Winter 2015 IMR Facility Grants
Awarded by the OSU Institute for Materials Research (IMR)

Ten new research projects were awarded by the IMR in January 2015, for a total investment of $20,000 in nascent materials research. The ten projects support faculty researchers from six different departments within the College of Engineering and College of Arts and Sciences.

Second Harmonic Generation (SHG) and Confocal Reflectance Microscopy (CRM) for Imaging Collagen

Gunjan Agarwal, Biomedical Engineering

The goal of this project is to use second harmonic generation (SHG) and confocal reflectance microscopy (CRM) to understand how morphological and ultrastructural changes in collagen affect receptor binding. Specifically, the fiber morphology and distribution of collagen in physiological and pathological murine aortic tissue will be characterized.

Optimizing Schottky Contact for Silicon Carbide Alpha Particle Detectors

Thomas Blue, Mechanical and Aerospace Engineering; Co-Investigator: Lei Cao, Mechanical and Aerospace Engineering

In support of recent DoE efforts towards developing pyroprocessing of used nuclear fuel, we are proposing to manufacture silicon carbide (SiC) Schottky barrier alpha particle detectors for the purpose of monitoring actinide concentrations during reprocessing. Measuring actinide concentrations is an important factor for addressing non-proliferation concerns, allowing for accurate accounting of all nuclear material in the system. Previous work has been done on the feasibility of a nickel-titanium-gold Schottky contact, but failures at high temperature have led to a revision of the Schottky contact composition. Two revised contact compositions will be considered: a thicker nickel-titanium-gold contact and a nickel contact with a diamond layer for corrosion resistance. The facilities available at the NanoSystems Laboratory will be used to develop and manufacture the revised detectors.

Identifying Nucleation and Growth Intermediates for Zeolite Crystalization

Nicholas Brunelli, Chemical and Biomolecular Engineering

The structure of microporous materials is intimately related to the resultant material properties. The mechanism through which these complex structures form is not well understood. This project will utilize the core facilities to identify key species responsible for the crystallization and growth of microporous materials.

Three Dimensional Imaging of Point Defects in Functional Materials Using Quantitative Scanning Transmission Electron Microscopy

Jinwoo Hwang, Materials Science and Engineering

We propose to identify the individual point defects that directly relate to the important properties in functional materials using an atomic-scale 3D imaging technique. Determining the exact 3D location, distribution, and segregation of point defects will be done using quantitative scanning transmission electron microscopy (STEM), which allows for direct interpretation of the image in terms of the number of atoms and atomic species. We will advance this technique in an aberration corrected STEM with a high-brightness electron source, which will enable unparalleled lateral resolution and depth precision in the 3D mapping of point defects in emerging materials for device applications.

Investigation of "Microalloying" Effect in Precipitation Strengthening in Lightweight Magnesium Alloys

Alan Luo, Materials Science and Engineering

Micro-alloying has been widely used to stimulate precipitation strengthening in many alloy systems, but current alloy development using this approach is primarily based on trial-and-error experimentation, which is time-consuming and ineffective. The mechanisms for micro-alloying are not well-understood, but generally related to the nucleation and growth of precipitates in the alloy microstructure. This project explores the science behind the mysterious "micro-alloying" effect in magnesium alloys, to develop a scientific framework in selecting the most effective and economic micro-alloying additions in designing new lightweight alloys.

Improved Wirebond Multichip SiC Power Module for Harsh Environment

Fang Luo, Electrical and Computer Engineering

This research focuses on the design and evaluation of multichip SiC power module for harsh environment application. The research covers packaging material system/ and layout design and optimization. The man content includes the selection and comparison of the module substrate, high- temperature/high-reliability solder and encapsulation material, failure mode analysis and electrical layout structure optimization. The goal of this research is to build a SiC power module for high frequency and high-temperature operation in large swinging ambient temperature.

Site Specific TEM Specimen Preparation of Devices with Sub-Surface Features

David McComb, Materials Science and Engineering

High quality TEM analysis requires high quality, thin specimens, which are often prepared using a focused ion beam (FIB) instrument. However, if the features of interest lie below the surface of the structure or device, the FIB operator is often left to guess as to exactly what area of the sample from which the TEM specimen should be extracted, making it inefficient and difficult to capture particular features or defects of interest for further investigation. Recently we have shown that electron channeling contrast imaging (ECCI) in the SEM can be used to see sub-surface features using a standard secondary electron (SE) detector. This opens the opportunity to combine ECCI and FIB to image and target specific sub-surface features in the dual beam FIB. The project proposed here will serve to develop this method, ECCI-FIB, into an extensible tool for use in a wide range of research projects where sub-surface features need to be captured within the prepared specimens for TEM analysis.

STEM-Cathodoluminescence Studies of Oxide Nano-heterostructure Interfaces

Patricia Morris, Materials Science and Engineering

This work seeks to take advantage of a new prototype STEM-Cathodoluminescence detector at CEMAS which will allow the defect levels and band gap properties of semiconducting oxide nano-heterostructures to be mapped with a spatial resolution of ~2 nm in the Image Corrected Titan3 S/TEM. These are a relatively new class of materials that have been heavily studied in the past few years primarily for gas sensing, catalysis, and photovoltaics. Specifically, this study will analyze widely-used n-type SnO_2 nanowires that are coated with a 5-30 nm layer of other n-type and p-type oxides. Many groups that use these types of heterostructures explain their often unique behavior with bulk band theory which largely should not be assumed valid in these materials. This study will demonstrate this new capability and will map the electronic structure of each material and directly show how it varies on a nano-scale as affected by the distance from the surface and as moving across the n-n or p-n junction interface, which has never before been reported in this class of materials.

Directing Cancer Cell Migration through Non-Contact Induced Electric Fields in Confined Microfluidic Channels

Jonathan Song, Mechanical and Aerospace Engineering; Co-Investigator: Vish Subramaniam, Mechanical and Aerospace Engineering

Revealing the mechanisms for cancer cell migration is necessary to ultimately achieve the goal of preventing metastasis. Recent studies have shown that migrating cancer cells can directionally respond to applied electric (E) fields, a phenomenon called electrotaxis, while the mode of cell migration is influenced by topological cues provided by narrow microtracks < 10 μm diameter. However, the exact cellular mechanisms that narrow microtracks regulate electrotaxis is not known. To address this important question, we will build off our recent work on cancer cell electrotaxis in response to inductive alternating E fields produced by a time-varying magnetic fields, and leverage our expertise in microsystems engineering to develop readily scalable electrotaxis chambers for live imaging of cell migration under well-defined E fields and microscale topology.

Construction of Broadband THz Quarter Wave Plate

Rolando Valdes Aguilar, Physics

THz experiments using broadband circularly polarized pulses are very rare, as circular polarization is typically obtained from birefringent materials that can convert linear to circular polarization at discrete frequencies only. We will construct a broadband THz quarter wave plate by using several single crystalline sapphire (Al_2O_3) wafers stacked on top of each other.