

UC San Diego

MATERIALS SCIENCE AND
ENGINEERING PROGRAM

MATERIAL NEWS

Materials Science & Engineering
University of California, San Diego

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*Cover Figure:
Graphene grain boundary*

*Image courtesy:
Dr. Prab Bandaru's Research Group*

LETTER FROM THE DIRECTOR



In this unprecedented period, where all of the world seems to have the Covid-19 pandemic on its mind, we hope that this newsletter provides a respite. Here, we highlight representative work of the constituents in the Materials Science Program (MATSE) at UC, San Diego. The program is wide-ranging and encompasses engineering (Mechanical and Aerospace, Electrical, Structural, Nanoengineering, and Bioengineering), and the science (Physics, Chemistry and Biology) departments, and the School of Medicine. Indeed, MATSE is dynamic proof of the pervasiveness of materials science. Close to one hundred faculty are associated with the program, which is on a continual upward trajectory of growth and development.

You will find, in the newsletter, samples of the work by faculty in the program, ranging from fluid flow on specifically prepared superhydrophobic surfaces, arranging multiple single atom thick graphene layers for light detection, data mining related discovery and development of new materials systems, to biomedical research related to monitoring prostheses in amputees.

A few significant faculty honors, e.g., with respect to innovations in biomedical materials engineering, are highlighted. A seminal award named after a pioneering ex-colleague, the late Prof. Gareth Thomas (who worked at both UC, Berkeley and UC, San Diego), was given to Zhenbin Wang, a productive graduate student whose work included contributions to the mechanical properties of state-of-the-art materials, such as high entropy alloy systems.

We were also glad to welcome more than 50 new graduate students this year with far reaching diversity and scientific and technological range. In addition to regarding the accomplishments of our students, we take immense pride, and follow the career trajectories of our alumni. Dr. J. Park, presently in academia, discusses how he spent most of his doctoral training in the cleanroom! Dr. Alma Zhanaidarova, who is on the entrepreneurial track, advises students to "strive to be the best". The program has also organized, in association with the Chemistry Department, a Semi-Conductor Industry Interaction Day, where students in the program get to network with alumni in the industry.

We hope you enjoy reading the newsletter and always welcome your feedback, support and good wishes.

Sincerely yours,

A handwritten signature in blue ink that reads "Prab R. Bandaru". The signature is stylized and cursive.

Prab R. Bandaru

Salt Water Flow on Patterned Surfaces for Power Generation

Professor Bandaru's group has developed specific surface patterns that can be used to generate electrical voltage, when salt water flows over such surfaces. The team from the Mechanical Engineering department in the Jacobs School of Engineering, consisting of Bei Fan, a graduate student, and Professor Prab Bandaru, published their work in *Nature Communications* and *Langmuir*.

The surface pattern was made by etching tiny ridges into a silicon substrate and then filling the ridges with synthetic oil. In tests, dilute salt water was transported by syringe pump through a microfluidic channel containing the pattern and then the voltage was measured across the ends of the channel.

The team's research indicates the development of new energy sources, that may be used in integrated microfluidics, such as for lab-on-a-chip platforms and may someday even be extended to powering wearable devices.

The main idea is that the relative motion of positive (e.g., Na) ions in salt (NaCl) water with respect to a charged surface (say, with negative charge) results in an electrical potential difference and voltage. Previous work was aimed at increasing the surface fluid slip velocity through using superhydrophobic ("lotus leaf") surfaces. However, such surfaces have air which does not hold charge and hence does not contribute to the voltage. In their seminal work, the team replaced the air by a saltwater immiscible liquid, such as a synthetic oil, with significant increase in the electrical voltage, to around 50 millivolts – more than 50% larger than by using air alone. By replacing air with a liquid that holds charge, the team not only boosted their surface's water repellency, but also the voltage it created.

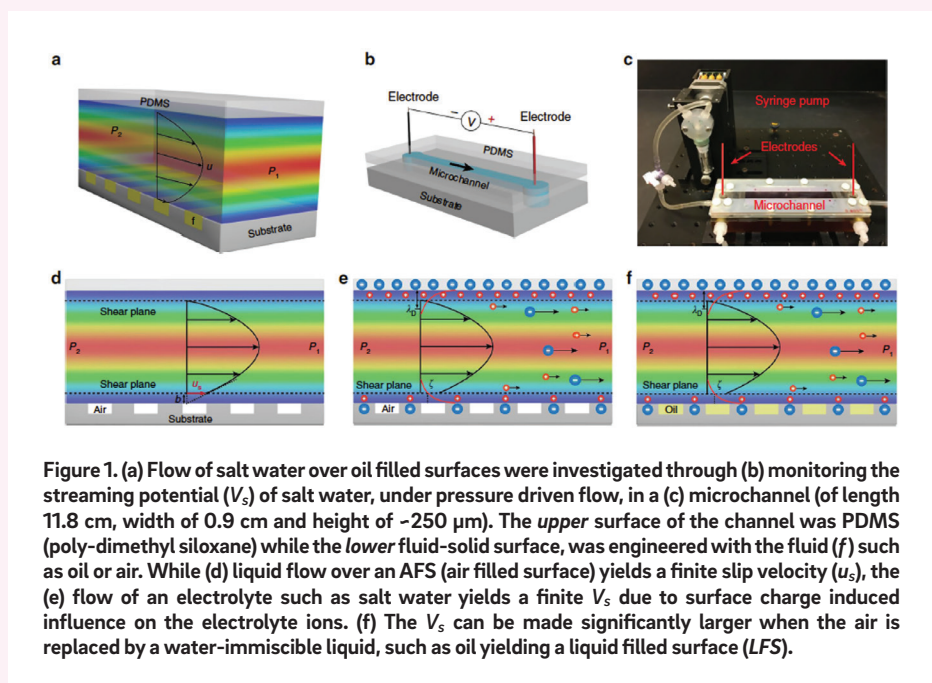


Figure 1. (a) Flow of salt water over oil filled surfaces were investigated through (b) monitoring the streaming potential (V_s) of salt water, under pressure driven flow, in a (c) microchannel (of length 11.8 cm, width of 0.9 cm and height of $\sim 250 \mu\text{m}$). The upper surface of the channel was PDMS (poly-dimethyl siloxane) while the lower fluid-solid surface, was engineered with the fluid (f) such as oil or air. While (d) liquid flow over an AFS (air filled surface) yields a finite slip velocity (u_s), the (e) flow of an electrolyte such as salt water yields a finite V_s due to surface charge induced influence on the electrolyte ions. (f) The V_s can be made significantly larger when the air is replaced by a water-immiscible liquid, such as oil yielding a liquid filled surface (LFS).

Higher voltages may be obtained through faster liquid velocities as well as narrower and longer channels. The team is working on enhancing the electrical power that may be obtained from channels employing such surfaces as well as related systems engineering for practical application. For instance, the team has also looked into electroosmotic mobility related tensorial effects on the electrokinetic streaming potential. A significant modulation – as high as 100%, due to transverse pressure gradients, was demonstrated. Insights into understanding geometrical effects in electrolyte flows with implications to the establishment of local electric fields, energy generation, and biological separations were obtained through such investigations.

References: "Enhanced voltage generation through electrolyte flow on liquid-filled surfaces", *Nature Communications*, vol. 9, p. 4050, (2018); "Tensorial Modulation of Electrokinetic Streaming Potentials on Air and Liquid Filled Surfaces", *Langmuir*, vol. 35, p. 1481, 2019)



PRAB BANDARU

Prab Bandaru is a professor in UCSD's Mechanical Engineering department and is also affiliated with the Electrical Engineering and the Nanoengineering departments. His research group is mainly interested in analytical and experimental materials physics and chemistry and related applications to electrical, thermal, electrochemical, and electrokinetic fluids based engineering.

Monitoring Subcutaneous Infection in Amputees with Osseointegrated Prostheses

More than 2 million people in the U.S. suffered from limb loss with ~ 185,000 amputations occurring each year. In particular, a rapidly emerging prosthetic procedure is known as osseointegration, where it involves anchoring a portion of the prosthesis in bone with a percutaneous element connected to the artificial limb. It was found that osseointegrated implants improve amputees' quality of life, sitting comfort, and gait. However, infection due to caustic microbial attack could still occur. Therefore, the goal of this paper is to showcase a noncontact, noninvasive, imaging tool that can be used to accurately detect the early growth of subcutaneous infection occurring at the tissue-prosthesis interface. It is envisioned that the results from the proposed method can reduce the amount of unnecessary, complicated, expensive, and painful medical tests while facilitating diagnosis and use of appropriate infection treatment strategies. The proposed imaging technique is based on electrical capacitance tomography (ECT) and used in conjunction with embedded, passive, thin film, pH sensors that exhibit changes in its dielectric property due to pH.

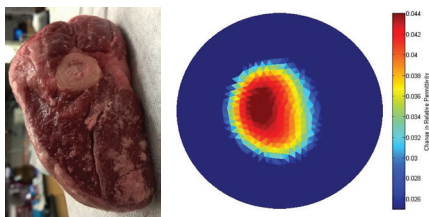
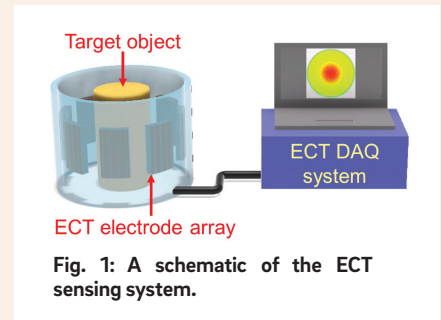


Fig. 2: Validation of ECT for imaging biological samples.

First, ECT can reconstruct the permittivity distribution of a predefined sensing domain using measured sets of capacitances obtained at electrodes surrounding a sensing domain (Fig. 1). During ECT testing, an alternating current (AC) excitation is applied to one of the electrodes, while all others remain grounded. This allows an electric field to propagate through the sensing domain. Changes in the distribution of dielectric properties in the sensing domain would affect the capacitance response at the boundary, where capacitances are used as inputs to the ECT inverse problem. To validate ECT, an experiment was performed using a lamb shank. The lamb shank was placed in the ECT sensing domain and interrogated, and the corresponding permittivity map of its cross-section is shown in Fig. 2. It is clear from Fig. 2 that the shape of the lamb shank was successfully captured. In addition, greater changes in permittivity were also observed near the bone, while the remainder of the permittivity changes were due to tissue.

Second, to enable the selective detection of subcutaneous infection, a nanocomposite coating whose electrical permittivity varied due to changes in pH (as an indicator of infection) was developed. The thin film sensor, which could be deposited by spray-coating them onto osseointegrated implants prior to surgery, was based on multi-walled carbon nanotubes (MWCNT) and polyaniline (PANI) emeraldine base. Test results showed that the permittivity of MWCNT-PANI thin films increase with increasing pH and in a near-linear fashion. Thus, the films were deposited onto a metallic rod (i.e., prosthesis surrogate). The film-coated rod was then wrapped in saturated foam to emulate the surrounding human tissue. The entire test phantom was placed in the ECT sensing domain and interrogated. To expose the surrogate to pH buffer solutions, the film-coated rod was carefully removed without disturbing the saturated foam and then immersed in different pH buffer solutions.

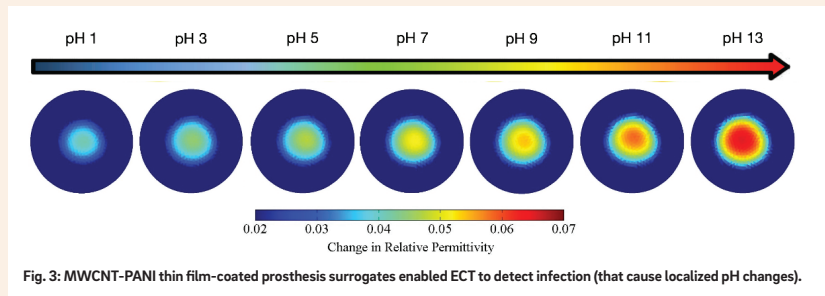


Fig. 3: MWCNT-PANI thin film-coated prosthesis surrogates enabled ECT to detect infection (that cause localized pH changes).

Upon drying the film-coated rod, the system was inserted back into the saturated foam (in the same position) and then interrogated by ECT. In total, the system was exposed to pH 1 to 13 buffers, and the resulting permittivity maps are shown in Fig. 3. It can be seen in Fig. 3 that drastic changes in electrical permittivity were observed corresponding to changes in pH. In addition, the location of the prosthesis surrogate was also correctly identified. Future research will assess the biocompatibility and cytotoxicity of the nanocomposite, followed by animal and clinical trials.



KENNETH LOH

Kenneth Loh, a Professor in the Department of Structural Engineering at UC San Diego, joined UC San Diego as an Associate Professor in 2015. Prior to this, he held the titles of Assistant Professor (2009–2013) and Associate Professor with tenure (2013–2015) in the Department of Civil & Environmental Engineering at UC Davis. He received his Ph.D. degree in Civil Engineering from the University of Michigan, Ann Arbor in 2008. At Michigan, he also completed two M.S. degrees in Materials Science & Engineering (2008) and Civil Engineering (2005). His B.S. degree in Civil Engineering was from Johns Hopkins University in 2004.

Improving Charge Transport by Using Intercalation Structure of Graphene and Quantum Dots Films

Using layer-by-layer multi-stacking intercalated graphene (Gr) inside quantum dots (QD) films structure, the Vazquez group at the University of California, San Diego has improved charge carrier transport inside quantum dots film beyond the diffusion length. This work breaks the limitation of practice thickness of quantum dots film in optoelectronic devices caused by the short diffusion length and paves the way for the development of high-efficiency quantum dot optoelectronic devices. This work is published in *Advanced Materials* 2019.

The collection of photogenerated charges is critical in optoelectronic devices for communication, imaging, and energy harvesting. However, efficiency charge collection is a major issue for amorphous and nanomaterials due to short diffusion length. If photocarriers need to transit distance beyond diffusion length to be collected, then they will recombine without producing photocurrent. This is the well-known restriction for a conventional top/bottom contact device, as the thickness of absorbing layers should not exceed the carrier diffusion length plus depletion width. In this work, a novel architecture based on multiple intercalated CVD graphene monolayers orderly distributed inside PbS QD films is studied.

Under illumination, the built-in potential at Gr/QD keeps the photogenerated electrons in QDs and drives holes transferring to graphene producing a photocurrent under a bias voltage. The intercalated graphene layers inside QDs films ensure that photocarriers will be efficiently collected at any point in the absorbing material. Vazquez's group shows that devices with intercalated graphene layers have superior quantum efficiency over a single bottom Gr/QD device, overcoming the restriction that diffusion length imposes on film thickness, and also that QD film with increased thickness shows efficient charge collection over the entire λ -500-1000 nm spectrum. A photodetector based on this architecture shows photoresponsivity of 10^7 A/W.

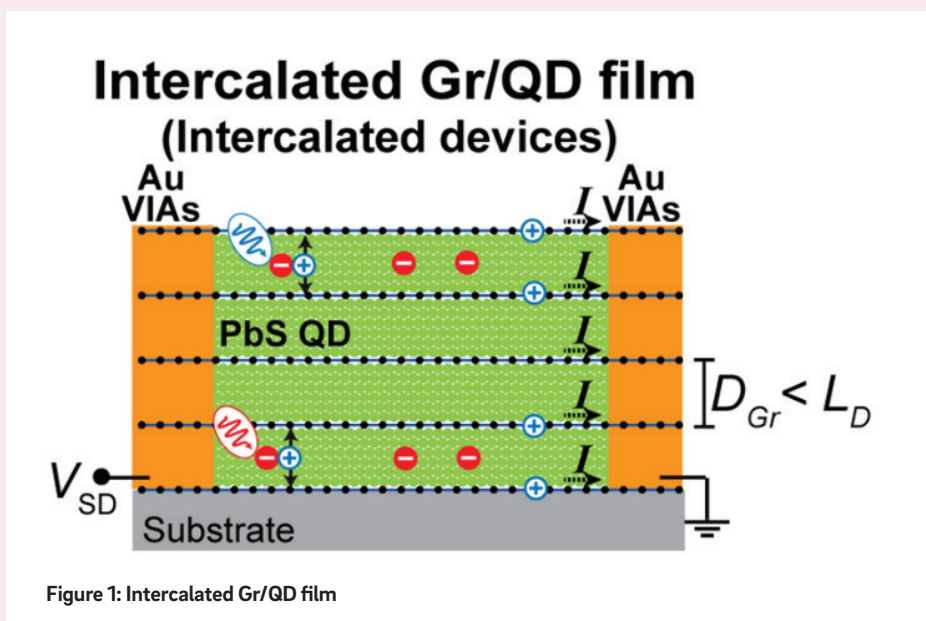


Figure 1: Intercalated Gr/QD film

"We're aiming to build ultra-thick QDs films for full light absorption and full charge collection using this intercalated architecture," said Vazquez. This novel structure was developed for quantum dots but is not limited to the QD system, as it could be applied to any light absorbers, for instance, perovskite or amorphous Si. Materials with short diffusion length would benefit most from this configuration. Graphene could also be alternated with other 2D materials for being charge collectors, such as MoS_2 and other transition metal dichalcogenides. With additional work, the team aims to further boost efficiency of quantum dots solar cells, and to develop new multi-color photodetection devices.

W. Chen, J. Castro, S. Ahn, X. Li, and O. Vazquez-Mena, "Improved Charge Extraction Beyond Diffusion Length by Layer-by-Layer Multistacking Intercalation of Graphene Layers inside Quantum Dots Films," *Adv. Mater.*, vol. 1807894, p. 1807894, 2019.



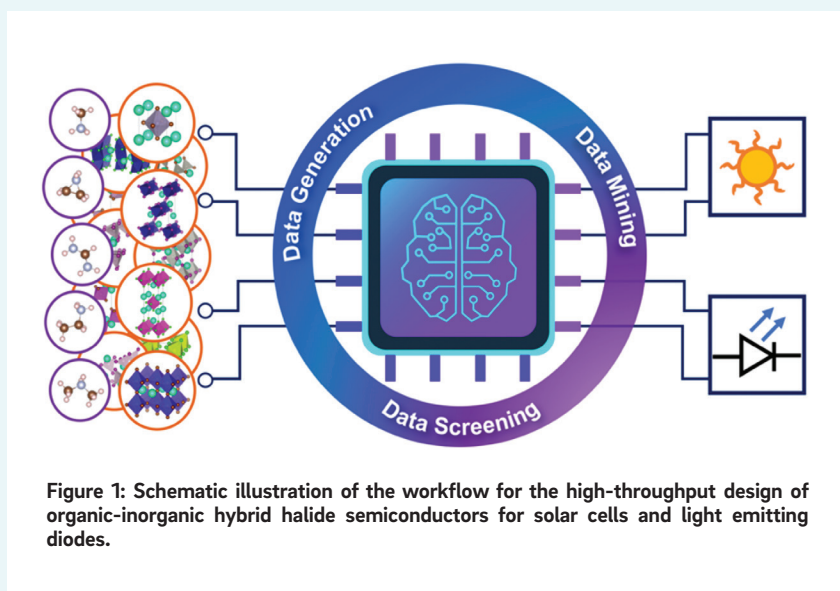
OSCAR VAZQUEZ MENA

Oscar Vazquez Mena, an Assistant Professor in Nanoengineering at UC San Diego, obtained his B.S. in physics engineering from the Monterrey Institute of Technology in 2000 in Mexico, and his M.S. degree in nanoscale science and engineering from Chalmers University of Technology in Sweden, completing his thesis at Delft University of Technology. He received his Ph.D. in 2010 from the Swiss Federal Institute of Technology of Lausanne (EPFL) in Switzerland. He completed postdoctoral research stages at the University of California, Berkeley in the Department of Physics from 2011 to 2014, and at the Institute of Photonic Sciences in Barcelona in 2015 with a Marie Skłodowska-Curie fellowship. At UC Berkeley, he founded the Indigenous Pipeline to support the educational development of children from indigenous communities in Mexico living in the Bay Area.

A Marriage Between Materials Science and Data Science Gives Birth to New Materials for Solar Cells and Light-Emitting Diodes

Materials scientists at the University of California, San Diego have discovered new organic-inorganic hybrid halide materials for next-generation solar cells and light-emitting diodes (LED) using computational tools, data-mining, and data-screening techniques. These predicted materials show robust materials stability and appropriate optoelectronic properties for solar cells and LED devices. Researchers published these new materials on May 22 in the journal *Energy & Environmental Science*.

Organic-inorganic lead halide perovskites are promising for the next-generation solar cells and light-emitting applications because of their exceptional optoelectronic properties and low-temperature solution processability. However, this class of materials is facing two major challenges including intrinsic poor stability and the presence of toxic lead for practical applications. To overcome these challenges, instead of focusing on perovskites, researchers at UC San Diego present a powerful approach to search for novel lead-free hybrid halide semiconductors beyond perovskites from a large variety of prototype structures using high-throughput computations and data-mining techniques. In total, 23 candidate materials for LED and 13 candidates for solar cells were discovered using a high-throughput computational materials design approach by the group of Dr. Kesong Yang, a nanoengineering professor at UC San Diego Jacobs School of Engineering and the lead principal investigator of the study.



Dr. Yang leads the computational materials design group in the Department of NanoEngineering, and is also a faculty member in the Materials Science and Engineering Program, Center for Memory and Recording Research (CMRR), Center for Energy Research, Sustainable Power and Energy Center, and a founding faculty of the Halicioğlu Data Science Institute at UC San Diego. His group used a combination of high-throughput quantum mechanics calculations and data-mining techniques to discover and design novel functional materials for optoelectronic, spintronic, and energy applications, including oxide electronics, spintronics, topological materials, catalysts for water-splitting, and hydrodesulfurization of petroleum.

Related research article: "High-throughput computational design of organic-inorganic hybrid halide semiconductors beyond perovskites for optoelectronics." Authors of the study are Professor Kesong Yang and his nanoengineering Ph.D. student Yuheng Li.

This work was supported by the Global Research Outreach (GRO) Program of Samsung Advanced Institute of Technology under award number 20164974 and the National Science Foundation under award number ACI-1550404. This work used the Extreme Science and Engineering Discovery Environment (XSEDE), which is supported by the National Science Foundation 30 grant number OCI-1053575, and computational resources supplied by the Department of Defense High Performance Computing Modernization Program (HPCMP).



KESONG YANG

Kesong Yang is an Associate Professor of Nanoengineering at UC San Diego, and is also a faculty member in the Materials Science and Engineering Program, Center for Memory and Recording Research, Center for Energy Research, Sustainable Power and Energy Center, and a founding faculty of the Halicioğlu Data Science Institute at UC San Diego. Yang joined UC San Diego faculty in July 2013. Before that, he was a Postdoctoral Researcher at Duke University (2010-2013). He received his Ph.D. Degree in Atomic and Molecular Physics in 2010 and his B.S. Degree in Physics in 2005 from Shandong University. The Yang group's research interests are in the areas of computational materials science, with particular emphasis on materials modeling and simulation using first-principles (or ab-initio) calculations. A theme of his research is to study structural, electronic, optical and magnetic properties of materials, and aiming to understand, optimize, and predict materials properties for the design of novel functional nanomaterials.

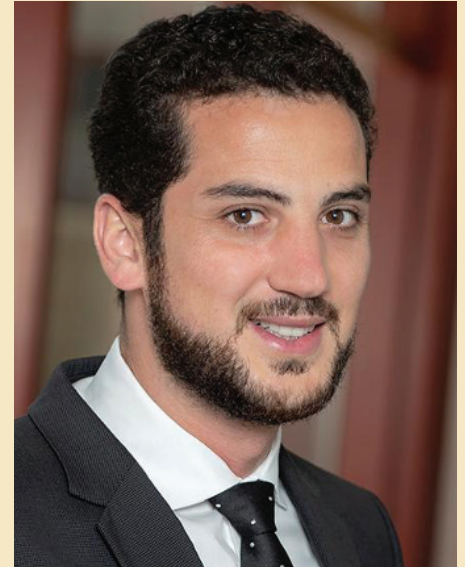
Shadi Dayeh, PhD, Receives the New Innovator Award, Recognizing Innovative Approaches in Biomedical Research

Shadi Dayeh, who joined UC San Diego in 2012, explores new nanofabrication techniques to build neural probes capable of mapping activity in individual neurons as well as across the entire human brain. The devices feature materials that are orders of magnitude thinner, more sensitive, flexible and less damaging to the brain than existing clinical devices.

Funding from the New Innovator Award will enable Dayeh and his colleagues to develop new brain mapping technologies that can better guide neurosurgeons to remove brain tumors and epileptogenic tissue more precisely without damaging healthy brain tissue. In this project, researchers aim to develop a next-generation version of a clinical tool called an electrode grid, which is a plastic- or silicone-based grid of electrodes placed directly on the surface of the brain during surgery to monitor the activity of large groups of neurons.

The new electrode grid that Dayeh proposes will be integrated with high-resolution, colored light displays to essentially color code fine cortical activity and structures in the brain. This type of device will provide immediate visual feedback to the operating neurosurgeon, making it possible to perform neurosurgery resections at higher precision, in a shorter time frame and with potentially reduced risk to the patients.

Dayeh's research spans expertise in materials science, electrical engineering and electrochemistry, and he works with experts from multiple fields, including neurosurgery, neuroscience and neurophysiology. His primary collaborator on this project is Sydney Cash, MD, PhD, at Massachusetts General Hospital. In previous projects, he has collaborated with clinicians at Jacobs Medical Center at UC San Diego Health, Brigham Women's Hospital (Boston), Massachusetts General Hospital and Oregon Health and Sciences University. His lab efforts in the last few years enabled clinical research studies for first-in-human electrophysiological recordings with hundreds to thousands of channels.



Shadi Dayeh, PhD, recipient of a New Innovator Award. Photo credit: Jacobs School of Engineering

Shadi Dayeh, a Professor in the Electrical and Computer Engineering Department at UC San Diego, received his B.S. in Physics/Electronics from the Lebanese University in Beirut, Lebanon in 2001, his M.S. in Electrical Engineering from the Southern Methodist University in Dallas in 2003, and his PhD in Electrical Engineering from UC San Diego in 2008. He completed his postdoctoral studies at Los Alamos National Laboratory as a Director's Fellow (2008-2010) and a Distinguished J. R. Oppenheimer Fellow (2010-2012) and then joined the faculty of ECE at UCSD in November 2012 where he currently directs the Integrated Electronics and Bio-interfaces Laboratory. He received many best paper awards for his graduate work and the distinguished performance award at Los Alamos for his postdoctoral work, the NSF Early Career Award in 2014, the Jacobs School of Engineering Teacher of the Year Award in Electrical and Computer Engineering in 2015, and the ICS Young Scientist Award in 2018.

MATSE ALUMNI INTERVIEWS



JEONGWON PARK

Associate Professor, Electrical & Biomedical Engineering, University of Nevada, Reno

Dissertation: *Electronic Properties of Organic Thin Film Transistors with Nanoscale Tapered Electrodes*

Advisors: Dr. Andrew Kummel and Dr. Sungho Jin

What was your thesis topic at UCSD? How did the related work impact your future career trajectory?

My thesis title is "Electronic Properties of Organic Thin Film Transistors with Nanoscale Tapered Electrodes", which was supervised by Dr. Andrew Kummel and Dr. Sungho Jin. At my first job at Applied Materials, I was thrown right into the lab and was able to pick things up and contribute from the beginning. I was very thankful for everything that I learned in my time at UCSD, which made this possible. I was working on Si, SiGe, and SiC epitaxy growth in the Front End Product group and the CTO group, and I'd been spending most of my time in the lab (clean room) tearing apart the chamber that I was working on and trying to adjust all of the process conditions so that it met the customer's specs. Many of the parts that I was pulling off, installing, and changing were tasks that I had previous exposure to when I was at UCSD, and virtually all of that guidance came through professors. (Special thanks to the following professors: Prabhakar Bandaru, Deli Wang, Ed Yu, Yu-Hwa Lo, Ivan Schuller, William Trogler, Andrew Kummel, and Sungho Jin.) I was very fortunate to have worked so closely with them for five years.

Could you briefly describe your career path - from UCSD to now?

After graduation at UCSD, I joined Applied Materials, Inc. in Santa Clara, California from 2008 to 2014. I worked as a process engineer in semiconductor research and conducted and organized research for electronic materials in nanotechnologies. Research topics included: semiconductor process developments, epitaxial growth for strained channel Si, SiGe, SiC, Ge materials, ALD, cleaning for new channel materials (III-V, Ge) and device integration, carbon base electronics, CNT, graphene, polymer, MEMS, energy applications, and Si deposition for nano-thin film battery and solar cells. During this period, I was a visiting research scholar at Stanford University as a part of a strategic learning assignment through Applied Materials. During this time, new electronic materials for advanced channel (Ge and III-V) applications were studied with Professor Krishna Saraswat. Next, I joined the SLAC National Accelerator Laboratory at Stanford University as a research scientist from 2014 to 2016 to develop nanofabrication and microfabrication methods for advanced x-ray optics and nano-photonics devices at the Stanford Nano Center, Stanford Nanofabrication Facility, and SLAC National Accelerator Laboratory. After experience in industry and national labs, I decided to move to academia. First, I worked as an associate professor at the School of Electrical Engineering and Computer Science at the University of Ottawa from 2016, and now I am an associate professor in the Department of Electrical and Biomedical Engineering at the University of Nevada, Reno

since July 2019. My expertise is in the areas of IoT sensors and sensor networks for advanced manufacturing, nanotechnology-enabled flexible hybrid electronics, nanoelectronics, semiconductors, and nanomaterials.

In retrospect, what were the highlights of the MATSE program?

The most notable advantage of the MATSE program was exposure to interdisciplinary, world-class researchers and access to many resources. For example, I enrolled in device physics classes and neurobiology classes at UCSD. I also had the opportunity to participate in a Multidisciplinary University Research Initiative (MURI) project that could accelerate research progress with a multidisciplinary team effort in areas particularly suited to this approach by the cross-fertilization of ideas. These unique opportunities at UCSD expanded my curiosity and ignited my thrill of discovery.

Any interesting memories (both good and bad) of the MATSE program?

I have very fond memories of the MATSE program at UCSD and the excellent way in which I was prepared for my future life. I enjoyed many of the MATSE student activities in San Diego, such as moonlight kayak trips at Mission Bay, nature exploring at La Jolla Cove, and weekly gatherings at beaches. I still miss these activities.

What are your suggestions/advice for MATSE students?

I encourage you to experience the world of work, particularly the work of future interests via internships and networking. As graduate students, we have to juggle research, coursework, managing relationships, family responsibilities, and squeezing in outside interests. However, please get support from your professors and friends. Treat yourself right by being in good shape physically, which increases your tolerance to stress.

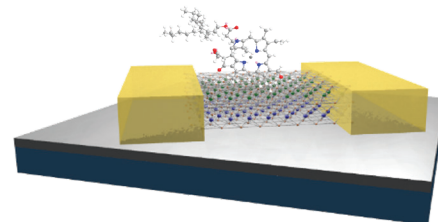


Figure. Schematic diagram of a chemical sensor with 2D materials



ALMAGUL (ALMA) ZHANAIDAROVA

Founder, Fixing CO₂

Dissertation: *Electrodes Modified with Molecular Catalysts for the Electrochemical Reduction of CO₂ to CO*

Advisor: Dr. Kubiak

What was your thesis topic at UCSD? How did the related work affect your future career trajectory? Could you briefly describe your career path - from UCSD to now?

My thesis topic at UCSD was: Electrodes modified with molecular catalysts for the electrochemical reduction of CO₂ to CO. During my PhD, I worked on the electrochemical reduction of carbon dioxide in Professor Kubiak's lab. My research was a part of the JPL/NASA program for the In-Situ Resource Utilization on Mars. During my PhD, I developed a heterogeneous catalytic material that efficiently converts carbon dioxide to CO on one side of the electrochemical cell and oxygen on the other side of the cell. Produced CO can be further converted to various fuels and chemicals using already existing technologies. After my graduation, my friends and I started a company called Fixing CO₂, that is focused on CO₂ utilization. We believe we can collect carbon dioxide from industrial emitters, and electrochemically convert CO₂ to clean fuels and chemicals, closing the carbon loop and aiding in solving the climate crisis. We hope to be a part of the economy where clean fuels and chemicals play an important role in the sustainability of our planet. I am a founder and the CTO responsible for the technological development at our company. The company's core technology is based on the research that I worked on at UCSD during my PhD program.

In retrospect, what were the highlights of the MATSE program?

The Materials Science and Engineering Program at UCSD gave me the opportunity to participate and contribute to the world's finest research. The uniqueness of the program is that students can choose to work at various labs around the campus from Biochemistry to Aerospace Engineering. When I first came to UCSD, I knew that I wanted to be a part of the engineering

community but also, I wanted to synthesize and study catalysts for CO₂ reduction, so the choice of working at Professor Kubiak's lab was obvious for me.

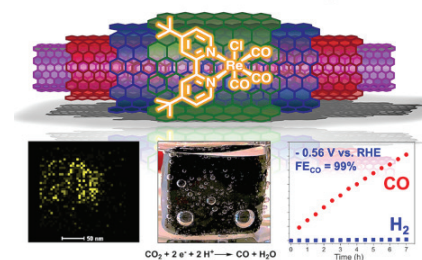
Any interesting memories (both good and bad) of the MATSE program?

I only have good memories about the MATSE program, and although I spent most of my time in the Chemistry Department on the other side of campus, I knew that all administrative staff of the MATSE Department always supported me and had my back. I'm very grateful that they provided support and had confidence in me.

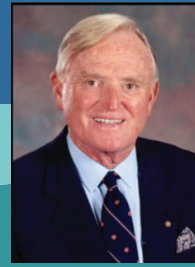
What are your suggestions/advice for MATSE students?

When I was in graduate school, I received the advice to strive to be the best in your class, the best in your lab, and the best in your research area. If you are successful in your research area, you will build confidence that you will carry into your future career and other aspects of your life. So, my advice is to try to be the best at what you do, and stay motivated and focused.

Electrochemical reduction of CO₂ to CO



GARETH THOMAS AWARD RECIPIENT



This award is to honor the memory of the late Prof. Gareth Thomas, a pioneer in the use of electron microscopy in Materials Science.



Zezhou Li

Winner of the
Gareth Thomas Award

Describe your research interests.

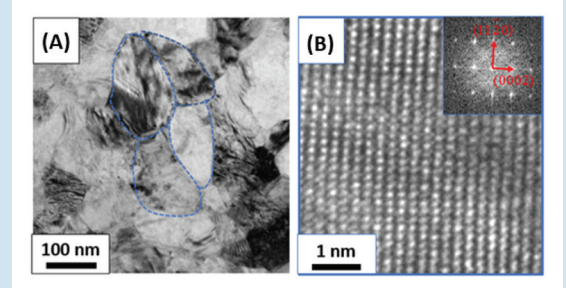
My research area is mechanical properties of state-of-the-art materials. I am especially interested in the linkage of microstructures and the mechanical behavior of advanced materials. My Ph.D. thesis focused on high strain-rate behavior of ultrafine-grained titanium with high strength and CrCoNi-based high-entropy alloys with superb fracture toughness.

What have been your experiences in the MATSE program? How has your training in the MATSE program at UC San Diego helped your growth?

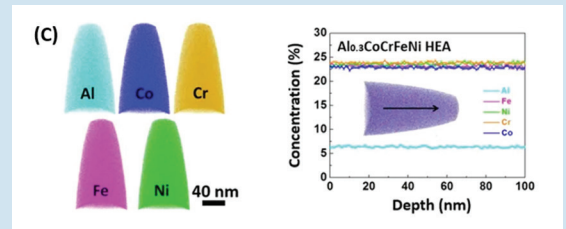
The MATSE program has allowed the research I have conducted to have an interdisciplinary nature, mainly due to the intellectual diversity of its faculty members. Being a Ph.D. student came with many challenges, such as becoming established as a researcher with the ability to conduct world-class interdisciplinary research. All of the MATSE members are very responsible, creating a comfortable and delightful environment for my Ph.D. studies. The MATSE program offered me the right tools and guidance to enrich my understanding of materials by multiscale microstructural and mechanical characterizations. Moreover, thanks to my advisor, Professor Marc A. Meyers, and the highly successful collaborations within the MATSE faculties, new advanced structural materials have been discovered, and fundamental insights on their performance under extreme conditions have been revealed through my Ph.D. studies.

Where do you see yourself in the future?

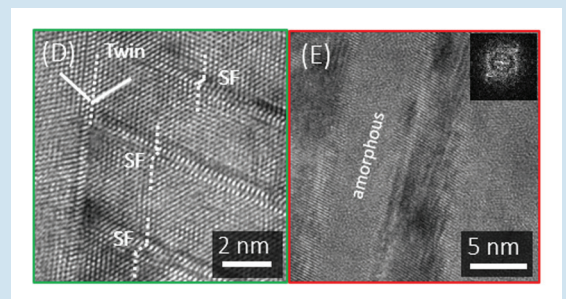
My goal is to find a position in a university or institute where I can grow and pursue my research interests over time. Hopefully, after years of effort, I am able to make great breakthroughs in the design of better impact-resistant structural materials to protect human life.



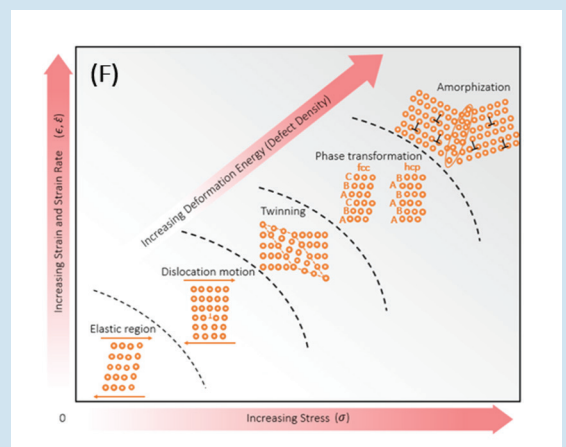
(A) Ultrafine-grained (UFG) Ti with grain size ~100 nm; (B) its (hexagonal close packed) atomic structures.



(C) Elemental distribution and concentration at nanoscale of the $Al_{0.3}CrFeCoNi$ alloy.



(D,E) Atomic structures in the CrMnFeCoNi alloy under extreme conditions.



(F) Design of impact-resistant materials.

Semi-Conductor Industry Interaction Day 2019



The Materials Science and Engineering Program, in collaboration with the Department of Chemistry and Biochemistry and the Division of Physical Sciences Center for Student Success, sponsored the Semi-Conductor Industry Interaction Day.

The goal was to enhance the interaction between our students with our colleagues in industry. The event, held in November of 2019, included talks by industrial scientists, lightning talks by postdoctoral and doctoral students, and a panel discussion to provide advice to our graduate students on how to pursue a career in industry.

The industry represented included Intel, TSMC, Lam Research, Wildcat Technologies, nanoComposix, Oculus, Leidos, Versum, RASIRC, and Illumina. The university-industry interactions yielded insights into means of collaboration, as well as provided opportunities for employment from alumni of the program.

Industry Speakers

Ana Kiricova, MS (Wildcat Discovery Technologies)
Boyan Boyanov, PhD (Illumina)
Daniel Spence, MS (Versum)
David Drake, MS (Leidos)
Erik Shipton, PhD (Oculus)
Greg Pitner, PhD (TSMC)
Jeffrey Marks, PhD (Lam Research)
Jeffrey Spiegelman, PhD (RASIRC)
Maria Lopez, PhD (Intel)
Shirley Meng, PhD (UCSD)
Steve Oldenburg, PhD (nanoComposix)

Student Lightning Talk Speakers

Alex Hojem- Postdoctoral Student, Physics
Christopher Coaty- PhD Student, NanoEngineering
Deniz Cakan- PhD Student, NanoEngineering
Erick Martinez Loran- PhD Student, NanoEngineering
Haibin Wu- PhD Student, Chemistry and Biochemistry
Haowen Ren- PhD Student, Materials Science and Engineering
Ivan Zaluzhnyy- Postdoctoral Student, Physics
Jessica Geisenhoff- PhD Student, Chemistry and Biochemistry
Mark Kalaj- PhD Student, Chemistry and Biochemistry
Michael Breeden- PhD Student, Materials Science and Engineering
Min-cheol Kim- Postdoctoral Student, NanoEngineering
Nicolas Vargas- Postdoctoral Student, Physics
Qingzhe Ni- Postdoctoral Student, Chemistry and Biochemistry
Sergio Ayala- PhD Student, Chemistry and Biochemistry

In Memoriam of

Dr. Joanna McKittrick

*October 11, 1954 -
November 15, 2019*



Dr. Joanna McKittrick joined the MAE department in 1988, and the Materials Science and Engineering Program in 1989, immediately after receiving her PhD in Materials Science and Engineering from MIT (with a concentration in ceramic science). Prior to that, she graduated with a BS in Mechanical Engineering from CU Boulder in 1979 and with an MS degree from Northwestern University in 1980. Interestingly, Joanna started her college career as a music major. Her main research interests in the past few years have been on luminescent materials, with a particular interest in rare-earth doped nitride alloy synthesis and zinc oxide band gap engineering; and on biological materials, especially in relation to bone demineralization and deproteinization and the structure and mechanical behavior of natural biological materials. Joanna's research gained worldwide attention by news outlets, including Popular Science, Science News, Tech Times, Nature Discovery and the Smithsonian. She served as Editor of the Journal of the American Ceramics Society and as Associate Editor for the Journal of Biomaterials Applications and for Materials Characterization and Ceramics. Among many other accolades, Joanna was the recipient of the 2017 UCSD Faculty Research Award, given in honor of her significant research contributions. Joanna was a beloved colleague, mentor and friend to many in the Materials Science and Engineering Program, and we celebrate the time we were given to spend with her.

NEW FACULTY



Alex Frano

Assistant Professor, Physics
Ph.D. Technical University of Berlin/Max Planck Institute

Investigates long-range periodicities in the spin, charge, and orbital quantum states observed in transition-metal-oxide films, superlattices, heterostructures and single crystals.



Kenji Nomura

Assistant Professor, Electrical and Computer Engineering
Ph.D. Tokyo Institute of Technology

Nomura's study aims to develop next-generation electronic devices that are transparent, flexible and low-cost, for applications such as display, sensor and solar cells based on new wide-bandgap semiconductor material development.



Ester Kwon

Assistant Professor, Bioengineering
Ph.D. University of Washington

Nanoscale engineered materials to study, diagnose, and treat diseases of the central nervous system.



Machel Morrison

Assistant Professor, Structural Engineering
Ph.D. North Carolina State University

Applies fundamental knowledge from material science and solid mechanics towards enhancing the resilience of civil infrastructure.



Nisarg Shah

Assistant Professor, Nanoengineering
Ph.D. Massachusetts Institute of Technology

Interdisciplinary research involving the development of materials at the nanoscale, which can advance our understanding of and drive molecular interactions between immune cells and their environment to program their function.



Todd Coleman

Professor, Bioengineering
Ph.D. Massachusetts Institute of Technology

Flexible bio-electronics, systems neuroscience, and quantitative approaches to understand and augment brain function.



Thomas Hermann

Associate Professor, Chemistry and Biochemistry
Ph.D. Max-Planck Institute for Biochemistry and Ludwig-Maximilians University

Explores structured RNA as (1) a drug target and a material for (2) self-assembling nano-architectures.

NEW STUDENTS IN 2019-2020

Allen, Anthony Michael
Arthor, Qazi Andrew Arzoo
Bissonnette, Zachary Rasins
Chen, Huiying
Chen, Xiangjun
Chen, Xue
Chen, Yu-Ting
Cheng, Li
Cronk, Ashley Elizabeth
Deysher, Grayson
Feng, Shijie
Feng, Xi
Ham, So-Yeon

Holm, Gillian
Huang, James
Jauregui, Evan Alexander
Kuo, Chenghsuan
Lazarus, Benjamin Seth
Li, Alex Ceng
Li, Minghao
Li, Shili
Lin, Tzeyu
Liu, Haoyu
Liu, Yi
Miao, Jiawei
Peng, Hexuan

Puri, Aniket S
Qi, Ji
Rengarajan, Shreya
Saxena, Suryansh
Shi, Keren
Shiple, Wade
Shu, Chang
Suarez, Francisco Javier
Tavares, Sheron Stephany
Tian, Xinyu
Turner, Ross Elliott
Wei, Weichen
Wen, Chenghua

Whittaker, Clifton Bradley
Wu, Shuoan
Yang, Rui
Yao, Lulu
Yim, Wonjun
Yu, Xiaolu
Zhang, Dawei
Zhang, Qixuan
Zhang, Yukang
Zhou, Sai

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University of California, San Diego

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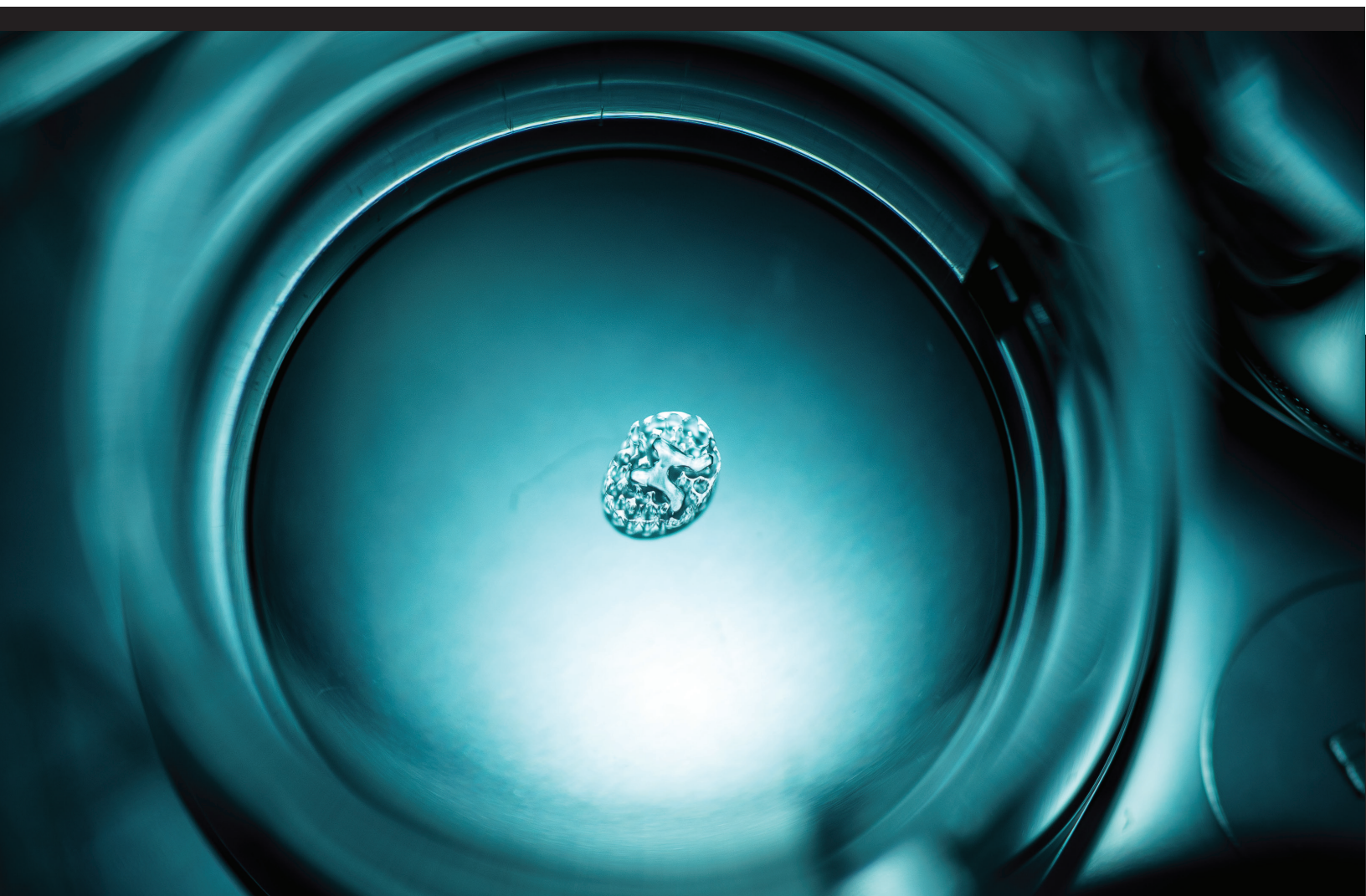


Figure: Shaochen Chen Lab 3D Printed Spinal Cord Implants

Image courtesy: UC San Diego Jacobs School of Engineering

mae.ucsd.edu/matsci