ADVANCING SCIENCE IN AMERICA

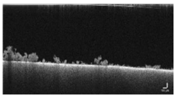
The Dr. Cyrus & Myrtle Katzen Cancer Research Center

3. Quantifying Biofilm Growth with OCT – with Shuai Lab from CEE

graphitic carbon nitride (g-C_3N_4)



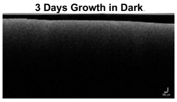
Visible light-activated photocatalyst



3 Days Growth in Dark

Visible light-activated photocatalyst

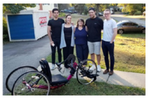
We are using OCT imaging to quantify biofilm growth on new light-activated antimicrobial materials.



No Growth in Light

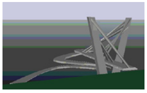
4. Engineering for the Public Good – with representatives of all GW Engineering Departments

While nearly all engineering programs are engaging with their communities, most community projects with public agencies or spaces are not infused with EML and the 3Cs in mind. This pilot project aims to encourage KEEN partners to reframe these projects with EML in mind in order to increase the engagement of students and develop their entrepreneurial mindsets.



BME Design Project to Develop a Prosthetic Leg Carrier for a Bicycle (with Lee from BME)

Clef inspired bridge for Kennedy Center REACH Project (with Silva from CEE)



THE KERN FAMILY FOUNDATION