Fall 2010 Facility Grants
Awarded by the OSU Institute for Materials Research (IMR)

Thirteen new research projects were awarded by the IMR in December 2010, for a total investment of $26,000. The thirteen projects support faculty researchers from seven departments within the College of Engineering and the Division of Natural and Mathematical Sciences.

Characterization of Single Domain Superparamagnetic Nanoparticles

Lead Investigator: Gunjan Agarwal, Biomedical Engineering; Co-Investigator: P. Chris Hammel, Physics

This project aims to characterize the magnetic properties of single-domain superparamagnetic nanoparticles with respect to their crystalline orientation. A combination of analytical transmission electron microscopy (TEM) and atomic-force microscopy (AFM) based techniques will be employed for qualitative and quantitative analysis of data.

Characterization of Dendritic Barium Titanate Formed by Hydrothermal Conversion from Nanostructured TiO_2 Precursors

Lead Investigator: Sheikh Akbar, Materials Science and Engineering; Co-Investigator: Prabir Dutta, Chemistry

Titania (TiO_2) nanowires grown by a simple one-step thermal oxidation process are used as precursors for hydrothermal conversion to dendritic barium titanate. Preliminary tests have shown the dendrites to exhibit ferroelectric response to an applied electric field. The proposed study focuses on the characterization and optimization of the growth and conversion process to enhance the ferroelectric behavior and understand the basics governing the production of the dendritic morphology.

Freestanding Infrared Plasmonic Mesh

Lead Investigator: James Coe, Chemistry

The Coe group will create a mask and procedure for producing freestanding metal films with arrays of subwavength holes, i.e. plasmonic metal mesh, at the OSU facilities. The holes will be used to capture airborne dust particles that are sucked out of the air. The plasmonic properties of the mesh will enable infrared absorption spectra to be recorded of single, individual dust particles which enables their chemical composition to be determined. Since the concentration of respirable dust is directly correlated with human health, these results will provide some preliminary results for an NIH proposal.

Self Patterning of Zirconia Substrate Surfaces for YBCO Superconductors

Lead Investigator: Suliman Dregia, Materials Science and Engineering; Co-Investigator: Michael Sumption, Materials Science and Engineering

Surfaces of yttria-stabilized zirconia (YSZ) are patterned by a simple process, to produce arrays of self-assembled epitaxial nano-islands with strong order in size, spacing and alignment. The patterned surfaces are used as substrates for the pulsed-laser deposition of YBCO superconducting coatings, in an investigation of the potential enhancement of flux pinning and critical current density. The immediate focus of the study is on characterizing the microstructure of the films and correlating the defect types and content with measured flux pinning and critical current. In the long term, and owing to the ease and scalability of the patterning process, the benefits of substrate surface patterning can be transferred smoothly to the leading large-area technologies for producing coated conductor tapes.

Spintronic Phenomena in Organic-based Materials and Organic-based Biosensors

Lead Investigator: Arthur Epstein, Physics; Co-Investigators: Bin Li and Jesse Martin, Physics Graduate Students

IMR support will go to two sub-projects of the team's program for spintronics phenomena based on the organic and organic-based biosensors are: (1) Use of the fully spin polarized semiconductor V[TCNE]x (TCNE = tetracyanoethylene) with TC as high as 400 K in spin light emitting diodes and spin valve devices, and (2) Use of polyaniline nanoparticles and nanostructured thin-films in biosensors.

Hybrid Lamellar Lattices as a Platform for Molecular Electronics

Lead Investigator: Joshua Goldberger, Chemistry

Hybrid materials that consist of inorganic – small molecule junctions have shown great promise as inexpensive, solution-processible active matrices in a variety of energy conversion technologies, such as thermoelectrics, or photovoltaics, although the heterogeneity in bonding arrangements and variability of the nanostructure limits our ability to predictably and reproducibly achieve desired properties. Here, we seek to create crystalline solid-state materials comprised from conducting organic mono- or bilayers that are bound to two-dimensional metallic or semiconducting inorganic frameworks with molecular scale thicknesses. These hybrid lamellar materials feature an extremely high-density of inorganic-small molecule interfaces in parallel, oriented orthogonal to the lamellar axes. With this IMR facilities grant, we will develop the capabilities of measuring the electronic properties across specific crystalline axes, in order to provide a fundamental understanding of how to chemically control the flow of charge across the organic/inorganic interface as well as within each component.

A Novel Immunoisolation System for Islet Transplantation

Lead Investigator: Jianjun Guan, Materials Science and Engineering

The research objective is to explore a novel immunoisolation system with efficient immunoisolation and enhanced islet survival properties. The successful development of the proposed immunoisolation system will significantly augment islet survival after transplantation, and will eventually lead to a remarkable improvement in the efficacy of islet transplantation. To achieve this goal, we will create a capsule-type immunoisolation system possessing two critical functions: 1) efficient immunoisolation to decrease immune response-induced islet apoptosis. This includes immunoisolating both immune proteins and pro-inflammatory cytokines; and 2) favorable microenvironments to actively enhance islet survival and function.

High-Quality Gate Dielectrics by Atomic Layer Deposition for III-Nitride-based Power Electronics

Lead Investigator: Wu Lu, Electrical and Computer Engineering

This project aims to develop high-quality gate dielectric for higher breakdown voltage, faster power-switching speed, and higher current capability required for wide-bandgap semiconductor power switching devices. Such devices can contribute to energy saving and can be used as smart power grid interfaces for solar, wind and other renewable energy generations, and traction drives in electric or hybrid electric vehicles. This IMR Facility Grant will cover partial cost of facility user fees at NanotechWest (NTW) and Nanoscale Material Processing Center (NanoMPC) for device development.

Analysis and Characterization of Metal-Oxide Thick Films for Use in Gas Sensor Applications

Lead Investigator: Patricia Morris, Materials Science and Engineering

Metal oxide semiconductor materials are useful for analyzing trace amounts of off-gases through changes in their electrical properties (resistance). Our work will involve the development, analysis, and characterization of metal-oxide thick films for use in detection of off-gases in the steel making industry. A special emphasis will be placed on characterization of microstructure in order to maximize sensitivity and reproducibility. The goal is to produce a metal oxide thick film sensor array that can accurately and repeatably analyze off-gas concentrations in harsh industrial conditions.

Self-Assembly of Nanostructured Hybrid Materials

Lead Investigator: Jon Parquette, Chemistry

The self-assembly of small molecules into one-dimensional nanostructures offers many potential opportunities for electronic and biomedical applications. Most applications require the assembly or co-integration of molecules with specific properties within the nanostructures. Thus, the self-assembly process must not only be controllable with regard to nanostructure, it must be capable of integrating these functional components. The long-term objective of this work is to understand how the nature, dimensions and composition of the nanostructures can be controlled on the nanoscale, and to correlate these structural factors with the corresponding physical, chemical and functional properties.

Tissue Scaffolds: Connecting Synthesis, Structure, and Mechanical Environment

Lead Investigator: Heather Powell, Materials Science and Engineering; Co-Investigator: Peter Anderson, Materials Science and Engineering

A clear understanding of the interconnection between synthesis, structural properties and mechanical response in scaffolding materials is needed in order to advance the field of tissue engineering. A validated finite element model which can predict these behaviors based on single fiber properties and fiber architecture would provide a platform to make substantial advances at a far more rapid pace. This proposal seeks to utilize recent advances fibrous scaffold synthesis to develop a model scaffold system where mechanical properties of the macroscopic scaffold can be altered without a change in scaffold architecture or surface chemistry. State of art imaging and image analysis techniques will then be utilized to quantitatively describe the geometry of the scaffolds as a function of applied mechanical strain. Finally, micromechanical analyses using force AFM will be used to connect subfiber structure with single fiber mechanics and multifiber mechanical response. This new information will be utilized to generate a finite element model which can predict the mechanical response of a scaffold to an applied load or strain.

Micro-Electro-Mechanical Switches for Integrated Optical Applications

Lead Investigator: Siddharth Rajan, Electrical and Computer Engineering; Co-Investigator: Gregory Washington, Mechanical Engineering

By modeling, designing, developing and fabricating a GaN-based micro-electro-mechanical optical switching device, the research team will add valuable momentum to the nascent, promising field of GaN micro-devices that can go beyond the limitations of conventional optical-MEMS. In order to meet the aforementioned broader goal, the proposed research involves the following specific objective: The development of a novel microfabrication process based on PhotoElectroChemical (PEC) etching necessary towards realizing the device and characterizing the GaN material.

Micelle-Mediated Self-Assembly of Multifunctional Hybrid Nanoparticles

Lead Investigator: Jessica Winter, Chemical and Biomolecular Engineering; Co-Investigators: Barbara Wyslouzil, Chemical and Biomolecular Engineering; Gang Ruan, Chemical and Biomolecular Engineering

The great potential of nanoparticles with a single function (e.g. fluorescence OR magnetism) has been widely demonstrated. Recently, we successfully developed a platform technology based on micelle-mediated self assembly to create nanoparticles with multiple functions. This proposed work seeks to develop a large-scale production strategy for these hybrid nanoparticles. Fundamental studies on the production process and the structure of the hybrid nanoparticles will also be pursued.