2011-2012 OSU Materials Research Seed Grant Program Awards

This Winter, the new **OSU Materials Research Seed Grant Program** was established as an enhanced seed program unifying the primary internal research funding opportunities offered by the Center for Emergent Materials (CEM), the Center for Electronic and Magnetic Nanoscale Composite Multifunctional Materials (ENCOMM), and the Institute for Materials Research (IMR). The OSU Materials Research Seed Grant Program provides three distinct Funding Tiers designed to achieve the greatest impact for seeding and advancing excellence in materials research of varying scopes.

We are excited to announce that after a thorough internal and external review process, seven new one-year awards have been made to fund innovative and exciting materials research on campus through the OSU Materials Research Seed Grant Program. These awards total $480,000 in internal research funding to 15 OSU researchers in seven departments.

2011-2012 Proto-IRG Grants

Proto-IRG Grants provide funds up to $100,000/year per award in direct costs, require one Principal Investigator (PI) and two Co-Principal Investigators (Co-PIs), and may have unfunded collaborators. Proto-IRG Grants have the goal of forming new Interdisciplinary Research Groups (IRGs) that could be incorporated into the CEM renewal proposal in 2013. Three Proto-IRG Grants were awarded this year:

1. *Thermal Spintronics: Engineering Spin Currents and Dissipation,* Principal Investigator: Roberto Myers, Materials Science & Engineering; Co-Investigators: Joseph Heremans, Mechanical and Aerospace Engineering; Ezekiel Johnston-Halperin, Physics

   Abstract: This proposal aims to continue the proto-IRG begun last year to study the thermodynamics of spin transport and magnetism in semiconductors through the development of new materials and measurement schemes that combine spintronic materials with high sensitivity thermal transport and calorimetry. In one year of work we have studied the thermal generation of local spin currents in several materials, uncovering a material dependence to the spin-Seebeck effect as well as experimentally revealing the phonon-driven nature of the microscopic physics. Additionally we have begun development of new experimental schemes for studying thermal dissipation due to spin injection/transport, as well as developed new materials for spin injection and magnetism in semiconductors. In the second year, we will expand the scope of our experimental and theoretical efforts through a team of internationally renowned collaborators. Projects

include theoretical modeling of our spin-Seebeck data taking into account the recently uncovered phononspin physics, spin calorimetry using free standing membranes to examine the dissipation due to optical spin injection, and microwave spin-injection into wide band gap semiconductors. Our proto-IRG team will be strengthened through continued co-authored publication of our results in high impact journals and their dissemination at international conferences.

2. *Characterization & Synthesis of Mimetic Cell-Secreted Exosomes for Cell Signaling*, Principal Investigator: Michael Paulaitis; Chemical & Biomolecular Engineering; Co-Investigators: Andre Palmer, Chemical & Biomolecular Engineering; Chia-Hsiang Menq, Mechanical & Aerospace Engineering

   Abstract: We propose to design and assemble synthetic vesicles that have the structural, mechanical, and biophysical/chemical characteristics of cell-derived exosomes – small (< 200 nm diameter) membrane encapsulated particles secreted by cells in response to specific intracellular signals. Exosomes have biological significance as intercellular signaling complexes, most notably, through their ability to transmit genetic information that can effectively trigger the reprogramming of target cells. Although the cell signaling functions attributed to exosomes depend critically on their specific interactions with target cells and subsequent internalization of their contents, the targeting mechanisms, as well as the biophysics of membrane adhesion and fusion, in general, are poorly understood. The overall objective of this project is to resolve these exosome-specific targeting mechanisms. To meet this objective, we will create synthetic exosomes that mimic properties of cell-derived exosomes considered to be important factors controlling these mechanisms, and then systematically study how these properties affect exosome binding and fusion to cell membranes. An important component of the project is to devise cell-membrane models to study exosome binding and fusion, and to measure the kinetics of these processes. Our long-range goal is to predict the target cells of biological exosomes as a means to control this mode of intercellular communications.

3. *Magnetic Resonance Studies of Chromatin Dynamics and Function*, Principal Investigator: Michael Poirier, Physics; Co-Investigators: Chris Hammel, Physics; Christopher Jaroniec, Chemistry

   Abstract: Each human cell contains a complete genome where all of our genetic information is encoded within DNA molecules that total a meter in length. Normal functioning cells use only a fraction of the genes encoded into their DNA, which implies that each cell must control which genes are expressed. This is accomplished by changes in the physical compaction of the DNA molecules into a highly conserved structural polymer, chromatin. This implies that changes in the physical and material properties of our genome are a central mechanism for regulating gene expression and stability. A human chromosome contains a centimeter length DNA polymer that appears to be

organized into a multi-level structure. However, beyond the first level of DNA organization, little is known about chromosome structure and dynamics. We are investigating the structure and dynamics of an intermediate level of chromosome organization, chromatin, by using established magnetic resonance techniques, solid state NMR and EPR, and developing optically detected magnetic resonance at the single molecule level. Renewal of this seed project will continue the development of a multi-disciplinary group that aims to understand the physical and material properties of entire human chromosomes.

2011-2012 Multidisciplinary Team Building Grants

Multidisciplinary Team Building Grants provide funds up to $60,000/year per award in direct costs, require one PI and one Co-PI, and may have unfunded collaborators. The goal of the Multidisciplinary Team Building Grants is to form multidisciplinary materials research teams that can compete effectively for federal block-funding opportunities. One Multidisciplinary Team Building Grant was awarded this year:

Engineered Heart Tissue: A Multidisciplinary Team Centered on Scaffold Structure and Mechanics, Principal Investigator: Jianjun Guan, Materials Science & Engineering; Co-Investigators: Gunjan Agarwal, Biomedical Engineering; Peter Anderson, Materials Science & Engineering

Abstract: A multidisciplinary team spanning three academic departments is proposed to enhance both the intellectual merit and broader impacts of engineered heart tissue research at The Ohio State University. The intellectual merit is to understand how the material design of 3D fiber scaffolds, coupled with cells that can secrete collagen with tunable properties, can be used to direct stem cell differentiation into heart cells. A structured set of key aims will demonstrate the ability of 3D fiber arrays to regulate differentiation, and then correlate this differentiation with the material properties of the collagen matrix and the material design of the fiber scaffold. This effort draws on recent developments of how 2D material environments affect cell differentiation, by expanding to 3D fibrous structures that are inherent in heart tissue. The broader impacts are to support two graduate students in a unique educational setting not available in a single academic setting. It will identify and strengthen a multidisciplinary team for future block grant funding not currently available to OSU researchers, and foster new interaction between the medical and physical sciences at OSU.

2011-2012 Exploratory Materials Research Grants

Exploratory Materials Research Grants provide funds up to $40,000/year per award in direct costs, require one PI, and may have Co-PIs and/or unfunded collaborators. The goal of the Exploratory Materials Research Grants is to enable nascent materials research to emerge to the point of being competitive for external funding. Three Exploratory Materials Research Grants were awarded this year:

1. *Towards Si- Graphene Analogues: Development of Air- and Water-Stable Layered Polysilanes,* Principal Investigator: Joshua Goldberger, Chemistry

   Abstract: Since the discovery of single-layer graphene's unique electronic properties, there has been great interest in the synthesis, properties, and application of single layers of graphene and other inorganic twodimensional layered sheets. Even with graphene's success, there are many potential applications that would benefit with the advent of single-layer sheet materials that have a direct and tunable band gap, and can be chemically functionalized. These properties can be achieved in layered polysilanes, the singleatom thick silicon sp3-hybridized analogue of graphene. Application of these layered polysilanes has been limited due to their relative ease of oxidation in air and water environment. The focus of this proposal is to establish the synthetic chemistry of passivating these layered polysilanes with organic functional groups for the purpose of increasing their resistance towards oxidation in air and water. We will also study how the electronegativity of the passivating component can be used to tune the band gap of the material. Creating air- and water-stable derivatives of these graphene analogues would enable their integration and study into a host of applications including photovoltaics, spintronics, molecular electronics, and thermoelectrics.

2. *Atomic Scale Characterization of Defects in Wide Bandgap Semiconductors*, Principal Investigator: Jay Gupta, Physics; Co-Investigator: Leonard Brillson, Electrical & Computer Engineering

   Abstract: A microscopic understanding of interfacial defects is important in a variety of emerging fields, from silicon-based nanoelectronics to advanced structural materials to next-generation catalysts. The principal objective of this seed proposal is to build core synergies for multi-scale characterization of interfacial defects in oxides and wide-gap semiconductors. We propose to integrate scanned probe, electron beam and optical methods to study interfacial defects in TiO_2, with nm-scale depth and lateral resolution. Molecular beam epitaxy will be used to grow thin films with a variety of interfaces and defect distributions. These studies will lay a foundation for understanding photocatalysis, charge transport, and ferromagnetism in such materials. The target and scope of this seed research were chosen to enhance future block funding proposals built on existing local programs.

3. *Sonochemical Synthesis of Metal Hydrides*, Principal Investigator: Yiying Wu, Chemistry

Abstract: The objective of this proposal is to understand the fundamental mechanism of the sonochemical synthesis of metal hydrides and to develop sonochemistry into a general synthetic method. *This exploratory proposal represents the first effort to utilize sonochemistry for the synthesis of hydrides, which have wellknown applications in organic synthesis, rocket propellant, hydrogen storage and rechargeable batteries*. The proposal is based on our recent discovery that ultrasound irradiation of an aqueous Cu^{2+} solution can produce pure CuH products. *This is the first time that a metal hydride has been synthesized through sonochemistry*. We believe new materials chemistry can come out from this study, which will expand our knowledge of sonochemistry and its applications in materials synthesis. In the proposal, a reaction mechanism is proposed and a research plan is outlined to examine this mechanism and to optimize the production yield of CuH. Moreover, we will explore sonochemistry in non-aqueous solutions in order to expand the synthetic method to other materials such as $LiNH_2$ and hydrazine, N_2H_4. These materials have important applications in hydrogen storage and rocket propellant. Results and publications obtained from this seed project will help us pursue external funding from NSF, AFOSR and DOE.