UC San Diego
MATERIALS SCIENCE AND
ENGINEERING PROGRAM

MATERIAL NEWS

Materials Science & Engineering

University of California, San Diego

CONTENT

CONTACT

Sandra C. De Sousa
Graduate Student
Services Advisor

858-246-3213
mats-gradadm@eng.ucsd.edu

Cover Figure:
Time domain simulation of acoustic wave propagation in topological matter
(Figure Courtesy: Prab Bandaru, New Journal of Physics, vol. 20, p. 123011, 2018)

LETTER FROM THE DIRECTOR

Greetings! This newsletter presents a glimpse of a few of the wide-ranging activities in the Materials Science and Engineering (MATSE) Program at UC, San Diego. The range incorporates engineering (Mechanical and Aerospace, Electrical, Structural, Nanoengineering, and Bioengineering), and the sciences (Physics, Chemistry and Biology) as well as the School of Medicine. Indeed, our program is dynamic proof of the pervasiveness of materials science. As many as a hundred faculty across the university are associated with the program which continue its upward trajectory of intellectual growth and development.

As examples of the activities, we are happy to present insights into the synthesis and properties of iron alloys subject to extreme conditions (e.g., at greater than 2000 K) as well as detailed characterization of lithium battery electrodes for high energy density applications. You will also find explorations of new methodologies of generating light using nanostructures and ways that light can be used to read-out molecular level forces and flows. Approaches for enhancing the viability of stem cells for clinical application through engineered polymeric biomaterials are presented.

We are glad to welcome more than 70 new graduate students with far reaching diversity and scientific and technological range. 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 won by Zhenbin Wang, whose work on materials design through computational techniques, has implications ranging from solid state lighting to fuel cells. The program is truly proud of its students – both present and past. We keep in close contact with our alumni – the reputation of the program indeed rests on their shoulders. Two of them look back at their time in MATSE at UC, San Diego. Wil Melitz considers how his doctoral training enabled him to navigate life in industry in the semiconductor industry. Sunghoon Park, now a Professor in Korea, gives advice for preparing for the research of the future as he reminisces on his "painful" senate exam!

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

Sincerely yours,

Prab R. Bandaru

RESEARCH 1

Full-scale Profiling of Lithium Metal Anode

Lithium (Li) metal is the ultimate anode solution for next-generation high-energy-density (> 500 Wh/kg) batteries, due to its lightweight (0.534 g cm-3), low potential (–3.04 V vs. SHE) and high theoretical specific capacity (3860 mAh g–1). The dendritic growth and low Coulombic efficiency (CE) are the two major obstacles that prevent the widespread adoption of Li metal batteries (LMBs). Since the first introduction in 1976, the safe operation of LBM has not been demonstrated. This is primarily because none of the existing characterization tools alone could reveal the true failure mechanism of the Li metal anode.

Professor Meng's group has creatively implemented a set of new characterization tools that enable both qualitative and quantitative investigation of Li plating/stripping behavior from multi-scales. Thus, revealing the principle underlying cause of low CE in LMBs and providing important guidance to Li metal protection towards the daily use of LMBs in next-generation electric vehicles.

Nano-scale morphology and chemical information. Li metal and Li compounds in the solid electrolyte interphase (SEI) are highly reactive and very sensitive to air and electron beams. Room temperature transmission electron microscopy (TEM) fails to provide atomic resolution information, because high-resolution images require high electron dose rate, which causes detrimental beam damage issues to the Li-containing species. Cryogenic TEM has emerged over the past two decades as a structural biology characterization technique. The cryogenic conditions preserved the structural features of the biologic samples, enabling studies in their native state. Professor Meng's group has extended this application of cryo-TEM to the Li metal anode and revealed the detailed structure of electrochemically deposited Li metal (EDLi) and the SEI composition at the nanoscale while minimizing the beam damage (Fig. 1).

Micro-scale morphology. Focused ion beam (FIB) is a versatile tool for sample milling, deposition, cross-section observation, and preparing TEM specimen. Cryogenic protection for Li metal is critical because of its low melting temperature, density, thermal conductivity, and shear modulus, which are especially sensitive to deleterious cascade effects from Ga-ion implantation. Fig. 2 clearly compares the cross-section morphologies of EDLi milled at room (Fig. 2b) and cryogenic (Fig. 2c) temperatures. The comparison clearly demonstrates how cryo-FIB maintains the true micro morphology of the EDLi. When combined with 3D reconstruction of a sequence of cryo-FIB-SEM images, the porosity of EDLi could be accurately quantified. Mr. Thomas Wynn is one of the main contributors to this work. He is a 4th year PhD student in the Materials Science program.

Global mass quantification. The formation of inactive Li is the immediate cause of low CE, short cycle life, and violent safety hazards of LMBs. An outstanding challenge was to quantify the Li+ in SEI and the electrically isolated unreacted metallic Li, which together comprise the inactive Li. Ms. Chengcheng Fang, a 4th year PhD student in the Materials Science program, invented a new method, named Titration Gas Chromatography (TGC, Fig.3), to accurately quantify the metallic Li amount. Coupling with Cryo-TEM and Cryo-FIB, the complete full-scale information about inactive Li has been achieved. Mitigation strategies are thus proposed to enable the highly efficient Li deposition and stripping to enable the Li metal anode for next generation high energy LBMs.

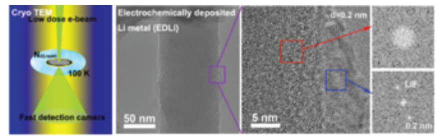


Fig. 1. Nano-scale morphology and chemical information. Inspired by biological imaging techniques, the cryogenic transmission electron microscopy (Cryo-TEM) is employed to reveal the detailed nano structure of electrochemically deposited lithium metal and the SEI composition. (Xuefeng Wang *et al*, Nano Letter, 2017, 17, 7606)

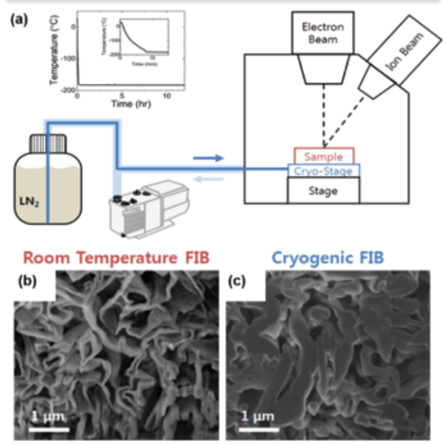


Fig. 2. Micro-scale morphology. (a) Operating principle of cryogenic focused ion beam (Cryo-FIB) system maintaining sample temperature at -170°C during ion beam milling and electron beam imaging. (b) and (c) show the cross-section morphologies of deposited lithium in commercial carbonate electrolyte. (b) is cross-sectioned at room temperature. (c) is cross-sectioned at cryogenic temperature. (Jungwoo Lee, Thomas Wynn *et al*, manuscript under review)

Fig. 3. Global mass quantification. Titration Gas Chromatography (TGC) is invented to quantify the metallic Li amount from the whole complicated inactive Li, the biggest puzzle challenging the Li metal battery cycling performance and safety. (Chengcheng Fang *et al*, manuscript under review, arXiv identifier is 1811.01029)

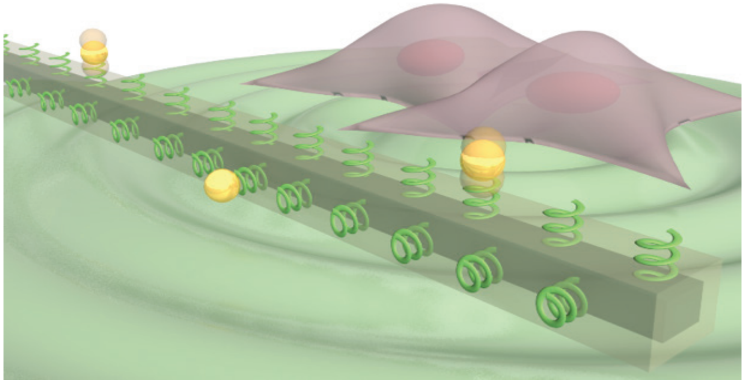
PROF. S. MENG

Shirley Meng is a Professor of NanoEngineering and Materials Science at the University of California San Diego (UCSD). She is also an affiliate faculty member of the Electrical and Computer Engineering Department. She previously held the position of Assistant Professor in NanoEngineering since 2009. From 2008 to 2009, Meng held an Assistant Professor position in Materials Science and Engineering at the University of Florida. From 2007 to 2008, Meng worked as a Research Scientist in Materials Science and Engineering at the Massachusetts Institute of Technology (MIT). Meng received her Ph.D. in Advance Materials for Micro & Nano Systems from the Singapore-MIT Alliance in 2005. She is the founding Director of the Sustainable Power and Energy Center (http://spec.ucsd.edu).

RESEARCH 2

Ultrasmall Fiber Optics That Can Feel and Hear

At the center of any biological process, from nucleic acid and protein production to cellular division and differentiation, there exists small mechanical cues that are critical in the design and execution of the process. Having the ability to track and quantify these nanomechanical events can provide deep insight into the function of Nature's bio-machinery and the quest for novel diagnostic and therapeutic strategies. Instruments such as the atomic force microscope (AFM) and optical/magnetic tweezer have revolutionized the ability to probe mechanical phenomena at the molecular level by offering high force sensitivities, but it remains extremely challenging to access localized areas such as those inside a cell or in living tissue. This is due mainly to the size of the transducers and complicated feedback systems.



Cartoon showing a NOFT device listening and feeling forces generated by nearby cells.

Recently the Sirbuly group has developed a novel nanofiber optic platform that can optically read-out molecular level forces in the femtonewton (10-15 newtons) regime while maintaining a small footprint of only a few square micrometers. In an original paper published last year in Nature Photonics and a Nature Protocols paper this year, his group describes the fabrication and operation of such a system they call a nanofiber optic force transducer (NOFT). They demonstrate that not only could NOFT detect forces with ~ 200 fN sensitivity, but the device could also hear small acoustic signatures with a sensitivity ~ 1000x that of the human ear. The device starts with a single crystalline tin dioxide (SnO2) nanofiber that can guide light with subwavelength dimensions. Because of the small size of the nanofibers, a portion of the guided light extends beyond the surface of the nanofiber in what is known as the evanescent field. This field can be leveraged to detect subtle movement of objects placed near the surface of the waveguide. For example, when a metal nanoparticle is submersed in the evanescent field, it strongly scatters light out of the waveguide and the intensity of the scattered light is strongly correlated to its distance from the surface of the nanofiber. In fact, the separation distance between the nanoparticle and waveguide can be optically tracked with a resolution of ~ 1 angstrom which is equivalent to a chemical bond length. To convert this molecular ruler platform into a force transducer a thin, compressible polymer coating was deposited on the waveguide prior to decorating it with gold nanoparticles. The polymer molecules underneath the gold nanoparticles act as a spring, which can convert the distance-dependent optical scattering signals into force if the mechanical properties of the polymer film are known. Proper calibration of the NOFT system was achieved by using a combined optical/AFM microscope that could extract the mechanical properties of the polymer film and quantify the force resolution of the NOFT devices.

The group demonstrated the force sensing capabilities of NOFT by first detecting sub-piconewton microflow forces generated by swimming bacteria. In addition to detecting forces from direct contact with a material, they went on to show that the devices could hear the acoustic energy produced by beating heart cells. Prof. Sirbuly and his group are excited by this technology and believe this new tool not only opens up possibilities of carrying out fine nanomechanical analysis inside of cells or between individual molecules, but offers a touch-less detection mode that has immediate impact on sound-based biological probing and stethoscopic applications.

Related articles:
Huang, Q.; Lee, J.; Arce, F. T.; Yoon, I.; Angsantikul, P.; Liu, J.; Shi, Y. S.; Villanueva, J.; Thamphiwatana, S.; Ma, X. Y.; Zhang, L. F.; Chen, S. C.; Lal, R.; Sirbuly, D. J., Nanofibre optic force transducers with sub-piconewton resolution via near-field plasmon-dielectric interactions. Nature Photon. 2017, 11 (6), 352-355.
Shi, Y. S.; Polat, B.; Huang, Q.; Sirbuly, D. J., Nanoscale fiber-optic force sensors for mechanical probing at the molecular and cellular level. Nature Protoc. 2018, 13 (11), 2714-2739.

PROF. D. SIRBULY

Donald J. Sirbuly is an Associate Professor in the NanoEngineering Department at UC San Diego, which he's held since 2009. He received his Ph.D. in Inorganic Chemistry from the University of California, Santa Barbara in 2003 under the supervision of Prof. Steven Buratto. He was a postdoctoral researcher in the laboratory of Prof. Peidong Yang at the University of California, Berkeley from 2003-2006. He was the recipient of the Harold C. Graboske Jr. Postdoctoral Fellowship at Lawrence Livermore National Laboratory (LLNL) from 2006-2008 and held a staff research scientist position at LLNL from 2008-2009. He holds a B.S. in chemistry from Westmont College, Santa Barbara.

Nanocrystals Emit Light by Efficiently 'Tunneling' Electrons

Using advanced fabrication techniques, engineers at the University of California San Diego have built a nanosized device out of silver crystals that can generate light by efficiently "tunneling" electrons through a tiny barrier. The work brings plasmonics research a step closer to realizing ultra-compact light sources for high-speed, optical data processing and other on-chip applications.

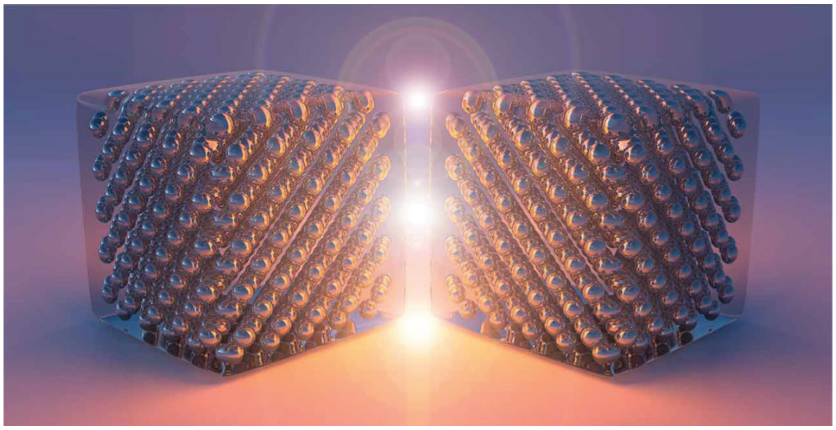


Illustration of nanosized device made of two joined silver single crystals that generate light by inelastic electron tunneling. Artwork by Steven Bopp.

The work is published July 23, 2018 in Nature Photonics.

Plasmonics researchers have been interested in using inelastic electron tunneling to create extremely small light sources with large modulation bandwidth. However, because only a tiny fraction of electrons can tunnel inelastically, the efficiency of light emission is typically low—on the order of a few hundredths of a percent, at most.

UC San Diego engineers created a device that bumps that efficiency up to approximately two percent. While this is not yet high enough for practical use, it is the first step to a new type of light source which may get significantly improved in the future, said Zhaowei Liu, a professor of Electrical and Computer Engineering at the UC San Diego Jacobs School of Engineering.

"We're exploring a new way to generate light," said Liu.

Liu's team designed the new light emitting device using computational methods and numerical simulations. Researchers in the lab of Andrea Tao, a professor of Nanoengineering at the UC San Diego Jacobs School of Engineering, then constructed the device using advanced solution-based chemistry techniques.

The device is a tiny bow-tie-shaped plasmonic nanostructure consisting of two cuboid, single crystals of silver joined at one corner. Connecting the corners is a 1.5-nanometer-wide barrier of insulator made of a polymer called polyvinylpyrrolidone (PVP).

This tiny metal-insulator-metal (silver-PVP-silver) junction is where the action occurs. Electrodes connected to the nanocrystals allow voltage to be applied to the device. As electrons tunnel from a corner of a silver nanocrystal through the tiny PVP barrier, they transfer energy to surface plasmon polaritons—electromagnetic waves that travel along the metal-insulator interface—which then convert that energy to photons.

With additional work, the team aims to further boost efficiency another order of magnitude by exploring different geometries and materials for future studies.

Qian, H., Hsu, S., Gurunatha, K., Riley, C.T., Zhao, J., Lu, D., Tao, A.R. and Liu, Z.,"Efficient light generation from enhanced inelastic electron tunneling," Nature Photonics 12, 485–488 (2018).

This work is supported by the Defense Advanced Research Projects Agency (DARPA) Microsystems Technology Office (W911NF-16-2-0156).

PROF. Z. LIU

Zhaowei Liu is a Professor of Electrical and Computer Engineering at UC San Diego. His interdisciplinary research focus includes nanophotonics, plasmonics, nanomaterials and life science. Lui received his Ph.D. in mechanical engineering (MEMS/Nanotechnology) from UCLA in 2006. Before joining the Jacobs School faculty, Liu was a post-doctoral researcher at the NSF Nanoscale Science & Engineering Center (NSEC) in the Mechanical Engineering Department at UC Berkeley.

Investigating the Transport Properties of Iron Alloys under High Temperatures and Pressures

Understanding the behavior of iron alloys under pressure and temperature is of interest to both material scientists and planetary scientists. In material sciences, the application of pressure under controlled heat allows probing stress-induced phase transformations and the crystalline structure of alloys with different chemistry. In planetary sciences, iron alloys are analogues of the metallic core of terrestrial planets and moons (such as the Earth, Moon, Mars, Mercury) as well as analogues of sulfide melt that can be present in the Earth's mantle and could be detected using field (seismic, electromagnetic) measurements. The transport properties of these alloys at pressure and temperature conditions relevant to a planet's interior are key to understand a planet's structure, its cooling history, and the generation of an intrinsic magnetic field (Figure 1).

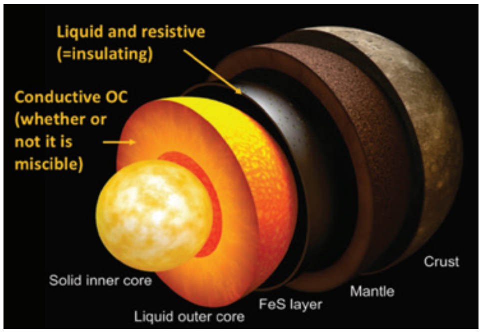


Figure 1: Application to planetary sciences: example of Mercury. Experimental investigation of the transport properties of core analogues (FeS, Fe-Si, Fe-Si-S) have shown that the outermost core of Mercury is likely insulating and in the liquid state. Such properties would impact the generation and sustainability of a magnetic field, providing an explanation to Mercury's weak magnetic field today (Pommier et al., under review). (Image: Charlier and Namur, 2019).

The Planetary and Experimental Petrology Laboratory (PEPL) located at UCSD-SIO investigates the properties of iron alloys by performing experiments under pressure (several GPa) and temperature (up to >2,000K). In particular, we use in situ and real-time electrical measurements to monitor the electrical response of a sample under compression/decompression and heating/cooling cycles. Figure 2 illustrates the cell assembly used for these experiments in the multi-anvil press, designed to measure electrical data at pressures up to 12 GPa. The samples consist of a mixture of high-purity powders (for instance, Fe, FeS, Fe_2O_3, $FeSi_2$). Their electrical response is sensitive to temperature, chemistry, phase transitions (including melting), and pressure. Samples are quenched at the highest temperature and their texture is analyzed using SEM-EDS and electron microprobe techniques (Figure 2). Our group is also developing viscosity measurements under the same temperature and pressure conditions at APS-GSECARS in the Argonne National Laboratory, in order to constrain the mobility of molten iron alloys.

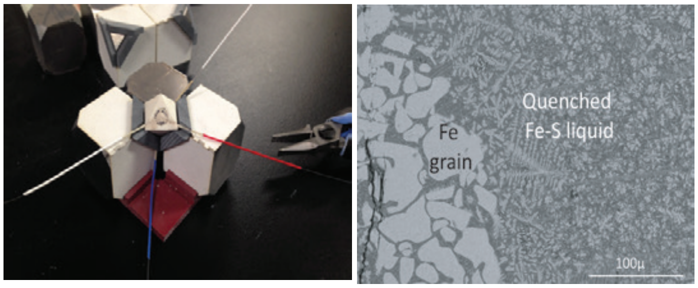


Figure 2: Left: cell assembly for electrical experiment. The wires serve as both thermocouple and electrodes. The sample placed at the center of the octahedron is about 1mm thick. Right: Retrieved Fe-S sample quenched at 1506K and 8GPa presenting a partially molten texture (Pommier, 2018).

Electrical and textural information is used to constrain the phase equilibria of iron alloys and develop electrical models in the solid and molten states. Phase equilibria are relevant to material sciences and in particular, steelmaking; for example, slag production is used to withdraw impurities in metals, and in ferrous smelting, millworkers introduce slag that is designed to minimize iron loss. Understanding the phase changes of specific oxide and sulfide compositions at high temperatures is necessary to adjust the slag composition in order to improve metal purification. In planetary sciences, the insulating or conductive properties of core materials are used to understand core crystallization processes, as well as the cooling history and the present-day structure of terrestrial planets and moons. In geophysics, the electrical models can be used to interpret field electrical data in the Earth's mantle, in order to constrain the mobility and stability of sulfide melt in the planet's interior.

Pin-Cheng Chen also contributed to this article.

Anne Pommier is an Assistant Professor at Scripps Institution of Oceanography at UC San Diego. She earned a Civil Engineering degree and a Master's degree in Earths sciences from the University of Orleans, France, and her Ph.D. in experimental petrology at the Institut des Sciences de la Terre d'Orleans (ISTO), CNRS-University of Orleans. From 2010-14, she was a postdoctoral researcher at MIT and a SESE Postdoctoral Fellow at ASU, and from 2014 to the present, she has been a faculty at UC San Diego Scripps Institution of Oceanography in the Institute of Geophysics and Planetary Physics, where she has developed a high-pressure experimental lab. Recently, she became the COMPRES Distinguished Lecturer (2018-2019).

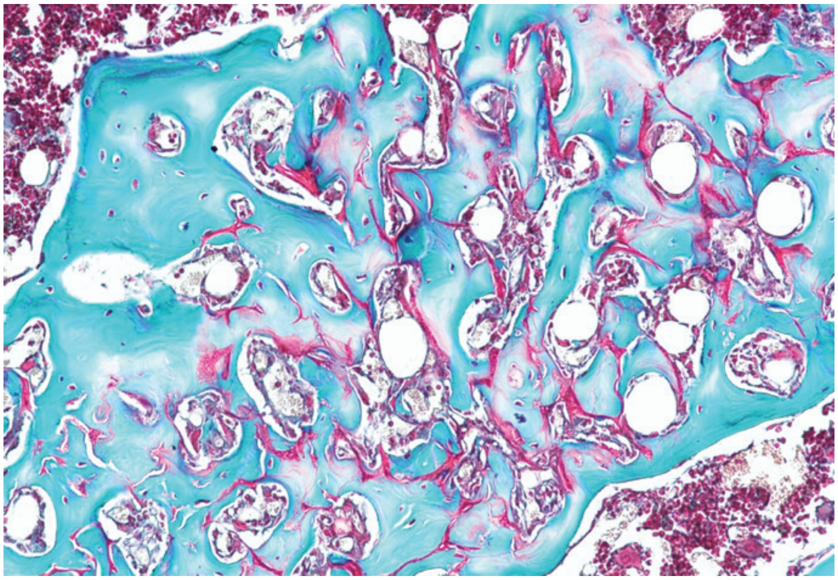
PROF. A. POMMIER

RESEARCH 5

Controlling Cell Fate Decisions through Molecular Engineering

Our work focuses on the design and synthesis of polymeric biomaterials that regulate the fate of cells resident in tissues by providing cell-instructive cues to control spatiotemporal cellular behavior. We develop these polymeric systems to mimic features of the native extracellular matrix to develop new therapeutic approaches which harness the immune system. Through this design of chemical and biophysical tools to control molecular, cellular and tissue interactions we aim to shed new light on the functioning of immune cells which can be used to develop therapies for a broad range of diseases, including cancer, antibiotic-resistant bacterial infection, and autoimmune disease.

Our recent work focused on improving bone marrow transplantation, also known as hematopoietic stem cell transplantation (HSCT), which are life-saving treatments for aggressive diseases, such as leukemia and multiple myeloma, and infections such as HIV. The procedure entails infusion of blood stem cells from a matched donor into the patient to 'reset' the blood and immune system. In order to treat the disease and prevent the patient's body from rejecting the transplanted cells, patients undergo intensive conditioning, which involves administration of chemotherapy and radiation. However, the conditioning regimen also significantly compromises the functioning of normal cells in the bone marrow, and their ability to regenerate the immune system. This includes a reduced ability to generate T cells, and causes profound long-term post-transplant immune deficiency, increases the risk of opportunistic infectious diseases and immunological complications such as graft-versus-host-disease.



A histological section of bone (solid blue-green) containing blood stem cells (red dots) generated using an alginate-based biomaterial (red strands).

In this work, we engineered a cell-free biomaterial-based scaffold that mimicked key features of the bone marrow niche and promoted regeneration of immune-competent T cells after HSCT. Subcutaneously administered scaffolds interfaced with host vasculature to form a host–device interface and presented lineage-instructive cues to recruited various transplanted hematopoietic and host stromal progenitor populations and self-assembled into a bone nodule. Incorporation of bioactive Notch ligand DLL-4 on the polymer scaffold promoted early enhancement in the generation of T cell progenitors in the scaffold and led to a significant increase in the number of thymic progenitors relative to controls receiving lineage-depleted bone marrow grafts that are similar to established models of HSCT. These findings suggest that the scaffold represents a simple-to-administer system that can enhance T cell regeneration after HSCT. If the scaffold system performs similarly in a human context, it may be a means of abrogating the immunological complications and opportunistic infections that limit clinical application of potentially curative HSCT.

Shah, N.J., Mao, A.S., Shih, T.Y., Kerr, M.D.. Sharda, A.S., Weaver, J.C., Vrbanac, V.D., Deruaz, M.D., Tager, A.M., Mooney, D.J., Scadden, D.T. (2019) An injectable bone marrow–like scaffold enhances T cell immunity after hematopoietic stem cell transplantation, Nature Biotechnology (DOI: 10.1038/s41587-019-0017-2, in press).

PROF. N. SHAH

Nisarg Shah is an Assistant Professor in the Department of NanoEngineering at UC San Diego. His laboratory develops biomaterials at the nanoscale to drive molecular interactions and program cellular processes for biomedical applications. Shah obtained his Ph.D. in Chemical Engineering from the Massachusetts Institute of Technology. His graduate research focused on developing nanoscale polymer films and colloidal particles for regenerative medicine. He was a postdoctoral fellow at the Wyss Institute and the School of Engineering and Applied Sciences at Harvard University, where he received the Cancer Research Institute's Irvington postdoctoral fellowship to develop biomaterials to enhance T-cell immunity. He received his Bachelor of Science degree in Chemical and Biomolecular Engineering from Johns Hopkins University where his research focused on developing nanoparticle-based delivery systems for cancer therapy.

Shah has received research and scholarship awards as an undergraduate, graduate and postdoctoral fellow including the Materials Research Society Graduate Student Silver Award, the Collegiate Inventors Competition Silver Medal, the American Chemical Society Graduate Polymer Research Award, the Biomedical Engineering Society Graduate Design and Research Award and the Cancer Research Institute Irvington postdoctoral fellowship. Shah teaches undergraduate and graduate core classes in Chemical Engineering.

MATSE ALUMNI INTERVIEWS

WILHELM MELITZ

Technical Staff, Intel

Dissertation: *Surface Preparation for ALD of High-k Dielectrics on InGaAs*

Advisor: Prof. Andrew Kummel

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

My thesis topic was, "Surface preparation for ALD of High-k dielectrics on InGaAs". The fundamental ALD research translated well to a career at Intel where I work in the Thin Films department. It gave me a great foundation of skills and related experiences that are utilized on a regular basis.

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

I joined Intel's development lab in Hillsboro, Oregon in April of 2013. Since then, I have worked on multiple technology nodes and products. Within that time, I have worked my way up to a senior engineer.

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

The highlight of the MATSE program was working and studying with a tight-knit group of classmates with a wide range of backgrounds. Additionally, the breadth of classes in the MATSE program really set a good foundation for working in industry, where you interact with people from a wide range of technical backgrounds on a variety of projects.

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

I will always remember the time in the lab when the power went out in all of the San Diego area, and the backup generator failed. The whole lab had flashlights, helping each other out trying to warm down our equipment to protect it from what was going to be a long blackout. It reminded me that things can go south quickly and the best thing to do is to contain the issue and make sure it does not get worse. As a team, you can do a lot of work quickly if you work together and trust your teammates. I am very grateful to have had the chance to work with so many talented personalities in my group.

What are your suggestions/advice for MATSE students who would like to get into industry?

My advice for new or senior MATSE students is to not get caught up in the grind that is graduate school. Every problem is a learning experience that you may reflect on later. Every experience is an opportunity to be creative in developing a solution. Every solution is an opportunity to take pride in "doing it right".

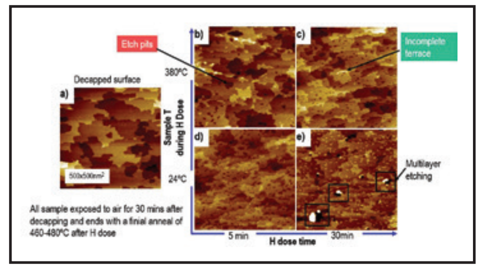
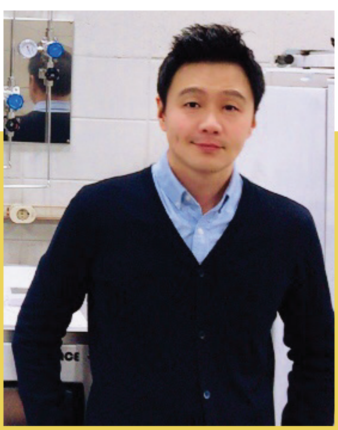


Figure 1: 500×500 nm2 filled state STM images of a) a typical decapped InGaAs(001) surface, with a surface step coverage (SSC) of 5.66%. For STM images b)-e) all samples after decapping then exposed to air for 30 minutes followed by hydrogen cleaning and annealing to 460-480°C. b) Shows a STM image of a sample dosed with hydrogen at a sample temperature of 380°C for 5 minutes with SSC= 7.65%. c) Is for 30 minutes at 380°C with SSC=13.9%. d) Sample is dosed with hydrogen at 24°C for 5 minutes with SSC=13.4%. e) Is for 30 minutes at 24°C with SSC=15.4%. The images are corrected for global tilt.



SUNGHOON PARK

Professor, Department of Mechanical Engineering, Korea

Dissertation: *Electrical, Electromagnetic and Structural Characteristics of Carbon Nanotube-Polymer Nanocomposites*

Advisor: Prof. Prab R. Bandaru

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

My thesis topic was electrical, electromagnetic, and structural characteristics of carbon nanotube-polymer composites. Owing to their lightweight and processability, nano-composites containing conducting fillers such as carbon-based materials and metal fibers have been extensively investigated by industry. The experimental skills and theories related to my thesis could be applied to electronic packaging, structural reinforcement, electric heating and fuel cell materials. Consequently, I got many job offers from research organizations and industry.

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

After graduation, I joined Samsung Advanced Institute of Technology (SAIT). There, I realized the huge gap between industry research and academic research. I focused on patents and practical realization. After six years at SAIT, I moved to Soongsil University in Korea as an assistant professor, for research opportunities.

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

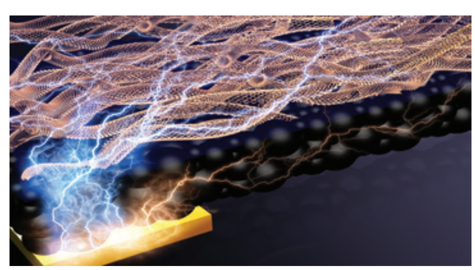
The biggest highlight was the Senate Exam. Of course, it was hard and painful. However, after the test, I realized my research proficiency had increased dramatically. I could see how I should finish and prepare for my Ph.D. degree and my future career.

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

Academic seminars from other researchers yielded some good memories. Many times, I could meet outstanding scholars in my research field and have private discussion time. Such a chance is very rare after you graduate!

What are your suggestions/advice for MATSE students?

There is huge gap between industrial research and academic research. In industry, they care about very practical issues and mass products. Just a proof of concept without cost availability and processability is useless in industry. If you are interested in industry after graduation, please remember three words during your graduate studies: "Novelty", "Inventive Step", and "Industrial Applicability". These are essential conditions in patentability. If your thesis content meets these three conditions, industry will be interested in your work.



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.

Zhenbin Wang

Winner of the Gareth Thomas Award

Describe your research interests.

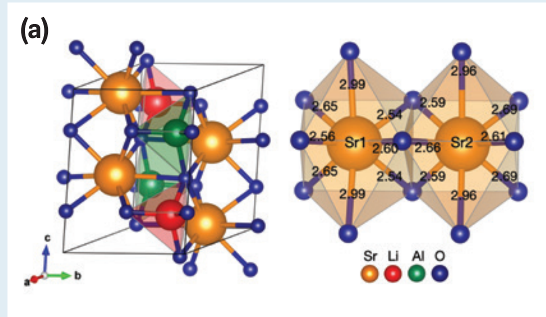
My research area is in Computational Material Science. Particularly, I am interested in the fundamental understanding of the energy conversion processes with applications in solid-state lighting and fuel cells. I also work on developing new materials using material informatics and insights that have emerged from fundamental studies.

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

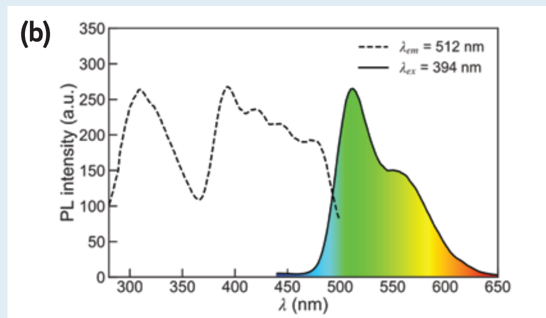
The MATSE program has allowed the research I have conducted to have an interdisciplinary nature, mainly due to the intellectual diversity of its faculty members. Being a Ph.D. student came with many challenges, such as becoming established as a researcher with the ability to conduct world-class interdisciplinary research. The MATSE program offered me the right tools and guidance to enrich my understanding of materials with the aim of designing and tuning their properties from computational calculations. Moreover, thanks to the highly successful collaborations within the MATSE faculty (Dr. Joanna McKittrick and Dr. Olivia Graeve), new fundamental insights on materials had been achieved and novel compounds had been discovered and synthesized throughout my Ph.D. studies.

Where do you see yourself in the future?

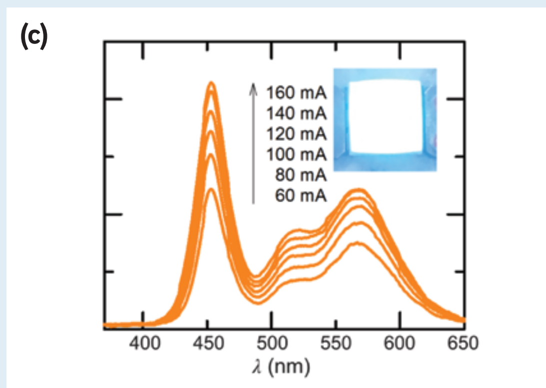
My goal is to find a position in a university or institute where I can grow and pursue my research interests over time. Hopefully, after years of effort, I am able to make great breakthroughs in the design of novel materials for sustainable energy conversion in order to better human life.



(a) crystal structure of Sr2LiAlO4 ($P2_1/m$) and two symmetrically distinct Sr sites (numbers in angstroms).



(b) photoluminescence spectra of Sr2LiAlO4:Eu2+.



(c) the LED device fabricated with InGaN chip + Sr2LiAlO4:Eu2+ phosphor.

(d) untouched shots lit by an LED with the commercial phosphor (left) and the Sr2LiAlO4:Eu2+ phosphor.

Industry Interaction Day

The Materials Science and Engineering Program along with the Department of Chemistry and Biochemistry and the Physical Sciences Center for Student Success sponsored an industry interaction day in early May. The goal was to enhance the interaction between our PhD students and postdoctoral associates with our colleagues in industry.

The program included several talks by industrial scientists and managers, from local and international companies, including TSMC, Applied Materials, Intel, ASML, General Atomics, Illumina, etc. There were lightning (~ 3 minute) talks by doctoral students in the areas related to their areas of research. The day concluded with a panel discussion with the invited speakers, who provided advice to our graduate students on how to pursue a career in industry, networking, and related issues on work-life balance. It was great to see exchange of resumes, as well as internship and job offers!

NEW FACULTY

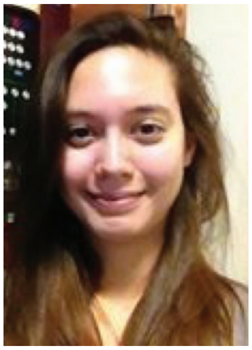
Jinhye Bae

Assistant Professor

Ph.D. University of Massachusetts, Amherst

The Bae lab focuses on understanding and exploiting physics, mechanics, and dynamics of soft matter to develop new pathways of programmable assembly and deformation of soft matter at the nano to macro-scales. The group is interested in integrating material characteristics into new structural design and fabrication approaches for applications in biomedical devices, soft robotics, actuators, and sensors.

j3bae@ucsd.edu



Monica Allen

Assistant Professor

Ph.D. Harvard University

Our research aims to combine scanning probe microscopy with transport techniques to spatially visualize electronic phases in quantum materials and utilize them for emerging technologies, such as quantum information processing.

mtallen@ucsd.edu

Oscar Vazquez Mena

Assistant Professor

Ph.D. Swiss Federal Institute of Technology of Lausanne

Professor Oscar Vazquez Mena's research focuses on integration and application of nanoscale nanomaterials like graphene for energy harvesting, biological applications, and flexible technologies. His research experience covers the fields of two-dimensional (2-D) atomic materials, nanofabrication, photovoltaics and biophysics. He aims to exploit nanoscale physics phenomena to address challenges in energy harvesting. He also aims to develop novel biomedical micro-devices by combining nano- and bio-engineering, and integrating nanoscale materials to biological structures like cell membranes and proteins to study biological processes. His research also looks into developing two-dimensional hybrid metamaterials with novel functionalities for flexible devices.

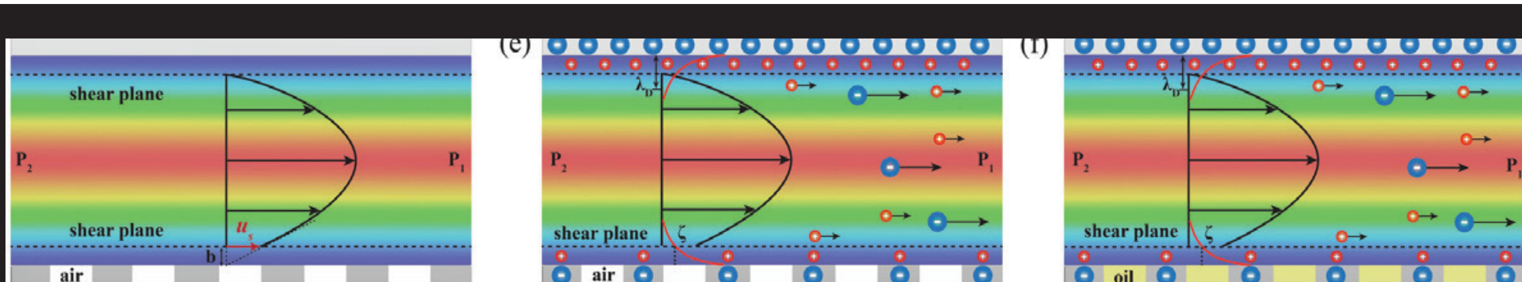
ovmena@ucsd.edu

NEW STUDENTS IN 2018-2019

Chang, Chen-Wei
Chen, Pin-Cheng
Chen, Xinran
Chung, Ka Man
Crane, Gabriel Badillo
Esparza, Guillermo Lazaro
Gao, Hongpeng
Ghazikhanian, Nareg
Grider, Jordan Timothy
Guo, Zhilin
He, Tengyu
Hou, Yifan
Hua, Xiaotian
Huang, Aomin
Huang, Tianjun
Ko, Shu-Ting
Lawrence, Natalie
Lee, Alex Wootae
Lee, Yueh-Lin
Li, Boya
Li, Junjie
Li, Junqiao
Li, Minghao
Li, Qiaochu
Li, Zhengxing
Liang, Stacy
Liang, Sylvia
Ling, Mingheng
Liu, Mingyang
Ma, Xiaotian
Massey, Justin Torasuke
Mesgarzadeh, Neda
Metera, Jenna Marie
Nair, Gokul S
Nibbelink, Luke
Nuanez, Cordero
Park, Yujin
Qari, Nada
Qi, Baiyan
Ree, Jinkyue
Romelczyk, Monica
Sayahpour, Baharak
Schraut, Marile Elise
Shang, Zhaoru
Shao, Siyuan
Song, Jiawei
Statham, Otis
Tsai, Jacob M
Vijayakumar, Sanahan
Wang, Chenglai
Wang, Haotian
Wang, Yufei
Wang, Zijun
Yao, Guangyi
Yao, Weiliang
Yu, Mingyu
Yu, Sicen
Yuan, Yihui
Zeng, Zijian
Zhang, Jingxin
Zhang, Yichen
Zhuang, Tianhao
Zimo, Yang

UC San Diego
JACOBS SCHOOL OF ENGINEERING

Materials Science and Engineering Program
University of California, San Diego
9500 Gilman Drive, Dept. 0418
La Jolla, California 92093-0418



The flow over solid, air, or liquid filled surfaces may be used for controlling fluid drag as well as generating electrical power.
B. Fan, A. Bhattacharya, and P.R. Bandaru, "Enhanced voltage generation through electrolyte flow on liquid filled surfaces", Nature Communications, 9, 4050, (2018).

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