Online Proceedings

2P

Dynamics and Novel Materials

Session Moderator: Nicholas Boechler, Mechanical Engineering

JHN 111

3:30 PM to 5:15 PM

* Note: Titles in order of presentation.

Analysis of Current and Future Uses of Polylactic Acid in Packaging

Mark Sterling Forsnes, Junior, Pre Engineering
Mentor: George Mayer, Materials Science & Engineering

As the worldwide population grows and society's thirst for goods continues to thrive, mankind's negative impacts on Earth are quickly becoming visible. Environmental concerns have led scientists and engineers to take a critical look at packaging, one of the foremost contributors to landfill waste. Manufacturers have in response begun substituting compostable and biodegradable polymers in place of non-degradable petroleum based plastics. The purpose of this project has been to analyze, within the realm of packaging, the current and potential uses of one such polymer, polylactic acid (PLA), as well as the consideration of barriers to its widespread use and solutions to these obstacles. While PLA has comparatively good mechanical properties, the downsides to the plastic have been its brittleness and low melting temperature. Packaging applications often require a material that is tough and, in the case of food packaging, one that can withstand temperature variations. Several different approaches have been taken to improve the properties of PLA, and while many of these approaches have been successful, the continued biodegradability and food safety of the polymer becomes a concern. Another issue is the amount of water used to manufacture the polymer; most PLA is derived from corn, giving it a high rate of water used per kilogram produced compared to other plastics. These barriers present considerable challenges, yet PLA remains at the forefront of innovative packaging materials, offering a potentially sustainable pathway to a packaging industry free of petroleum-based plastics.

Oxide-Based Colloidal Synthesis of Stable Bismuth Nanocrystals

Peter Benjamin (Peter) Meisenheimer, Senior, Mat Sci & Engr: Nanosci & Moleculr Engr
UW Honors Program
Mentor: Peter Pauzauskie
Mentor: Matthew Crane, Chemical Engineering

High aspect ratio nanostructures have been targeted for use in nanoscale electronics and photonics integration, as well as energy storage and conversion due to quantum confinement effects and high curvature. For instance, 3rd generation solar cells based on Si semiconductor nanowires exhibit improved absorption and current generation due to high aspect ratio and quantum confinement, yet widespread adoption of these technologies is limited due to lack of scalable synthesis methods. Solution-liquid-solid growth of semiconductor nanowires is a cheap, potentially scalable, environmentally-benign process that uses bismuth nanocrystallites as a growth site. Synthesis of Bi nanoparticles, however, is currently achieved by using costly and lethal reagents, in a technically difficult process that is sensitive to O2 and H2O. Furthermore, storage of these reagents is a large concern due to their volatility and the particles themselves tend to oxidize extremely quickly. In this work, we evaluate a one-pot reaction for the production of bismuth nanoparticles using benign Bi2O3 as a precursor. We observe that the size of these particles depends directly on reaction time, and we hypothesize particle synthesis occurs through nucleation-and-growth process. In addition, these Bi nanoparticles show a remarkable resistance to oxidation after storage for weeks in an atmospheric environment. We speculate surface is passivated with a fluoride shell as a synthesis byproduct, which inhibits oxidation. We have studied these particles in different ways including SEM and XPS to determine the size and composition respectively. Our synthesis uses safe precursors and produces particles which are much more stable over the long term; this has the potential to make the use of bismuth nanoparticles a much more viable process and increase our understanding of bismuth on the nanoscale.

Optimizing Hole Transporting Layer Thickness for Organic Solar Cells

Malia Steward, Senior, Electrical Engineering (Bothell)
Mentor: Seungkeun Choi, STEM

The performance of polymer solar cells (PSC) have been a popular study in its applications and fabrication processes in the field of solar energy. Although the power conversion efficiency (PCE) for this type of organic solar cell increased to about 6%, there is a need for the improvement in its device architecture. Creating solar cells involve a strategic fabrication process that consists of several layers that must be built in sequence. Each layer serves a crucial role. The primary role in the performance of its PCE is in optimizing the parameter of transport layers that facilitate charge carriers from the active layer. Fabricating solar cells start with a premade indium-tin oxide (ITO) coated electrode glass slide, followed by ZnO, an electron transport layer (ETL) created with specific measurements. The active layer, P3HT:PCBM is then created with appropriate concentration levels. MoO_3, a hole transport layer (HTL), is deposited on top of the active layer, at a different thicknesses. Lastly, Ag is deposited to serve as our second electrode. Completing the solar cell with the second electrode completes the circuit. Electron charge carriers transport through ZnO to ITO, while the hole charge carriers transport through MoO_3 to Ag. My research, therefore, aims to address what is the optimized thickness of the hole transport layer (HTL), MoO_3, in order to further improve the PCE. In focusing on MoO_3, results determined that as the layer thickness of MoO_3 is reduced, the PCE increases. In opposition, as the layer thickness of MoO_3 increases, the PCE decreases. By controlling the thickness of the hole transport layer, this allowed me to find an optimized thickness to produce high PCEs. This research opens new possibilities and opportunities for future processes when optimizing a particular layer.

Dynamic Mode Decomposition for Resolution of Coherent Temporal-Spatial Plasma Structures

Roy Kenneth (Roy) Taylor, Senior, Political Science, Physics: Comprehensive Physics
Mary Gates Scholar
Mentor: Brian Nelson, Electrical Engineering
Mentor: J. Nathan Kutz, Applied Mathematics
Mentor: Kyle Morgan, Aeronautics and Astronautics

As magnetohydrodynamic (MHD) systems exhibit incredible nonlinearity, computational models have become increasingly common for parsing difficult engineering problems in plasma experiments. The dynamic mode decomposition (DMD) is a principled, data-driven, equation-free approach to extracting coherent temporal-spatial structures from raw data, with particular success in hydrodynamics and fluid-flow problems. We consider the DMD applied to MHD systems in the particular example of spheromak plasmas simulated in the Helicity Injected Torus experiment. We find that the DMD successfully resolves magnetic field structures in simulated magnetic field measurements that closely match expected physical properties. We further find that, under certain constraints, the DMD provides a powerful tool for further validation of simulation to experiment. Given the nonlinearity of magnetohydrodynamic systems, existing mechanisms for feedback controlling plasmas as instabilities occur are limited. Because the dynamic mode decomposition effectively serves as an approximate, linear reduced order model built from experimental and simulated magnetic field measurements on the fly, it offers considerable promise as a predictive feedback controller. This is significant as the detection of and control over plasma instabilities remains a major barrier to the use of spheromaks for fusion energy.

Modelling of Nano-Scale Phase Change Memory Devices

Evan Wen Wang, Senior, Electrical Engineering
Mary Gates Scholar
Mentor: Anant M.P. Anantram, Electrical and Compuer Engineering

Flash memory, the predominant long-term storage device, is rapidly approaching its scaling limit, and among next-generation memory devices, phase change memory is a promising alternative. Phase change materials such as germanium telluride store information through electrical differences between crystalline ordered and amorphous disordered states. Since the speed and power consumption of a phase change device is directly related to the melting point of the material, we seek to find methods to reduce the melting point of germanium telluride. In particular, it has been hypothesized that small doping concentrations of bismuth could greatly reduce the melting point of germanium telluride. To investigate the effects of these dopants on germanium telluride's melting point and electrical properties, we utilize ab-initio modelling techniques to simulate these phase change devices on the nanoscale level. These simulations are performed using the modelling software Siesta where we can examine the impact of small changes in parameters such as doping concentration, temperature, and device geometry. Already, we have found that bismuth doping at high concentrations causes the germanium telluride to display metallic properties. We are still hoping to explore lower doping concentrations and the effects of bismuth on melting point.

Dynamically Modeling Insect Wings

Ziwen Guo, Junior, Mechanical Engineering
Mary Gates Scholar
Mentor: Steve Shen, Mechanical Engineering
Mentor: Mark Jankauski, Mechanical Engineering

Dynamically modeling insect wings helps engineers understand the principles of flapping-wing MAVs (Micro-Aerial

Vehicle). Due to its insect size and low visibility, flapping-wing MAVs are broadly used in surveillance missions, remote observation of hazardous environment and even artificial pollination. Although several MAVs have been successfully developed so far, there still exists a large space for engineers to optimize the design, such as reducing the weight, energy consumption and cost. Based on the biological evidence that the wing deformation is mainly caused by inertial-elastic forces rather than aerodynamic loads, we developed an inertial elastic deformable hawk moth's fore-wing model. Using this model, we determined the instantaneous power consumption of the flapping wing by adding the time derivatives of kinetic and potential energies together. The model revealed that significant power is required to compensate for the wing elasticity. We are trying to apply this model to various insects' wings with various length scales to compare their structural properties and look for universal trend of the change of instantaneous power output. We hypothesize the model can predict the power requirement more accurately at smaller length scale wings, because inertial force tends to dominate aerodynamic force in smaller flying insects.