THE OHIO STATE UNIVERSITY
INSTITUTE FOR MATERIALS RESEARCH

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EXPLORATION OF NOVEL COMPLEX MATERIALS

2017 OSU MATERIALS RESEARCH SEED GRANT PROGRAM AWARDS

We are pleased to announce that after a thorough internal and external review process, 8 awards have been made to fund exceptionally promising, innovative materials research on campus through the 2017 OSU Materials Research Seed Grant Program. These awards total $360,000 in internal research funding to 17 Ohio State researchers from 8 departments in two colleges. The program was able to fund 28% of the proposals submitted this year; 8 out of a total 28. Congratulations to the eight research teams whose projects were selected this year for seed grant funding.

The 2017 OSU Materials Research Seed Grant Program provides internal research funding opportunities through two distinct Funding Tiers designed to achieve the greatest impact for seeding and advancing excellence in materials research of varying scopes.

The OSU Materials Research Seed Grant Program is jointly funded and managed by the Center for Emergent Materials (CEM), the Center for Exploration of Novel Complex Materials (ENCOMM), and the Institute for Materials Research (IMR).

2017 Exploratory Materials Research Grants

Exploratory Materials Research Grants enable nascent and innovative materials research to emerge to the point of being competitive for external funding. Six Exploratory Materials Research Grants were awarded this year:

Development of In-situ Atomic Force Microscopy for Fundamental Investigation of Advanced Battery Binder for Li-Ion Batteries

PI: Hanna Cho, Mechanical and Aerospace Engineering; Co-Investigator: Jung Hyun Kim, Mechanical and Aerospace Engineering

High energy storage materials can significantly advance lithium-ion battery performance and vehicle electrification, but their applications are currently limited by the instability in electrode adhesions and unwanted surficial reactions. This project aims to identify primary parameters governing the quality of battery binders so that we can establish fundamental engineering principles for the design, synthesis, and application of new binder chemistry. Through this seed grant, we will develop in-situ Atomic Force Microscopy to investigate physical, mechanical, and chemical bonding properties of new binders depending on electrode fabrication process and battery operating conditions in operando.

Tunable CuMO2 delafossites for the electrocatalytic conversion of oxygen

PI: Anne Co, Chemistry and Biochemistry; Co-Investigators: Yiying Wu, Chemistry and Biochemistry

The objective of this proposal is to investigate the electrocatalytic properties of Cu(I) delafossites for oxygen reduction in low-temperature solid oxide fuel cells (SOFCs) based on the hypothesis that low-coordination Cu(I) sites actas the active sites for oxygen storage and reduction.This proposalaimsto demonstrate the tunabilityof the delafosite structure anditschemistry that enhances the electrocatalysis of oxygen at relatively low temperature (< 500 oC) for solid oxide fuel cell applications. Demonstratinglow temperature catalyticactivity with relevant current production will be very impactful for the SOFC community. We plan to verify (1) the ability to alter the layer spacing by the size of the MIIIcation, (2) synthesis of a range of M that can influence the CuIredox site, and (3) availability of low-coordination Cu(I) sites, which are accessible by O2molecules.We seek to establish collaborative relationshipsto pursue funding opportunities from NSF and DOE.

Welding metallurgy and weldability of single-phase and multi-phase high entropy alloys (HEA)

PI: Carolyn Fink, Materials Science and Engineering; Co-Investigator: Marat Khafizov, Mechanical and Aerospace Engineering

We propose to perform a fundamental weldability assessment of high entropy alloys (HEA) for structural applications. Fusion zone and heat-affected zone microstructures exert a potent influence on the properties of structural materials. The ability to join and form the material into complex shapes is a major requirement for structural HEA and must be considered in the early stages of alloy development. At this point, it is not clear whether weld solidification, non-equilibrium microstructure and/or defect formation in these complex multi-principle-element alloys are simple extensions from those of conventional single-principle-element alloys. Using computational thermodynamics and experimental techniques for weldability analysis, we will evaluate weld solidification behavior, heat-affected zone microstructure and weld cracking susceptibility of single-phase and multi-phase HEA compositions. As an outcome of the proposed research, we will identify potential weldability issues to focus future efforts on understanding the fundamentals of non-equilibrium microstructural evolution and defect formation in welded HEAs.

Exploration of magnetic order in TMTCs, a new family of layered magnetic semiconductors

PI: Jay Gupta, Physics; Co-Investigator: Roland Kawakami, Physics; Yuan-ming Lu, Physics

We propose a joint experimental/theoretical efortthat compares predicted magnetic ordering phase diagrams (Lu) with spin polarized scanning tunneling microscopy (SPSTM)studies (Gupta) of the highest quality MBE-grown transition metal trichalcogenide (TMTC)films (Kawakami).TMTCs are a promising family of layered semiconductors which exhibit weak interlayer van der Waals interactions. A rich phase diagramof FM and AFM states have been observed in bulk crystals, and these states are predicted to be highly dependent on layer thickness, composition and strain. These parameters will be tuned via MBE growth, to realize thin film samples suitable for atomic resolution spin polarized STM studies.

Establishing a Computational Foundation for the Investigation of Magnetoelastic Metamaterials

PI: Ryan Harne, Mechanical and Aerospace Engineering; Co-Investigator: Marcelo Dapino, Mechanical and Aerospace Engineering

The research goal of this project is to establish a computational foundation that will propel long-term studieson a new class of magnetoelastic metamaterials. Using non-contact, external magnetic fields, these materials are experimentally shown to adapt static and dynamic properties by multiple orders of magnitude, suggesting promise for their use in myriad applications where elastomeric materials are deployed, such asfor shock and vibration control. Yet, a fundamental understanding of the interactions among aligned ironparticles, elastomer cellular architectures, and applied magnetic fields is lacking, which prohibits further development. To surmount this knowledge gap, this research will create a multiphysics finite element model framework to probe the intersections between magnetic and elastic physics cultivated in magnetoelastic metamaterials and will uncover strategies by which control over mechanical and dynamic properties may be best achieved. The formulation of this framework for computational study will strategically enhance the viability of an ensuing proposal that will deliver a long-term research program to transition the emerging discoveries with magnetoelastic metamaterials to a more complete science.

Coupling of magnons and electromagnons to Terahertz metamaterials

PI: Rolando Valdés Aguilar, Physics

Abstract:The purpose of this Seed proposal is to study and understand the coupling ofmagnetic excitations in multiferroic materials (magnons and electromagnons) to resonant modes ofterahertz (THz) metamaterials. Although extensive research has been done in the THz properties of metamaterials, in most of these cases the metamaterial is grown on substrates with featureless THz response. Multiferroics, on the other hand, are known to show excitations with energies in the THz frequency range, including magnons and electromagnons. The ultimate goal of this research is to develop design principles that optimize the coupling between the fundamental excitations in multiferroic materials and metamaterials as the future basis of THz photonics applications such as one-way transparency, saturable absorbers, among others.

2017 Multidisciplinary Team Building Grants

Multidisciplinary Team Building Grants form multidisciplinary materials research teams that can compete effectively for federal block-funding opportunities. Two Multidisciplinary Team Building Grants were awarded this year:

Engineering approaches for profiling the mechano-material properties of the tumor microenviornment

PI: Jonathon Song, Mechanical and Aerospace Engineering; Co-Investigators: Carlos Castro, Mechanical and Aerospace Engineering; Michael Ostrowski, Molecular Biology & Cancer Genetics Program; Samir Ghadiali, Biomedical Engineering

The proposed study addresses the emerging principle in cancer research that the microenvironment of tumors exhibit unique physical properties to promote malignancy. Our objective is to explore how genetic modifications to cancer associated fibroblasts manifest in alterations to these physical properties of tumors. To meet this objective, we will develop an imaging-based methodology using DNA nanotechnology to produce dynamic and quantitative force maps for measuring cell-generated changes in 3-D extracellular matrix (ECM) rheology or mechanical stiffness. Our study is enabled by our interdisciplinary team of investigators who bridge across the College of Engineering and College of Medicine. Collectively, we have previously developed a panel of approaches to probe for tumor-generated forces across different length scales, including subcellular, cellular, and tissue-level. Successful completion of the proposed study will produce an innovative nanoscale rheology sensor that will enable a more complete view of the physical dynamics of tumor initiation and progression with unprecedented spatiotemporal resolution. Moreover, results from this study will contribute to future applications for federal block-funding opportunities that support biomedical research (e.g. NIH) and applied engineering science (e.g. ONR and DARPA)

Entropy and Charge Transport in Weyl Semimetals

PI: Nandini Trivedi, Physics; Co-Investigators: Jos Heremans, Mechanical and Aerospace Engineering

The discovery of topological insulators has introduced a new paradigm for quantum materials in which the electronic wave function shows non-zero winding across the Brillouin zone due to spin-orbital coupling. Recently, topological Weyl and Dirac semimetals have expanded the paradigm with unique signatures: (a) Berry monopoles in the bulk with linearly dispersing electronic states, and, (b) topologically robust gapless “Fermi arcs” on the surface that terminate on the projections of bulk nodes. Our preliminary investigations already suggest that Fermi arcs and bulk monopoles combine to produce a unique “conveyor belt” transport of entropy in Weyl semimetals that produces an anisotropic and strongly magnetic field-dependent magneto-thermal conductivity. Remarkably, the circulating currents result in no net charge transport. In very general terms, charge and entropy transport related to the difference and sum of Weyl fermion fluxes provide incontrovertible evidence for the existence of internal flux loops enabled by topologically protected surface states. We propose a systematic theoretical and experimental investigation of thermoelectric and thermomagnetic transport in type I and type II Weyl semimetals that either break inversion or time-reversal symmetry, based on several fundamentally new theoretical and experimental concepts and the availability of a wide assortment of samples from Dr. Felser.