Stanford | ENGINEERING
Materials Science & Engineering

Program Details

Department Overview

Materials Science and Engineering is concerned with the relation between the structure, processing and properties of materials. One important goal of this work involves the development of processes for altering the structure of materials and thereby controlling their properties. This field brings together, in a unified discipline, developments in Physics, Chemistry and Biology that can be, and in fact are, applied to modern materials of technological, engineering, and scientific significance. Materials scientists and engineers utilize a distinctive suite of characterization techniques that probe materials structure down to the atomic level. Moreover, our faculty is extremely active with nano-technology, energy-related materials and bio-materials.

REU Program Overview

The MSE department was granted VPUE and SOE funding to support undergraduate research during the summer of 2015 as part of the MSE Research Experience for Undergraduates (REU) Program: Science and Technology at the Nanoscale. REU participants will have an opportunity to work closely with an MSE faculty member in an area of interest to the student (ex. nanotechnology, energy materials, bio-materials, mechanical behavior of materials, etc). REU students are paired with a Ph.D. student or post-doctoral scholar who will serve as a mentor on a daily basis. Weekly meetings of the REU students are held where, over the course of the summer, each student will have an opportunity to present their project and research results to his or her fellow REU participants. At the end of the program, students will present their work during a poster session at the 2015 MSE Summer Research Symposium. Previous summers have also included field trips to Applied Materials and Solyndra, as well as social events.

Application Process

The application form is available online at http://mse.stanford.edu/student-resources/research-experience-for-undergraduates

Applications are due Friday, March 6, 2015 at 5 pm, by email to Prof. Renee Sher at msher@stanford.edu. **Please include a copy of your unofficial transcript**.

The initial application process involves a short questionnaire in which students will rank their research project preferences. Please note that project titles are subject to change due to the dynamic nature of materials research. Students are strongly encouraged to familiarize themselves with a faculty member's research areas, as it is possible that students will be assigned to another project within the group. Multiple students may be assigned to each faculty member. Each student will have his or her own unique project.

After reviewing applications, individual faculty members may, depending on availability, meet with selected students before making a final decision. Final decisions will be communicated early April.

All Stanford undergraduates in good academic standing are eligible and encouraged to apply. Seniors graduating in June 2015 or earlier are not eligible.

Program duration

The program runs from **Monday, June 22nd - Friday, August 28th**. Attendance on both the first day and last day are mandatory. On Monday, June 22nd, REU students will have an orientation, lunch with faculty, and a mandatory lab safety training. On Friday, August 28th, students will present their summer's work to the broader Stanford community at the 2015 MSE Summer Research Symposium.

Financial Support

Students will receive a stipend of $6400. Room and board are NOT included.

Housing

Students are responsible for arranging their own housing for the summer. Housing on campus can be obtained by applying for summer housing through the University (http://www.stanford.edu/dept/rde/cgi-bin/drupal/housing/)
In addition, plenty of off-campus housing is available in nearby Palo Alto, and summer sublets in graduate student residences are often available on campus. These can be found on Craigslist.org, SUpost.com, and similar websites.

Program requirements

The expected time commitment for the 10 week program is a minimum 40 hours/week. This will vary from week to week and from project to project. Typically, students will find themselves busier towards the end of the summer as they become fully independent researchers. Students are encouraged to fill free time during the beginning weeks with reading background materials and familiarizing themselves with the lab's research activities and equipment. A strong sense of initiative is a crucial ingredient to having a successful experience in the program.

Students will be expected to prepare for their summer project during the Spring quarter by attending research group meetings, reading background material related to their project, and completing any specialized safety and equipment training if possible or necessary before the start of the summer. During the summer, students will attend weekly group meetings with their respective research groups and faculty mentors and participate in enrichment activities with the other undergraduates, including weekly meetings where REU students will present on their projects. At the conclusion of the summer, each student will prepare a poster with results from his or her research project for a departmental symposium.

Stanford undergraduates in good academic standing are eligible to apply. Seniors graduating in June 2015 or earlier are not eligible. This grant may not be used to support honors research projects. Students participating in this program may not register for more than 5 units of coursework nor may they work for more than 10 hours per week in addition to their research appointment. Academic credit for participating in the summer program will not be awarded.

Contact Information

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Participating Faculty and Summer Research Project Descriptions

Professor Bruce Clemens

“Nanoparticles for photoelectrocatalysis”

The goal of this project is to develop novel nanoparticles to promote photoelectrocatalysis, where incoming solar energy is converted into storable energy such as hydrogen or methanol.

Professor Yi Cui

"Nanomaterials design for energy applications"

This project explores the materials design to address the problems in the area of energy conversion and storage. Some applications examples include thermal textile, batteries and electrocatalysis. Students will have an opportunity to learn the skills of nanomaterials synthesis, structure characterization, energy device fabrication and testing.

Professor Reinhold Dauskardt

“Complex mechanical behavior in nanostructured thin films”

The intent of this project is to study the nano-mechanical properties and adhesion of advanced thin-film structures that have applications in a wide range of emerging technologies. The goal of the work is to develop a fundamental understanding of how the films’ mechanical properties are related to their nanostructure and processing conditions. In particular, we will be interested in how the films are affected by the presence of selected solution chemistries that may be associated with processing or operating conditions. The student will gain familiarity and experience with a number of experimental techniques, including thin-film sample preparation and adhesion testing, and the use of atomic force microscopy, X-ray photoelectron spectroscopy, and possibly scanning electron microscopy for analyzing fracture surface composition and morphology.

“Biomechanical function of human skin”

A quantitative in-vitro experimental biomechanics approach to examine the biomechanical properties of human skin which are vital for its function but poorly understood. Students will use a range of thin film characterization techniques to explore the outermost stratum corneum layer of skin and determine the effects of preconditioning treatments and cellular structure. We would also like to expand the research project to include multiple layers of skin. The project involves applying novel and new micromechanical and characterization techniques to study the structure and biomechanical function of human skin. Students will learn to separate, enzymatically treat and condition human skin, fabricate specimens, and conduct testing and analysis using methodologies developed in our research group. Analysis techniques such as scanning electron and optical microscopy will be employed, together with newly developed techniques involving wafer curvature and bulge testing of soft tissues.

Professor Jennifer Dionne

"Seeing is believing: High sensitivity nano-optical biosensors for your smart phone"

Real-time diagnosis of diseases and point-of-care clinical evaluation requires fast, small, and sensitive biological sensors. This project will investigate novel designs of miniaturized, high-throughput, and label-free plasmonic biosensors. A goal is to develop a portable, smart-phone compatible biosensor that can detect very low concentrations of biological toxins. The student involved in this project will work on the design optimization, fabrication, and optical characterization of the plasmonic nanosensor, as well as potential smart-phone integration.

"Lights, Chemistry, Action! Light-induced synthesis of novel catalysts for energy"

Light absorption and scattering in metal nanoparticles gives rise to plasmon resonances that generate large temperature and electric-field gradients at their surface. Here we propose to make use of these large gradients to drive the formation of novel nanoparticle catalysts for solar fuel conversion. Initial studies will focus on silver-titania core-shell systems, which have been shown to be particularly good catalysts for water-splitting. The student will learn how to synthesize and purify metal nanoparticles; determine a suitable metal-oxide precursor with proper decomposition kinetics; design and assemble an optical set-up for the light-induced synthesis of nanoparticles; and accomplish the first light-induced syntheses of novel silver-titania core-shell nanoparticles.

Professor Sarah Heilshorn

"Design of biomaterials with nanoscale precision through protein engineering"

A unique approach to designing biomaterials involves mimicking the tools evolved by nature to create functional materials at the molecular level. The REU student will be involved in the synthesis, purification, and characterization of protein-based biomaterials using engineered bacterial hosts. These biomaterials will be evaluated for use as regenerative medicine scaffolds to induce the formation of new tissue.

Professor Aaron Lindenberg

"Femtosecond measurements of materials as they transform"

This project is focused on visualizing the first dynamical steps in how materials transform between different structural phases, and their underlying speed limits. The focus is on the study of materials for next generation information storage technologies, including both crystalline-amorphous transitions in phase-change materials, and ferroelectric switching dynamics. Summer students will learn to use light sources spanning the frequency range from THz to x-rays, novel aspects of lasers, photonics, and accelerators, and apply these towards the understanding of new light-driven functional devices.

Professor Michael McGehee

“Perovskite solar cells”

It is now possible to spin cast perovskite semiconductors to make solar cells with over 20% power conversion efficiency. There will be projects to understand why these semiconductors perform so well in solar cells, improve long-term stability, and make tandems with perovskite solar cells on top of conventional silicon solar cells. Summer interns could make and test solar cells, use characterization techniques such as x-ray diffraction, scanning electron microscopy and x-ray photoelectron spectroscopy, and use device modeling software.

Professor Paul McIntyre

"Characterization of Ge-Sn nanowires"

Semiconductor nanowires are molecular-scale building blocks for future electronic and photonic devices. We are interested in Ge-Sn alloy nanowires because they hold the potential for excellent performance as nanometer-scale photodetectors and, possibly, light emitters. A starting point is to grow Ge nanowires using a Sn catalyst layer that encourages local deposition of the chemical precursor for Ge growth in a chemical vapor deposition reactor. This summer REU project in the McIntyre Lab would focus on characterization of these Sn-catalyzed Ge nanowires using electron microscopy, and a study of their structural stability after annealing to moderate temperatures. Data obtained by the REU researcher would be correlated with results on the optical properties of these nanowires.

Professor Nicholas Melosh

"New synthetic routes to low dimensional chalcogenides"

Chalcogenides are one of the hottest materials areas right now, with reports of single monolayer superconductivity, high water-splitting activity, and ability to behave as topological insulators. In this project we will explore a newly discovered synthetic method to create these materials in 1D and 2D forms using self assembly with unique structure directing agents. You will asked to investigate the structure properties relationship for different growth conditions, and try to identify predictive metrics between the molecular structure and the resulting crystal structure and opto-electronic properties.

Professor Evan Reed

"Computer modeling of nanomaterials"

This project involves the development and use of computer algorithms to calculate materials properties from the atomic structure. Students will develop expertise in calculation of electronic, optical, or acoustic properties of bulk materials and nanostructures.

Professor Alberto Salleo

"Art+Science research project with SSRL and Cantor"

The focus of the Fellow's research can address a wide range of issues, including studies in technology and identification of materials. The Fellow can assist in authentication, validating authorship, age, state of preservation, and method of construction, and also could help determine provenance in collaboration with faculty, science students, conservators and other institutions. Other areas of research could include testing new materials for artists and conservators, or studying the aging and degradation of artist's materials. New analytical equipment might be developed. Students will be supported by museum professionals, Stanford faculty and research scientists as they develop and lead their rigorous research project ("technical art history"), using scientific equipment at Cantor and at relevant laboratories on campus. Techniques and technologies might include: x-ray fluorescence; reflectance spectroscopy, microscopy; mass spectrometry; x-ray diffraction; laser; and hyper-spectral imaging, among others. Alberto Salleo is the Materials Science mentor, Apurva Mehta will be the SSRL mentor and Susan Roberts-Manganelli the Cantor mentor.

"Soft materials for mixed ionic and electronic transport"

This project will focus on the fabrication and characterization of thin film devices for the transduction of ionic fluxes into electrical currents. These devices find applications in bioelectronic and sensing of physiological signals. The materials involved are typically polymer blends. The student will learn how to make electrochemical thin film transistors and how to characterize their electrical properties. Both the ionic and electronic conductivity will be measured as a function of processing and morphology. The ultimate goal is the fabrication of a non-volatile transistor, which is a type of device that cannot be easily made using conventional electronic materials.

Professor Robert Sinclair

"FIB and SEM of nanomaterials"

This research project will compare the relative merits of the scanning electron microscope, focused ion beam/scanning (transmission) electron microscope, and transmission electron microscope for characterizing the structure of nanomaterials, especially nanoparticles and nanowires. Nanoparticles for medical application such as cancer detection will be synthesized and characterized by these advanced microscopes.

Professor Shan Wang

“Magnetic nanoparticle-based collection and analysis of circulating tumor cells from blood samples”

Collection and analysis of circulating tumor cells (CTCs) from blood samples could someday serve as "liquid biopsies" to yield insights into cancer diagnosis and treatments. This project involves the development of magnetic nanoparticle-based collection and analysis of CTCs from blood samples. Using a microfabricated magnetic sifter device, CTCs in blood are conjugated to magnetic nanoparticles and collected by flowing the blood through a dense array of micropatterned slots. Students will develop lab expertise in biological sample processing and analysis techniques according to their interests, including fluorescence microscope image acquisition, cell culturing, polymerase chain reaction (PCR) for DNA and RNA characterization, device fabrication and testing, and data analysis.