Proceedings

SURF

Research Symposium

2016

August 4th, 2016

PURDUE UNIVERSITY

Welcome to the 2016 SURF Undergraduate Research Symposium!

The Summer Undergraduate Research Fellowships (SURF) program was launched in 2003 to meet the ever-increasing research demands of academia and industry. Using a portion of an unrestricted gift from Purdue alumnus Patrick Wang, SURF has sought to provide students with a dedicated laboratory experience to strengthen integrated, hands-on learning through discovery.

The core of the SURF program is to provide students across all engineering, science and technology disciplines with an intensive research component that allows them to work closely with professors and graduate students.

For 11 weeks this summer, 147 SURF students from 16 institutions have participated in an intensive research experience on the Purdue University campus. These students received mentorship and guidance from 130 graduate students and post docs, and 120 professors from 19 Schools/Departments in 3 Colleges at Purdue.

We want to thank the professors, post docs, and graduate students who have mentored SURF students this summer. Your time and commitment have been invaluable.

To the SURF students, we congratulate you on the completion of an intensive research program this summer. We honor you today. You should be proud of your accomplishments. We wish you all the best in the future as you pursue your goals and continue on your journey of discovery.

Melba M. Crawford

Melba M. Crawford
Associate Dean for Research in Engineering

SURF Symposium Overview—August 4th, 2016

Morning Session

8:00 AM – 8:30 AM	**Student Check-in** ……………….…………….………	ARMS Atrium
9:00 AM – 9:20 AM	**Symposium Welcome and Instructions** …..	ARMS 1010
9:30 AM – 10:45 AM	**Oral Presentations (5 talks per room)**	
	Sessions organized around common themes:	
	Energy I ………………………………………………	ARMS B071
	Modeling & Simulation I ……………………….	ARMS 1021
	Health ……………………..………………………….	ARMS 1103
	Nanotechnology ………………………………..	ARMS 1109
	Sensing & Controls ……………..……………………	ARMS 1010
11:00 AM – 12:15 PM	**Poster Presentations**	
	Posters organized around common themes….	ARMS Atrium
12:15 PM – 1:15 PM	**Lunch Break**	

Afternoon Session

1:30 PM – 2:45 PM	**Oral Presentations (5 talks per room)**	
	Sessions organized around common themes:	
	Energy II ………………………………………………	ARMS B071
	Modeling & Simulation II ………………………	ARMS 1021
	Environment …………………..………………..	ARMS B061
	Biotechnology ……………..……………………	ARMS 1103
	Materials Science ….……………………………...	ARMS 1109
3:00 PM – 4:15 PM	**Poster Presentations**	
	Posters organized around common themes….	ARMS Atrium

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MORNING ORAL PRESENTATIONS

MO

Energy I

ARMS B071, 9:30 AM – 10:45 AM

Effect of Lignin Variation on Biomass Conversion: An Analysis of Pretreatment Methods for Poplar Samples

Presentation ID:
MO-1

Room:
ARMS B071

Keywords:
*Biomass,
Lignin,
Poplar,
Value added chemicals,
Thermochemical conversion*

Austin J Cannella, Nathan S Mosier, Barron Hewetson, and Amanda N Kreger
Purdue University

The conversion of lignocellulosic polysaccharides has been studied as an alternative to petroleum for producing fuels and chemical products, such as those in plastics. However, biomass lignin has been shown to inhibit polysaccharide conversion. Lignin, an organic polymer, surrounds biomass polysaccharides, hemicellulose and cellulose, making the biomass resistant to deconstruction and limiting polysaccharide conversion yields. Increases in polysaccharide conversion yields are seen when using physical or chemical pretreatment methods that increase convertible cellulose, remove lignin, and restructure biomass. A physical pretreatment, liquid hot water (LHW), solubilizes hemicellulose and melts lignin using hot, pressured water. A chemical treatment, sodium-chlorite acetic acid (SCAA), uses a strong oxidizing agent coupled with acid to chemically remove the lignin. This study analyzed LHW and SCAA pretreatments, each at two levels of severity, for aiding in deconstruction of wild type poplar biomass and poplar genetically modified for increased lignin digestibility. Following pretreatments, biomass composition was analyzed via a standard method using a combination of acid hydrolysis deconstruction and biomass fractionation. We report that increasing length of SCAA treatments shows sequential reduction in total lignin (11.8%, 8.0%) when compared to untreated biomass (23.1%) and provides an average 27.3% increase in the portion of total lignin that is acid digestible. LHW pretreatments increase the proportion of available glucan for conversion while minimally changing biomass structure in contrast to the SCAA treatment which largely alters biomass composition. Reported biomass composition changes suggest that pretreatments used with previously studied biomass conversion methods increase polysaccharide conversion yields to value added chemicals.

Hydrophobic Zeolites for Applications in Adsorption and Catalysis

Presentation ID:
MO-2

Room:
ARMS B071

Keywords:
*Glucose isomerization,
Lewis acidic zeolites,
Silylation,
Biomass upgrading*

Zige Huang, Michael Cordon, and Rajamani Gounder
Purdue University

Lewis acidic zeolites such as Sn-Beta are commonly studied for use as selective catalysts for glucose isomerization to fructose in liquid water. Glucose to fructose isomerization is a critical reaction for lignocellulosic biomass upgrading, which converts abundant and renewable feedstocks into commercially desirable fuels and chemicals. Industrial applications require catalysts that maintain optimal reactivity over long time scales, yet at typical reaction temperatures, Lewis acidic Beta zeolites are known to deactivate in liquid water through poorly understood mechanisms. Recent work in our group has shown that interactions between water and Sn-Beta zeolites can cause leaching of active Sn sites from the zeolite framework, and can also hydrolyze siloxane linkages to form silanol groups that also lower catalytic isomerization rates. This study investigates how water exposure and treatment affects the structure of Sn-Beta, by systematically changing the water contact time and analyzing the resulting glucose isomerization rates, in order to determine the catalysts and treatments to maintain optimal reactivity. Functionalization procedures were performed on Sn-Beta using hydrophobic alkylsilane precursors to form an external hydrophobic shell and minimize water diffusion into the zeolite pores. Limiting water contact may slow the deactivation rates caused by active Sn site leaching or silanol group formation. Functionalized zeolites showed a substantial decrease in initial glucose isomerization rates compared to that of untreated zeolites, however, reaction rates remain constant for longer time scales after functionalization, suggesting that silylation treatments may improve time-on-stream stability of Sn-Beta catalysts in liquid water.

Pt-Cu Catalysts for Catalytic Dehydrogenation of Alkanes for Energy Production

Zixue Ma, Zhenwei Wu, and Jeffrey T Miller
Purdue University

More active, selective and stable catalysts are in demand to increase the yields of olefins production from light alkane dehydrogenation. Cu was reported to promote Pt catalysts and Pt-Cu catalysts has been shown to achieve increased olefin selectivity and decreased deactivation rate. Pt-Cu catalysts with different Pt:Cu molar ratios may have different crystal structure and performance. This study seeks to understand of the promotion effect of Cu on Pt alkane dehydrogenation catalysts. Four different Pt-Cu catalysts with different atomic ratios were prepared and tested for propane dehydrogenation at 550℃. Synchrotron *in situ* X-ray diffraction and X-ray absorption spectroscopy are used to characterize the structure of the Pt-Cu catalysts. For this series of catalysts, as the Cu loading increases, the selectivity also increases. A 0.66%Pt-2%Cu catalyst has the highest propylene selectivity. Cu was found to form random solid solution and also intermetallic alloy with Pt depending on the catalyst composition.

Presentation ID:
MO-3

Room:
ARMS B071

Keywords:
*Bimetallic catalysts,
Platinum,
Copper,
Propane dehydrogenation*

Pore Scale Transport of Miscible and Immiscible Fluids in Porous Media

Tolulope O. Odimayomi and Arezoo M. Ardekani
Purdue University

The separation of harmful or valuable substances entrapped in porous media has applications in processes such as enhanced oil recovery, diffusion in tissue, and aquifer remediation. In this study the motion and removal rate of immiscible and miscible solutions have been analyzed to gain understanding of solvent effectiveness as it is diluted due to diffusion or mixing within porous materials. The extraction of oil using a surfactant-aqueous solution is observed using two dimensional flows between parallel slides containing cylindrical obstacles. The fluid motion is visualized. As the spacing between the cylindrical obstructions decreases, the amount of residual oil seen in the device as well as ganglion size was reduced. The dissolution of two miscible fluids (glycerol and water) is visualized in square and round capillary tubes of various diameters. The capillaries are filled with solute before being immersed in a bath in which the solute concentration within the solvent is increased. The observation of the miscible liquid-liquid interfaces in a tube help us quantify the effective diffusion process.

Presentation ID:
MO-4

Room:
ARMS B071

Keywords:
*Porous media,
Microfluidics,
Liquid-liquid interface*

Influence of Thermal Boundary Conditions on the Vibration Based Deflagration of Particulate Composite Plates

Jaylon B Tucker, Allison R Range, and Jeffery F Rhoads
Purdue University

Vapor detection is one of the most effective ways to find hidden plastic-bonded explosives in the field today. In recent years, it has been demonstrated that providing near-resonant vibratory excitation to explosives dramatically increases their vapor pressure, allowing for easier detection. Unfortunately, there currently exists a limited understanding of the thermomechanics of energetic material. This study seeks to help fill this technical void by exploring the thermomechanics of mock plastic-bonded explosives using direct mechanical excitation with varying thermal conditions. Using two different ambient thermal boundary conditions (insulated geometric boundaries and boundaries with free convection), a 7"x10"x0.5" HTPB/Ammonium Chloride particulate-composite plate was tested by fixing it to an electrodynamic shaker and vibrating the sample at low frequencies (under 1000 Hz). Vibratory and thermal data was collected using a Polytec scanning laser Doppler vibrometer and a FLIR infrared camera. It was determined that insulating boundary conditions, allow the mock energetic material temperature to increase significantly as compared to the convective boundaries under near-resonant excitation. Future work will investigate alternate thermal boundary and initial conditions, as well as alternate mock energetic materials.

Presentation ID:
MO-5

Room:
ARMS B071

Keywords:
*Energetic,
Vibratory excitation,
Insulation*

Modeling & Simulation I

ARMS 1021, 9:30 AM – 10:45 AM

Large Scale Monolithic Solar Panel Simulation: A Study on Partial Shading Degradation

Suhas V Baddela, Xingshu Sun, and Muhammad A. Alam
Purdue University

Shadow-induced degradation is a major concern for both power output and long-term reliability in solar cells. Apart from the obvious fact that shading reduces the amount of solar irradiance available to solar panels, it may lead to formation of hot spots, where solar cells are forced to reverse breakdown with localized heating, and potentially, permanent damage. To get a better understanding of shadow-induced degradation, we develop an electro-thermal coupled simulator that can self-consistently solve the electrical and thermal distributions of solar panel under arbitrary shading conditions. The simulation framework consists of two part: a) compact models that can describe the cell-level IV characteristics; b) a circuit network of thousands of compact models connected in series and parallel to form a solar module. The framework is based on open-source software, namely, Verilog-A for industrial standard compact model development and a SPICE-based circuit simulator capable of parallel computation. It is found that power loss due to shadowing is dependent on both the percentage of area shaded and its orientation. The degradation is more prominent for cells that have lower reverse breakdown voltage. The ultimate outcome of the framework is to create the first open source, physics-based module simulation tool to accelerate the pace of PV research and development in academia and industry and to reduce the cost of development by revising qualification protocols (*e.g.* IEC612125) to better represent the actual operating condition.

Presentation ID:
MO-6

Room:
ARMS 1021

Keywords:
Solar cells,
Partial shading,
Compact models

Multi-objective Optimization under Uncertainty Using the Extended Expected Improvement over Hyper-volume

Martin Figura[1], Piyush Pandita[2], Rohit Tripathy[2], and Ilias Bilionis[2]
[1]South Carolina State University, [2]Purdue University

The design of real engineering systems requires the optimization of multiple quantities of interest. In the electric motor design, one wants to maximize the average torque and minimize the torque variation. A study has shown that these attributes vary for different geometries of the rotor teeth. However, simulations of a large number of designs cannot be performed due to their high cost. In general, design optimization of multi-objective functions is a very challenging task due to the difficulty to evaluate the expectation of the objectives. Current multi-objective optimization (MOO) techniques, *e.g.*, evolutionary algorithms cannot solve such problems because they require hundreds of thousands of function evaluations. Therefore, an alternative methodology must be used to identify a Pareto front, a set of optimal designs of MOO. Recent extensions of Bayesian global optimization are able to do exactly that. The idea is to replace the expensive objective functions with cheap-to-evaluate probabilistic surrogates trained using few input-output pairs and to sequentially query designs that maximize the improvement of the Pareto front. For these purposes, we developed SMOOT, a Rappture tool built on a NanoHUB platform. It enables experimentalists to optimize their expensive processes without a need to understand the optimization methodology and guides them to make better decisions in order to find optimal designs.

Presentation ID:
MO-7

Room:
ARMS 1021

Keywords:
Gaussian process regression,
Bayesian global optimization,
Expected improvement,
Uncertainty quantification,
Expected improvement over the dominated hyper-volume

Mobile Data Visualization For Farm Optimization

Presentation ID:
MO-8

Room:
ARMS 1021

Igal Flegmann, Shehzad Afzal, and David Ebert
Purdue University

Keywords:
Big data,
Data analysis,
Data visualization,
Mobile,
iOS

Massive amounts of data is generated in today's businesses on a daily basis and in order to make smarter and well informed decisions they are focusing more on big data analytics. Insights derived from data-driven analytics could help them optimize their business processes and make timely decisions. The growth in the smartphone industry gives users the opportunity to use a smartphone as a tool to analyze data and translate into informed actions based on the visualized data. In this paper, we present the design of a mobile based visual analytic application that helps farmers analyze data collected by different sensors in the field that could help them optimize their resources, and potentially improve the quality of the crop. Central component of this application is a map based view that visualizes interpolated values of moisture and temperature sensors across the field, incorporating soil composition properties in interpolation calculations. This application is an extended version of a web based visual analytics application developed for the same purpose.

Metamodels of Residual Stress Buildup for Machining Process Modeling

Presentation ID:
MO-9

Room:
ARMS 1021

Stuart B McCrorie and Michael Sangid
Purdue University

Keywords:
Simulation,
Machining processes,
Metamodels,
Residual stress

In the process of machining materials, stresses, called residual stresses, accumulate in the workpiece being machined that remain after the process is completed. These residual stresses can affect the properties of the material or cause part distortion, and it is important that they be calculated to prevent complications from arising due to the residual stresses. However, these calculations can be incredibly computationally intensive, and thus other methods are needed to predict the residual stresses in materials for quick decision-making during machining. By using metamodels --- a method of representing data where few data points exist --- we can achieve an accurate prediction of the residual stresses without the need for computationally intensive calculations for each process. This involves running a series of simulations and creating a response surface from this data using the Kriging Method, which smooths out the surface such that small changes in inputs result in small changes in outputs. This achieves the result of a model for predicting the relative stresses in materials after the machining processes, and allows computationally expensive simulations to be bypassed in situations where the inputs do not vary large amounts outside of the initial simulations ran. This can allow better tracking of residual stresses, and thus lead to better control of the complications that can arise from residual stress buildup.

Loading Architectures for the Virtual Prototyping of Pumps and Motors

Presentation ID:
MO-10

Room:
ARMS 1021

Rajith Weerasinghe, Paul Kalbfleisch, and Monika Ivantysynova
Purdue University

Keywords:
Fluid power,
Simulation

Virtual prototyping of positive pumps and motors is incredibly useful, increasing speed of development and lowering cost. The calculations of fluids discharge pressure, displaced by a swashplate-type-axial piston pump/motor is dependent on the load impedance driven by the unit. The load impedance is estimated by a variable orifice found downstream of the unit. Similarly, the suction line impedance is also estimated with an orifice. The current project aims to evaluate the various loading architectures in their ability to quickly and accurately create the desired impedance. The robustness of the loading architectures was tested on a wide range of pump sizes, speeds, pressures, and displacements. The estimated initial conditions of the loading architectures, such as the orifice areas and line volumes and pressures are very efficient means of converging to the correct discharge pressure. To develop a model, based on past simulation, a full factorial design of experiments (DOE) was performed to generate the required training data set. The DOE revealed the models sensitivity to the normally unknown variables which contributed to large variations in accuracy. However, after analyzing the impact of other variables, an alternate approach was taken. By creating a variant of the simulation, which sets port pressures equal to line pressures, orifice areas can be effectively removed from the equation. In order to compare the performance, ideal valve plates specific to each code variant should be used. This is because arbitrary valve plates may favor one over the other, yielding extraneous conclusions. An existing genetic algorithm found the accuracy was unaffected while greatly improving speed.

Health

ARMS 1103, 9:30 AM – 10:45 AM

Characterization of Left-Ventricular Thrombus Formation Using High Frequency Ultrasound

Kelsey A. Bullens, Arvin H. Soepriatna, Pavlos P. Vlachos, and Craig J. Goergen
Purdue University

Heart failure is a leading cause of death in the United States, and cardiac thrombus, a common morbidity associated with heart failure, significantly increases a patient's risk of embolic events. The objective of this project is to characterize left-ventricular (LV) thrombus development using high frequency ultrasound imaging in a murine model. C57BL/6J wild-type mice (n = 6) were injected intraperitoneally with iron dextran five times a week for six weeks to increase oxidative stress in the heart. Granulocyte-colony stimulating factor (G-CSF) was subcutaneously injected daily during the second week to initiate stem cell migration and stimulate endothelial cell activation, thus increasing the hypercoagulability state of the blood. A high-frequency, small animal ultrasound system (Vevo2100, VisualSonics FUJIFILM Inc.) and a 40 MHz central frequency transducer were used to track LV thrombus progression and evaluate LV function weekly. Four out of six mice developed thrombus, but no significant differences in LV performance were observed when compared to mice that did not form a thrombus. Further investigation is necessary to study the role of attenuated heart function on thrombus formation. Future work will incorporate a murine model of myocardial infarction to investigate if a severely compromised heart increases the risk of or accelerates LV thrombus formation. This study will aid in identifying patients who are predisposed to thrombus formation following a heart attack, leading to more effective prevention and treatment methods.

Presentation ID:
MO-11

Room:
ARMS 1103

Keywords:
Thrombus,
Heart failure,
Reduced heart function,
Cardiac thrombus,
Left ventricle

Leveraging Smart Infusion Pump Data for Workflow, Patient Care and Usability Improvement in Human Factors

Yan Ni Ding[1], Denny Yu[1], Poching DeLaurentis[2], Kang-Yu Hsu[1], and Joon Hong Kim[1]
[1]Purdue University, [2]Regenstrief Center for Healthcare Engineering

Infusion pumps are medical devices that deliver fluids like medication, and nutrients in a precise, timely, and controlled manner that is critical to patient care. It is widely used in clinical settings especially in hospitals, nursing homes and sometimes at home. Smart infusion pumps technology are supposed to be reduce nurses' workload, but due to the recurring number of alarms which disrupt the workflow of the infusion process, most nurses prefer to use the traditional infusion pumps or work-around the safety features of the smart pumps. Thus, the aim of this research is to leverage Smart Infusion Pump data to improve patient care, provider workflow, and usability. The data for this research is provided by the Regenstrief Center of Healthcare Engineering and a big data management hub, CatalyzeCare.org where a collaborative community of 123 health institutions contributed infusion pump data. By analyzing the data, the frequency and causes of the recurring alarms and also a detailed event of the workflow during the infusion process can be determined. However, one uncertainty about the data is the proper definition of one infusion process and ways to minimize the recurrences of the alarms. Hence, further analysis is being carried out to further investigate the problem and also to improve the usability of the Smart Infusion Pumps in the healthcare industry.

Presentation ID:
MO-12

Room:
ARMS 1103

Keywords:
Infusion pumps,
Human factors,
Workflow

Comparative Life Cycle Assessment of Direct and Indirect Solar Water Disinfection Processes in Developing Countries

Jason K Hawes, Margaret M Busse, and Ernest R Blatchley III
Purdue University

Presentation ID:
MO-13

Room:
ARMS 1103

Keywords:
Life cycle analysis, Ultraviolet, Disinfection, Safe water, International development

In July 2010, the UN General Assembly recognized the universal human right to sufficient water for health and sanitation (UN…, 2010). The reliable disinfection of this water plays a critical role in public health (Carter and Miller, 2005), and this study investigates the use of four ultraviolet (UV) disinfection methods for use in international development and disaster relief. The study focuses on the life cycle impacts of four direct and indirect solar ultraviolet disinfection systems. Direct solar disinfection refers to exposure of water to solar radiation, while indirect solar disinfection collects solar energy and uses this to power a UV lamp disinfection reactor. These four systems were compared to chlorine disinfection and automobile distribution as baseline methods. Existing literature was used to define a life cycle functional unit for each system, which quantified the material use, infrastructure required, and life cycle of the components of each system. The impact of each system was then defined in the Life Cycle Analysis software SimaPro. Analyses compared the use of each technology at “community, school, small group, and family” scales. Due to the significant impact that end-of-use of a system can have on rural communities, an end-of-life analysis was conducted in addition to the quantitative life cycle analysis. Life cycle analysis shows that both direct and indirect UV disinfection methods vary dramatically over several categories of impact assessment. End of life analysis and this variation highlight the extremely complicated process of designing the appropriate disinfection system for use in developing countries.

3D Modeling of Murine Abdominal Aortic Aneurysms: Quantification of Segmentation and Volumetric Reconstruction

Paula A Sarmiento[1], Amelia R Adelsperger[2], and Craig J Goergen[2]
[1]Universidad de Los Andes - Colombia, [2]Purdue University

Presentation ID:
MO-14

Room:
ARMS 1103

Keywords:
Abdominal Aortic Aneurysm, Ultrasound, 3D modeling

Abdominal Aortic Aneurysms (AAA) cause 5,900 deaths in the United States each year. Surgical intervention is clinically studied by non-invasive techniques such as computed tomography and magnetic resonance imaging. However, three-dimensional (3D) ultrasound imaging has become an inexpensive alternative and useful tool to characterize aneurysms, allowing for reconstruction of the vessel, quantification of wall stress through computational fluid dynamics (CFD) simulation, and possible prediction of aortic expansion and rupture. However, current analysis techniques for these images require the use of multiple software for either modeling or simulation, prompting the need for alternatives to improve data processing. This study monitors the development of AAAs in apolipoprotein E-deficient mice infused with Angiotensin II using 3D ultrasound imaging with the purpose of evaluating the accuracy of SimVascular a semi-automated specialized open source simulation software, for image reconstruction. The total volume to length ratio of the suprarenal aorta was obtained for 7 mice and compared to software that allows only segmentation and volume quantification (VevoLAB; FUJIFILM VisualSonics). We found that the volume per length measurements obtained with SimVascular (1.58 ± 1.17 mm^2) were not significantly different from those obtained by VevoLAB (1.56 ± 1.14 mm^2, $p = 0.47$). In conclusion, SimVascular is an optimal tool for reconstructing vessel geometries from 3D ultrasound data due to its robust accuracy, efficiency, and semi-automatic computational processing capabilities used for modeling that will allow for future CFD simulation.

Impact of Microscope, Loupes, and Video Displays on Microsurgeons' risk for Musculoskeletal Injuries

Presentation ID:
MO-15

Room:
ARMS 1103

Keywords:
*Postures,
Displays,
Microsurgeons.
Ergonomics*

Yiyu Shi and Denny Yu
Purdue University

Microsurgery is commonly performed with operating microscopes or loupes to repair traumatic injuries, damage from cancer surgery, *etc*.; however, the prolonged, awkward, and constrained postures from using these equipment puts microsurgeons at risk for musculoskeletal pain and injuries. An alternative heads-up displays may improve surgeons' ergonomics by allowing microsurgeons to perform the procedure in a more comfortable and ergonomic position. The study compares the effect of microscope, loupes and video displays on postures during microsurgical targeting task. This study incorporated three steps to contrast displays. Firstly, 12 participants wearing six reflective markers completed a surgery simulation using all three displays, and their sagittal planes were video recorded. Secondly, randomly selected frames were captured and coordinates calculated in Matlab. Lastly, angles of interests obtained were compared to suggest the optimal display that demand least stressful postures. The final results indicated that video displays would bring microsurgeons relatively comfort and freedom of postures. Future improvement on ergonomics in microsurgeons can be implemented through design of equipment, tasks, and work environments.

Nanotechnology

ARMS 1109, 9:30 AM – 10:45 AM

Dislocation Engineering in Novel Nanowire Structures

Presentation ID:
MO-16

Room:
ARMS 1109

Keywords:
*Nanowires,
Mechanical dampening,
Stacking fault energy,
Dislocation engineering,
Molecular dynamics*

Christopher Y Chow, Samuel T Reeve, and Alejandro Strachan
Purdue University

Leveraging defects is a cornerstone of materials science, and has become increasingly important from bulk to nanostructured materials. We use molecular dynamics simulations to explore the limits of defect engineering by harnessing individual dislocations in nanoscale metallic specimens and utilizing their intrinsic behavior for application in mechanical dampening. We study arrow-shaped, single crystal copper nanowires designed to trap and control the dynamics of dislocations under uniaxial loading. We characterize how nanowire cross-section and stacking-fault energy of the material affects the ability to trap partial or full dislocations. Cyclic loading simulations show that the periodic motion of the dislocations leads to mechanical dissipation even at frequencies up to $2x10^{10}$ Hz, orders of magnitude higher than the current state of the art.

The Turning-Off of Supernova Remnants: The Transition into the Radiative Phase

Presentation ID:
MO-17

Room:
ARMS 1109

Keywords:
*Radiation mechanisms,
Non-thermal methods,
Analytical supernovae*

Ryan A Lazur, Rodolfo Barniol Duran, and Dimitrios Giannios
Purdue University

Supernovae are amongst the most energetic events in the Universe. Understanding the different stages of the life of a supernova is currently one of the main objectives in astrophysics. During a supernova explosion, material with mass several times that of the Sun is ejected with a speed about $1/10^{th}$ that of light. In current models, the transition from the Sedov-Taylor to the radiative phase is assumed to be almost instantaneous, which is not entirely accurate. Here the physics of the transition to the radiative phase will be revisited. Observations indicate that the supernova ejecta remains bright in the radio band until it enters the radiative phase; then it gradually faints away. We will explore the role of the shock Mach number and the efficiency of synchrotron radiation and associated radio emission in that turning-off. A monte-carlo technique has been implemented to simulate the supernovae history in a galaxy. We apply this technique to the radio observations of the supernova remnants in the Magellanic Clouds.

Fiber-Optic Imaging in an Internal Combustion Engine Test Rig

Presentation ID:
MO-18

Room:
ARMS 1109

Keywords:
Engine optics, Diesel engines, Combustion/Flame visualization, Optical dIagnostics

Conor Martin[1], Michael Smyser[2], Aswin Ramesh[2], Greg Shaver[2], and Terrence Meyer[2]
[1]SUNY University at Buffalo, [2]Purdue University

The formation of particulate matter (PM/soot), nitrogen oxides (NO_x), and other byproducts of the combustion process in diesel engines is controlled by spatiotemporally varying quantities within the engine cylinders which traditional sensors cannot resolve. This study explores the use of an advanced sensing technique using an optical probe which can be used to produce highly spatiotemporally resolved in cylinder images of the flame formation during the combustion stroke. Using a fiber optic cable and custom lensing system adapted to fit a pre-existing pressure transducer port, light from within the cylinder can be transmitted through the imaging probe to a high speed camera where high resolution images of the flame are captured. This method enables no modifications to the engine geometry or materials, which ensures that the combustion and heat transfer characteristics are the same in the operating engine as they would be without the sensor implementation.

Reward Modulated Spike Timing Dependent Plasticity Based Learning Mechanism in Spiking Neural Networks

Presentation ID:
MO-19

Room:
ARMS 1109

Keywords:
Spiking neural networks, Reward based learning

Shrihari Sridharan, Gopalakrishnan Srinivasan, and Kaushik Roy
Purdue University

Spiking Neural Networks (SNNs) are one of the recent advances in machine learning that aim to further emulate the computations performed in the human brain. The efficiency of such networks stems from the fact that information is encoded as spikes, which is a paradigm shift from the computing model of the traditional neural networks. Spike Timing Dependent Plasticity (STDP), wherein the synaptic weights interconnecting the neurons are modulated based on a pair of pre- and post-synaptic spikes is widely used to achieve synaptic learning. The learning mechanism is extremely sensitive to the parameters governing the neuron dynamics, the extent of lateral inhibition among the neurons, and the spike frequency adaptation parameters. Hence, we explore a reward modulated learning methodology to further improve the synaptic learning efficiency. In our work, we define a target spiking pattern a priori for each neuron in the network. The primary objective is to cause the actual neuronal spiking pattern to converge to the desired pattern during the training phase. The STDP driven synaptic updates are modulated by a reward metric, which determines the distance between the actual and target spike train. We estimated the reward using the difference between the averaged version of the actual and desired spike train. Reward based semi-supervised learning scheme is implemented on a two layered SNN trained to classify handwritten digits from the MNIST image set. We obtained an accuracy of 73.16% on the testing image set for 100 spiking neurons which helped learning better in case of supervision.

Development of a New NanoHUB Simulation Tool: Coarse Graining of Crystalline Nano-Cellulose

Presentation ID:
MO-20

Room:
ARMS 1109

Keywords:
Crystalline Nano-cellulose, Bouligand, Nanohub, Rappture

Kuo Tian, Mehdi Shishehbor, and Pablo Zavattieri
Purdue University

Crystalline Nano-cellulose (CNC) is a general molecular structure obtained from acid hydrolysis of native fiber. They are often very short (100 to 1000 manometers) and the mechanical properties of CNC varies depend on length scale. Due to defect formation of the structure, the mechanical properties of the material composed of such CNC may vary drastically. This study was to provide a numerical tool to integrate a few valid modules and to better understand the mechanical properties of CNC and the overall performance of the bio-inspired material composed of CNC. Our focus is mainly on two type of composite structure (1) bouligand structure which is found in mantis shrimp and (2) staggered structure based on bone structure. The Mechanical test on these structures can provide useful information on their type of failure and the effect of length and arrangement of CNC on overall mechanical properties. The tool was built with the instructions from nanohub using Rappture as GUI designer and Python as programming language. The key method is to generate the structure file using base structure of CNC and user input, then send shell command to computation and visualization package. Advanced data structures were used to ensure when duplicating in length formation of the cellulose doesn't change. The results were almost the same with previous data obtain from a rather slow simulation. The simulation was 20% faster since the study optimized on structure generation. The computational package was external and it was where most of the time consumed. The overall performance of tool was sufficient to help fellow researchers and students to get a quick and accuracy mechanical property of a chosen CNC structure.

Sensing & Controls

ARMS 1010, 9:30 AM – 10:45 AM

Plant Phenotyping on Mobile Devices

Presentation ID:
MO-21

Room:
ARMS 1010

Keywords:
Plant phenotyping, Image processing, Smart phones

Ziling Chen, Jialei Wang, Jian Jin, and Zhihang Song
Purdue University

Plants phenotyping is a fast and non-destructive method to obtain the physiological features of plants, compared with the expensive and time costing chemical analysis with plant sampling. Through plant phenotyping, scientists and farmers can tell plant health status more accurately compared to visual inspection, thus avoid the waste in time and resources and even to predict the productivity. However, the size and price of current plant phenotyping equipment restrict them from being widely applied at a farmer's household level. Everyday field operation is barely achieved because of the availability of easy-to-carry and cost-effective equipment such as hyper-spectrum cameras, infrared cameras and thermal cameras. A plant phenotyping tool on mobile devices will make plant phenotyping technology more accessible to ordinary farmers and researchers. This application incorporates the use of physical optics, plant science models, and image processing ability of smartphones. With our special optical design, multispectral instead of RGB (red, green and blue) images can be obtained from the smartphones with fairly low cost. Through quick image processing on the smartphones, the APP will provide accurate plant physiological features predictions such as water, chlorophyll, and nitrogen. The sophisticated prediction models are applied which are provided by the Purdue's plant phenotyping team. Once widely adopted, the information collected by the smartphones with the developed APP will be sent back to Purdue's plant health big-data database. The feedback will not only allow us to improve our models, but also provide farmers and agricultural researchers easy access to real-time crop plant health data.

Hydrogen Peroxide Release as a Cellular Health Indicator: Preparing for On-Chip Sensor Measurements

Presentation ID:
MO-22

Room:
ARMS 1010

Keywords:
Hydrogen peroxide, Biosensor, Cellular peroxide release, Electrode array, Real time sensor

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[1]Rutgers University - New Brunswick/Piscataway, [2]Georgia Institute of Technology, [3]Purdue University

Hydrogen peroxide is traditionally associated with cellular damage; however, recent studies show that low levels of H_2O_2 are released by cells as part of normal intercellular communication. The mechanisms of hydrogen peroxide transport, uptake and release rates, and biological effects are not yet well known but have important implications for cancer, stem cells, and aging. Standard H_2O_2 assays cannot make spatially or temporally resolved quantitative measurements at a cellular scale. Previously we developed a microelectrode array (MEA) and calibration methods for quantifying H_2O_2 gradients in space and time. The sensor was validated using artificial H_2O_2 gradients at subsecond and micrometer scale resolutions. The present study begins cellular work on H_2O_2 release to identify appropriate cell lines in preparation for further sensor analysis. The morphology and H_2O_2 release from human pancreatic beta (MIN6) and human monocyte (u937) cell lines were analyzed after stimulation with glucose and phorbol myristate acetate (PMA), respectively. Monocytes were stimulated with PMA (2.5 ng/mL to 150 ng/mL) alone or in combination with 1 ug/mL of ionomyocin for up to 72 hours. Hydrogen peroxide release was quantified over time using a traditional amplex red flurometric assay method. Monocytes produced significantly more H_2O_2 than the pancreatic beta cells. Monocytes released H_2O_2 at a stready rate that varied with PMA concentration. These results indicate that PMA stimulated monocytes will serve as a good model system for cellular validation of the H_2O_2 MEAs. Merging traditional biological assays with electronics can provide more efficient analysis of cell populations. Fast quantification of cell population health is particularly important when transplanting cells, such as pancreatic islets or artificially inseminated eggs. Additionally, biofunctionalization of the electrodes for molecule specificity will allow for the expansion of the method to other analytes, giving the sensor potential use in non-traditional lab environments with the ability to perform multiple assays autonomously.

Real-Time Temperature and Heat Flux Measurements for Lyophilization Process Design and Monitoring: Part 1

Presentation ID:
MO-23

Room:
ARMS 1010

Keywords:
Wireless temperature sensors, Lyophilization, Freeze drying

Evan T Liechty, Nicholas J Huls, Andrew D Strongrich, and Alina A Alexeenko
Purdue University

Lyophilization is a common method used to preserve pharmaceutical and biological products. Accurately measuring temperature during the three stages of lyophilization: freezing, primary drying, and secondary drying, is important to ensure product consistency and to reduce operating costs. Wireless temperature sensors were evaluated to determine if temperature is monitored accurately and to determine if wireless temperature sensors offer advantages over traditional temperature measurement technologies. These sensors contain three capacitors to monitor temperature as the solvent is sublimated. A Millrock Technology REVO lyophilizer was used for testing. Water and 5% w/v sucrose solution were distributed in 3 mL fill volume increments into Wheaton 6R vials. Wireless temperature sensor measurements were compared with thermocouple measurements. Differences in temperature measurements between the top, middle, and bottom capacitors in each wireless temperature sensing unit demonstrates the sublimation pattern of the solvent in the primary drying stage. These sensors allow for heat flux through the product to be computed during the primary drying phase. Our goal is to assess the limitations and benefits of using wireless temperature sensors compared to commonly used thermocouples and other process monitoring technologies for lyophilization processes as well as to determine methods to further improve the wireless temperature sensors.

Optimization of a High-Speed Tube-Based X-Ray Imaging System for Studying Sprays

Presentation ID:
MO-24

Room:
ARMS 1010

Keywords:
Sprays, X-ray, Radiography, Imaging, Resolution

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[1]Fort Lewis College, [2]Purdue University

Spray-based liquid atomization and liquid mixing is critical for development of efficient combustors and drug delivery systems as well as for multiple coating-related applications. While optical methods allow characterization of low density regions of sprays, the scattering of optical photons hinders the characterization of a dense core. Unlike optical photons, higher-energy X-ray photons have the capability to penetrate and image the core structure of sprays. Here we characterized temporal and spatial resolution of an X-ray imaging system based on a commercially available tube source with an anode size of .6 mm. For high-speed imaging, a phosphor screen in combination with a high-speed CMOS camera equipped with a two-stage intensifier was used. Water was used as a model liquid with the addition of potassium iodide to increase the X-ray absorption coefficient. Two-dimensional images of 2 mm impinging jet sprays were taken with differing spatial resolutions, temporal resolutions, and potassium iodide mass concentrations. Depending on the spray conditions, optimal imaging settings were found. The technique can be extended to three-dimensional analysis of sprays with multiple viewing angles from two or more X-ray sources along with tomographic reconstruction.

How User's Visualization Literacy Relates to Their Cognitive Traits

Presentation ID:
MO-25

Room:
ARMS 1010

Keywords:
Information visualization, Visualization literacy, Numeracy, Need for cognition, Cognitive traits

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Researchers in the field of Information Visualization have suggested that users' cognitive abilities would likely to affect their understanding of data visualizations and deeper exploration in the visualizations. However, the evidence is still scant to link between user's visualization literacy and their cognitive traits. Thus, the research goal of this study is to explore how user's visualization literacy and their cognitive traits are related. In particular, we focused on two cognitive traits: numeracy and need-for-cognition. In order to achieve the goal, first, we measured visualization literacy, numeracy, and need-for-cognition using existing instruments with 46 Amazon Mechanical Turk workers, and the scores of the tree instruments were analyzed. The results showed that a moderate positive relationship between visualization literacy and numeracy (Spearman rho correlation coefficient = 0.571, P-Value = 0.000); a moderate positive relationship between visualization literacy and need-for-cognition (Spearman rho correlation coefficient = 0.403, P-Value = 0.006). In short, this study provides researchers of visualization literacy understanding of how users' ability to interpret visualization relate their cognitive traits.

MORNING POSTER PRESENTATIONS

MP

Biotechnology I

ARMS Atrium, 11:00 AM – 12:15 PM

The Effect of an Enhanced Isopentenyl Monophosphate Pool on Terpenoid Biosynthesis in vivo

Evan T Adams, Laura K Henry, and Natalia Dudareva
Purdue University

Found in all living organisms, terpenoids make up the largest group of natural products and are essential compounds for many major processes, including photosynthesis, respiration, hormone production, and electron transport. Additionally, they have commercial and medical value in products including fragrances, cosmetics, and medicines. Terpenoids originate from the five-carbon building blocks isopentenyl diphosphate (IPP) and dimethylallyl diphosphate (DMAPP), which are synthesized by the mevalonic acid (MVA) and methylerithritol phosphate (MEP) pathways. An alternative MVA pathway was discovered in Archaea with the final two enzymes being phosphomevalonate decarboxylase (MPD) and isopentenyl phosphate kinase (IPK). Even though this alternative pathway is not present in plants, presence of IPK was retained. The overexpression of IPK in planta indicates that IPK plays a significant role in the MVA pathway by synthesizing IPP/DMAPP from an IP/DMAP pool for terpenoid biosynthesis. It has been suggested that this monophosphate pool regulates downstream carbon flux by inhibiting farnesyl diphosphate synthase (FPPS). By utilizing MPD from the archeabacterium Roseiflexus castenholzii, we can see how an increased isopentenyl (IP) pool affects downstream terpenoid biosynthesis. To do this, RcMPD was overexpressed in the background of Arabidopsis thaliana T-DNA insertion lines of a knockdown of IPK. These lines were tested for expression of MPD/IPK using qrt-PCR and terpenoids were analyzed via sterol extraction and scent collection. We hypothesize that sterol and sesquiterpene levels, products of the MVA pathway, will be significantly reduced, suggesting that a larger monophosphate pool reduces downstream synthesis of farnesyl diphosphate, the precursor for sterol and sesquiterpene biosynthesis.

Presentation ID:
MP-1

Room:
ARMS Atrium

Keywords:
Plant terpenoids,
Prenyltransferases,
Isopentenyl Phosphate,
Metabolic engineering,
Mevalonate phosphate decarboxylase

Lysis and Amplifciation of Neonatal Sepsis Causing Pathogens

Gregory Berglund, Elizabeth A Phillips, and Jacqueline C Linnes
Purdue University

Neonatal sepsis, resulting from a bloodstream infection within the first few weeks of life, is the leading cause of newborn deaths worldwide. The gold standard of neonatal sepsis diagnosis requires a blood culture to identify the infecting bacteria, however require days of incubation, expensive equipment, and expertise. Any delay in diagnosis is critical, as the condition can be treated easily if appropriate antibiotics are administered promptly. A low-cost, rapid, and sensitive diagnostic test would enable more timely treatment and lead to better patient outcomes with fewer required resources. Point-of-care, nucleic acid amplification assays are a promising alternative to blood culture that quickly deliver sensitive results with minimal sample volume. However, these require isolated and purified template DNA from the pathogenic bacteria, a task that is difficult to achieve in a field setting. This study sought to develop a simple one-step lysis and amplification protocol for three common bacterial causes of neonatal sepsis, *Streptococcus agalacitae*, *Klebsiella pnemoniae*, and *Staphylococcus aureus*. The combined efficacy of enzymes, proteinase K and achromopeptidase (ACP), and heat to lyse each of these bacteria for direct DNA amplification was examined. Results showed that all three strains could be effectively lysed by applying 1 U of ACP and incubating for 10 minutes at 37°C. No adverse effects were seen in amplification reactions containing ACP if the compound was inactivated prior to amplification at 85°C for 2 minutes. The demonstrated effectiveness of ACP in rapid bacterial lysis validates its usefulness in a point-of-care device for neonatal sepsis.

Presentation ID:
MP-2

Room:
ARMS Atrium

Keywords:
Lysis,
Neonatal sepsis,
Point-of-care,
LAMP

Mechanical Reliability of Implantable Polyimide-Based Magnetic Microactuators for Biofouling Removal

Presentation ID:
MP-3

Room:
ARMS Atrium

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Keywords:
Magnetic microactuators, MEMS, Hydrocephalus, Polyimide, Fatigue, Biofouling

Hydrocephalus is a neurological disorder that typically requires a long-term implantation of a shunt system to manage its symptoms. These shunt systems are notorious for their extremely high failure rate. More than 40% of all implanted shunt systems fail within the first year of implantation. On average, 85% of all hydrocephalus patients with shunt systems undergo at least two shunt-revision surgeries within 10 years of implantation. A large portion of this high failure rate can be attributed to biofouling-related obstructions and infections. Previously, we developed flexible polyimide-based magnetic microactuators to remove obstructions formed on hydrocephalus shunts. To test the long-term reliability of these magnetic microactuators, here we evaluate the impact of actuation cycle on mechanical stability of these microdevices. Over 50 minutes, 8 devices were actuated at 100 Hz at 37°C continuously in phosphate buffered solution. By measuring the primary resonant frequency of each device, we were able to quantify changes in the structural integrity of each actuator. On average, the devices showed a drop of 2.15% in resonant frequencies. Although additional evaluations are necessary to ascertain appropriate actuation duty cycles, preliminary results suggest that our polyimide-based devices have good mechanical reliability, which bodes well for our ultimate goal of improving quality of life and care for hydrocephalus using our MEMS-enabled self-clearing catheters.

Design And Development Of A Plasmid Vector For Protein Expression And Purification

Presentation ID:
MP-4

Room:
ARMS Atrium

Mahima Grover, Craig Sweet, and David H Thompson
Purdue University

Keywords:
Recursive directional ligation, Plasmid, Fusion protein, Colony PCR

Production and isolation of proteins are difficult, costly and time-consuming processes. The aim of this project is for the development of plasmids, which allow for streamlined production and isolation of proteins. To allow for modular insertion of varying segments of DNA we are using “recursive directional ligation by plasmid reconstruction”. This technique uses type II restriction endonucleases, which cut downstream from their recognition site allowing multiple insertions without losing a restriction site. Using this process, we can ligate multiple DNA sequences together and express them to be able to construct a scar less fusion protein. In order to accomplish this, we have used techniques such as restriction digestion, ligation, dephosphorylation and transformation in order to ligate our vector, pET 25B+, and different DNA inserts together and inserted them into competent cells. To screen whether proper ligation has occurred we have used techniques such as colony PCR and running diagnostic restriction digestions on agarose gels. Sanger sequencing was used to confirm the successful insertion of individual sequences in our plasmid, which will allow for different modes of purification of any protein of choice.

Activity of Protein Kinase A Attached to Magnetic Beads

Presentation ID:
MP-5

Room:
ARMS Atrium

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Purdue University

Keywords:
Kinematics, Protein, Protein Kinase A, High throughput

Development of high throughput assays is a crucial step in developing more efficient techniques that aid in many important areas of research today such as drug development or identification of protein structure function relationships. Integration of high throughput assays into more research efforts could drastically decrease the time and cost it takes for a new drug to hit the market. Protein Kinase A (PKA) is an extensively studied protein as it is highly upregulated in cancer and is a hot spot for drug targeting. In this work, azide-tagged PKA is covalently attached to magnetic beads using azide-alkyne cycloaddition, a well-known click chemistry reaction that selectively and covalently links two compounds. Modified PKA is attached to magnetic beads and the activity of the covalently bound PKA is determined. Significant levels of PKA activity can open the door to development of more efficient drug screening processes. It is anticipated that the azide-PKA conjugated beads will have significantly more PKA activity than beads treated with non-tagged PKA since there is specificity in binding between the azide-tagged PKA and the magnetic bead. Additionally, preliminary data using an inhibitor assay and ATP gradient scale suggests that linked PKA has similar chemical properties with native state PKA subject to the same treatments.

Health I

ARMS Atrium, 11:00 AM – 12:15 PM

Analyzing Mutations of Spt7 Protein That Disrupt Interaction with SF3B Subunits

Presentation ID:
MP-6

Room:
ARMS Atrium

Keywords:
SAGA,
SF3B3,
SF3B5,
Spt7,
Protein interaction

Arryn T Harris, Peyton J Spreacker, Rachel Stegeman, Vikki M Weake, and Edwin C Acosta
Purdue University

Proper transcription, the process of converting DNA to RNA, is crucial for the health and viability of an organism. This process is regulated by many proteins, such as co-transcriptional activators; one being the protein complex known as Spt-Ada-Gcn5-acetyltransferase, or SAGA. While much is known about the roles of SAGA in cell processes, how SAGA's subunits promote functionality is still unknown. The focus of this study is to analyze the purpose of SAGA's SF3B subunits. These subunits are also found in the spliceosome, the compound responsible for generating mature RNA. SAGA has no known functions relating to this process, so the reason the SF3B components are in SAGA is unclear. Spt7, another SAGA subunit, interacts with both SF3B subunits. In this study, a yeast two hybrid assay was performed where different Spt7 mutants were screened. This was done by transforming yeast with Spt7 mutants, analyzing the protein interactions and sequencing the mutants to determine their mutations. A key result of this study is in the determining that the two SF3B subunits interact with different regions of Spt7. Although the overall goal is to find an Spt7 mutant that does not interact with the SF3B components but still maintains interaction with other SAGA subunits, we now have a better idea of what type of Spt7 mutant is needed. This discovery will lay the foundation for future experiments where a mutated SAGA with no SF3B components will be expressed in *Drosophila melanogaster* and analyzed to determine the function of SF3B subunits in SAGA.

Identifying the Effects of Unprocessed let-7a-1 and let-7a-3 in Non-Small Cell Lung Cancer

Presentation ID:
MP-7

Room:
ARMS Atrium

Keywords:
microRNA,
let-7,
Lung cancer,
Non-coding RNA

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MicroRNAs (miRNAs) are small, noncoding RNAs that regulate protein levels typically by interacting with the 3' untranslated region (3'-UTR) of target messenger RNA (mRNAs) and are often aberrantly expressed in cancer. The *let-7* miRNA family members are commonly regarded as cancer suppressors, by down-regulating the expression of oncoproteins such as RAS, HMGA2, and MYC. However, prior work indicates that unprocessed *let-7* RNAs may be positively correlated with cancer phenotypes in lung cancer cell lines. Our study aims to identify the effects of unprocessed *let-7a-1* and *let-7a-3* in non-small cell lung cancer, by transfecting plasmids that express unprocessed *let-7a-1* and *let-7a-3* into 3 different lung cancer cell lines. We then proceeded to conduct functional assays to measure the differences in anchorage independent growth, cell proliferation, and cell migration in all cell lines transfected with unprocessed *let-7*, in contrast to cells transfected with a control vector and thus far determined that unprocessed *let-7a-1* can enhance anchorage independent growth. Thus, we created truncations of the *let-7a-1* miRNA to identify the *cis* regions of this miRNA that is responsible for the change in phenotype. Our results suggest that cells transfected with truncated, yet unprocessed *let-7a-1* have increased anchorage independent growth, a major hallmark of cancer cell. There is still a need to replicate the functional assays that were conducted while continuing to create constructs of both *let-7a-1* and *let-7a-3* in order to further identify the sequence of the miRNAs responsible for the enhanced cancer phenotypes.

Lipid Detection in Pig Arteries Using Intravascular Photoacoustic Imaging

Presentation ID:
MP-8

Room:
ARMS Atrium

Keywords:
Atherosclerosis, Vulnerable plaque, Lipid core, Intravascular photoacoustic imaging, Lipid detection

Jieying Mai[1], Yingchun Cao[1], Ayeeshik Kole[1,2], Michael Sturek[1,2], and Ji-Xin Cheng[1]
[1]Purdue University, [2]Indiana University-Purdue University Indianapolis

Heart disease is the leading cause of death in the United States and worldwide. Each year over 370,000 people died from coronary artery disease in America. As the primary form of coronary artery disease, atherosclerosis behaves as lipid-rich plaque development inside an artery wall. Vulnerable plaques are those prone to rupture, which may result in thrombus or even death. Typical hallmarks of a vulnerable plaque include thin fibrous cap, a large lipid-rich necrotic core and inflammatory infiltrate. The identification and accurate detection of these lipid depositions in the arterial wall is crucial in the diagnosis of atherosclerosis. However, none of the current clinical imaging tools can provide accurate and reliable detection of the lipid-rich necrotic core in human arteries. Intravascular photoacoustic (IVPA) imaging is an emerging technique that can provide lipid-specific detection with depth resolution. Our research focuses on applying the catheter-based IVPA imaging technique for lipid-laden plaque detection within the artery of an Ossabaw swine model. A high sensitivity IVPA imaging system developed in our lab was performed to imaging the carotid arteries from the pig model ex vivo. The imaging results showed that the exact location and size of the lipid core can be identified, which agrees with the gold standard histology result. We also compared the results of our IVPA system with the commercial near infrared spectroscopy (NIRS) imaging system. They both successfully indicated the lipid appearance at the same location. However, our imaging modality provided more information of the lipid including lipid core size, depth and distribution. This is a significant improvement of plaque burden estimation and the diagnosis of atherosclerosis in the human artery.

Fabrication and Evaluation of Magnetic Micro Actuators for Implantable Self-Clearing Glaucoma Drainage Devices

Presentation ID:
MP-9

Room:
ARMS Atrium

Keywords:
Glaucoma, BioMEMS, Magnetic micro-actuator, Implantable devices, Glaucoma drainage device, Biofouling

Haritha Ramadorai, Hyunsu Park, and Hyowon Lee
Purdue University

According to the World Health Organization, glaucoma is the second leading cause of blindness in the world. It currently affects more than 2.7 million people in the United States alone and over 79.6 million people worldwide is estimated to be inflicted by this debilitating disease by 2020. Glaucoma patients are often characterized with elevated intraocular pressure (IOP) and are treated with implantation of glaucoma drainage devices (GDD) to maintain optimum IOP. In the recent years, micro-fabrication technologies have aided in the development of GDD. Although initially effective at delaying glaucoma progression, contemporary GDD often lead to numerous complications and only 50% of implanted devices remain functional after 5 years. Biofouling is seen to be one of the leading causes for the failure of GDD. In order to overcome biological blockage, we propose a self-clearing glaucoma drainage device using integrated magnetic micro actuators. Here we report on the mask-less photolithographic fabrication results of magnetic micro-actuators to be integrated into a bespoke GDD. The mask-less photography enabled rapid prototyping of micro-devices using low-cost materials in contrast to conventional lithographic methods. The fabricated devices were able to produce maximum deflection of RANGE degree @ magnetic field strength. The static response of the fabricated devices was compared with the theoretical data.

Development of Standard Criteria to Evaluate the Effectiveness of Helmets at Decreasing the Risk of Concussions

Daniel Y Shyu[1], Goutham N Sankaran[1], Kevin G McIver[1], Nicolas Leiva[2], and Eric A Nauman[1]
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In many sports, such as American football, accumulations of mild traumatic brain injuries have been suggested as a possible link to neurodegeneration and future mental disorders. With head impacts occurring at all levels of competition and in different sports, it is critical to develop an accurate method for quantifying the effects of head impacts and determining the efficacy of helmets. This study examines the derivation of different dimensionless numbers and ascertains the critical factors needed to predict the effects of head impacts, specifically the resulting accelerations from an impact. Given a known force of impact, parameters such as peak translation acceleration and impact duration were collected for a total of 200 impacts at 10 locations around the head. These parameters were used in conjunction with dimensionless numbers to compare various helmet designs across sports. Five input and four output criteria, or π variables, were derived using fundamental variables of total mass, width of neck, and the difference between muscle reaction time and the impact duration. By determining the coefficients of the governing equations for each output π variable, the impulse of impacts had a consistent effect on helmet efficacy, while the masses and radii of helmets contained confounding variables that made it difficult to predict the effectiveness of attenuating the head accelerations.

Presentation ID:
MP-10

Room:
ARMS Atrium

Keywords:
*Helmet,
Concussion,
Biomechanics,
Evaluation*

The Role of Osteocyte Estrogen Receptor Beta (ERβ) in Regulating the Skeletal Response to Mechanical Loading

Julia P Townsend and Russell P Main
Purdue University

Estrogen's biological functions are mediated by estrogen binding to estrogen receptors (ER). Understanding what role both ER*α* and ER*β* have in bone maintenance and formation can contribute to possible treatment of osteoporosis. This study examined osteocyte specific deletion of ER*β* in mice. The cross of ER*β*-floxed mice with DMP1-8kb-Cre mice provided both experimental knockout mice as well as littermate control mice. At 24 weeks of age the left tibiae of all mice were mechanically loaded five days per week for two weeks to induce bone formation. Analysis of cortical bone was conducted using microcomputed tomography (microCT) to measure load-induced changes in bone density and architecture of both loaded and non-loaded limbs. We found a significant effect of load on cortical bone geometry in both male and female knockout and control mice at 37% and 50% bone length. Based on our findings, osteocyte ER*β* appears to play a minor role in determining cortical bone geometry in 24 week old mice. We are still investigating the effect of load and genotype on cancellous bone.

Presentation ID:
MP-11

Room:
ARMS Atrium

Keywords:
*Estrogen receptor,
ERβ,
Mechanical loading,
Osteocyte,
Skeleton,
Bone*

Pathway by which Vagus Nerve Stimulation of B Fibers Affects Heart Rate

Kelsey Wasilczuk, Matthew Ward, and Pedro Irazoqui
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Heart failure (HF) affects over 5 million adults in the United States. Many HF patients have a high resting heart rate, which is correlated with a high mortality rate. In recent years, vagus nerve stimulation (VNS) has become an increasingly researched therapy to reduce the resting heart rate of HF patients. However, current dosage given during VNS is increased incrementally at the doctor's office until side effects present themselves in a patient. In addition, the means by which the therapy works is not completely understood. To better understand the therapy's mechanisms, the right cervical vagus nerve of several Long Evans rats was exposed and cuffed. Autonomous Nerve Control (ANC) was utilized to activate various percentages of B Fibers, which have been found to be the most influential fiber on heart rate. After the first round of stimulation, a vagotomy was performed superior to the stimulation cuff on the nerve, and the stimulation was repeated. Initial experimentation was performed to confirm the electronics set-up and the surgical approach as well as ensure that a decrease in heart rate could be achieved with stimulation. Further experimentation is still needed to fully characterize the relationship between VNS and heart rate both before and after vagotomy. Knowing the pathway by which VNS affects heart rate can give further insight into how VNS treatment works. Additionally, further research needs to be performed to characterize the interaction between VNS therapy and drugs routinely prescribed to HF patients.

Presentation ID:
MP-12

Room:
ARMS Atrium

Keywords:
*Vagus nerve
stimulation,
Heart failure,
Vagotomy,
Bradycardia*

Materials Science I

ARMS Atrium, 11:00 AM – 12:15 PM

Laser Assisted Manufacturing: A Comparison of Mechanical Properties Between LAM and Conventional Manufacturing Techniques

Presentation ID:
MP-13

Room:
ARMS Atrium

Keywords:
Laser welding,
Laser deposition,
Mechanical properties,
Titanium carbide,
304SS

William Blakeslee, Neil S Bailey, Kyung-Min Hong, Shunyu Liu, and Yung C Shin
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Laser assisted manufacturing methods, such as direct metal deposition (DMD) and laser beam welding (LBW), are promising methods because of their higher precision and greater productivity when compared to traditional manufacturing methods. Because these methods are relatively new, the mechanical properties of samples produced by laser assisted manufacturing are not well understood. In this study the mechanical properties of samples produced by laser assisted manufacturing methods are analyzed and compared with data obtained from traditional manufacturing methods. The DMD process used Fe-TiC and Ti-TiC metal matrix composites, while LBW used AISI 304 stainless steel. The results vary widely with the materials and processes used. Although their use is highly dependent upon the individual applications and their needs, laser assisted manufacturing methods present an alternative to conventional techniques. This study can serve as a guide to comparing the results of various manufacturing methods and choosing the appropriate technique for the desired results.

Classifying Pattern Formation in Materials via Machine Learning

Presentation ID:
MP-14

Room:
ARMS Atrium

Keywords:
Strongly correlated electronic systems,
Correlated materials,
Pattern formation,
Scanning probe,
Machine learning

Lukasz Burzawa, Shuo Liu, and Erica W. Carlson
Purdue University

Scanning probe experiments such as scanning tunneling microscopy (STM) and atomic force microscopy (AFM) on strongly correlated materials often reveal complex pattern formation that occurs on multiple length scales. We have shown in two disparate correlated materials that the pattern formation is driven by proximity to a disorder-driven critical point. We developed new analysis concepts and techniques that relate the observed pattern formation to critical exponents by analyzing the geometry and statistics of clusters observed in these experiments and converting that information into critical exponents. Machine learning algorithms can be helpful correlating data from scanning probe experiments to theoretical models of pattern formation. We analyze the use of machine learning algorithms for the identification of critical behavior and universality underlying scanning probe data sets taken from correlated materials. This method has complementary strengths to the cluster analysis methods. The cluster techniques have a clear physical interpretation while machine learning algorithms require less expertise from the user and are faster to implement. The complementary nature of the two techniques further facilitates our understanding of correlated materials. The training of machine learning algorithms has been done through artificial neural networks. The neural net was trained using data from theoretical simulations of percolation and Ising models. The trained net had a 3.00% average classification error during testing. This proves that machine learning algorithms can successfully distinguish whether the complex pattern formation of a specific novel material is governed by uncorrelated percolation or by an interaction model fixed point.

DNA bound Avicel Network: The Beginnings of a Self-Healing Material

Presentation ID:
MP-15

Room:
ARMS Atrium

Emily R. Coleman[1], Michael R. Ladisch[1], Eduardo Ximenes[1], Seockmo Ku[1], Kathleen Howell[1], and Marissa Karp[2]

[1]Purdue University, [2]United States Military Academy at West Point

Keywords:
Avicel, Cellulose, DNA super glue, Self-healing material, Materials science, Smart materials

Self-healing materials could potentially provide many improvements to engineering projects, including reduced maintenance and cost, and increased lifespan. It is desired to create a self-healing material proof of concept, which can then be altered for eventual application to the surfaces of small satellites with the goal of increasing material lifetimes. The intrinsic properties and abilities of DNA base pairing will be studied as a first test of proof of concept. The exploratory research will begin with the oxidation of small (50 μm) particles of Avicel using TEMPO. The next phase includes the activation of Avicel particles via an EDC (1-Ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride) reaction. Then, segments of single stranded DNA (oligonucleotides) will be bound to the cellulose particles. Complementary strands will be bound to a second aliquot of particles. The particles will be combined to test if they hybridize (bind in a directed manner), resulting in a network of Avicel particles glued together by DNA. A Malvern wet particle size instrument will be used to compare the size of particles before and after chemical alterations, and colored nanoparticles will be used to dye the individual aliquots to observe changes in color that may result from the binding of different particles. Key results thus far include experimental design and successful oxidation of cellulose. These experiments are part of a longer term project that is studying whether intrinsic self-healing materials are possible. Alterations in the particle and glue types may allow for applications in many fields, including the automobile, airline and healthcare industries.

Characterization of Suspension Polymerized Polyacrylamide and Poly (sodium acrylate-acrylamide) Copolymer and their Size Influence on the Properties of Concrete

Presentation ID:
MP-16

Room:
ARMS Atrium

Cole R Davis, Kendra A Erk, and Stacey L Kelly
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Keywords:
Suspension Polymerization, Characterization, Superabsorbent Polymer, Hydrogel, Concrete

Shrinkage leading to cracking and mechanical instability is a major problem for concrete due to the loss of water during the curing process. However, through the addition of Superabsorbent Polymer (SAP) hydrogels, shrinkage can be prevented, increasing the strength of concrete. Characterization of suspension polymerized polyacrylamide (PAM) poly(sodium acrylate-polyacrylamide) (PANa-PAM) copolymer microsphere sizes, morphology and swelling behavior was conducted before adding them to concrete. Size was determined using microscopy paired with ImageJ analysis. Coulter Counter size characterization was also used to determine the particle size distribution. Swelling behavior was determined using the tea bag method as well as size analysis before and after hydration. After characterization, concrete containing various sizes of SAP microspheres will be tested for shrinkage and mechanical strength. These tests will allow us to discover the optimal size of SAP microspheres in concrete to increase its mechanical properties as well as control shrinkage. We will also investigate if the shape of particles has an impact on the final properties of the concrete. The results of this study will contribute to the growing knowledge of applying SAPs in concrete and will give a better understanding on how the size and shape of SAP hydrogels influence the properties of concrete. Using this knowledge, concrete can be made to perform better resulting in more mechanically sound structures.

Microstructure Evolution During Powder Compaction

Presentation ID:
MP-17

Room:
ARMS Atrium

Keywords:
*Powder compaction,
Granular systems,
Simulation,
Plastic deformation,
Elastic deformation*

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The process of powder compaction consists of the synthesis of loose powders into a solid material. The applications of compaction of granular systems extend to pharmaceuticals, detergents, food, ceramic and metallurgical processes. It is indispensable to have a thorough understanding of the behavior of confined granular systems during compaction because the performance of the final desired product is related to the microstructural features that develop during the compaction process. To have a more realistic description of the compaction, it is also important to include the packing process of granular systems. However, there are different particle packing algorithms that account for the particle filling process. The Discrete Element Method (DEM) had been used to obtain a dynamic solution to this problem but requires high computational power. As an alternative to the computationally expensive DEM approach, a static based algorithm has recently been developed for the modelling and simulation of the particle packing process. The algorithm allows for the modeling of the packing process by depositing spheres inside containers of different shapes and sizes. In this study, we present a new version of the nanoHUB Powder Compaction tool. It currently simulates the microstructure evolution of compressible granular systems at high relative densities. The new features will use a general particle packing algorithm and thus allow the user to choose a particle size distribution and number of particles to fill the die. The information is passed to the solver that will simulate the compaction in Purdue's high-performance cluster.

Study of Oxidative-Crosslink Reaction in Polyphenyl Sulfide (PPS) / Carbon Fiber and its Influence in Additive Manufacturing

Presentation ID:
MP-18

Room:
ARMS Atrium

Keywords:
*Fused Filament
Fabrication (FFF),
Polyphenylene Sulfide
(PPS),
Carbon fiber,
Crystalization kinetics,
Oxidative cross-linking*

Dong Hee Kim, Eduardo Barocio, Bastian Brenken, Anthony Favaloro, and Byron Pipes
Purdue University

Ever since its development in 1980s, Fused Filament Fabrication (FFF) has been an attractive additive manufacturing technology due to its flexibility to create intricate shapes, low costs and fast manufacturing. These advantages make FFF technology suitable for printing molds for the carbon fiber industry. The composite material currently used for printing is Polyphenylene Sulfide (PPS) reinforced with up to 50% by weight of long discontinuous carbon fiber. Combining FFF with composites enables the production of molds that not only have low coefficient of thermal expansion (CTE) but also high thermal stability for autoclave applications. However, PPS is been found to be sensitive to processing conditions since exposures to oxidative atmospheres at the processing temperature causes an oxidative reaction in the polymer. Hence, the effects of oxidation on the performance of the polymer are investigated including the effects on crystallization kinetics and the change in the polymer architecture. Differential Scanning Colorimetry (DSC) is used first to investigate the kinetics of the oxidative reaction in the polymer, and second to characterize the changes in crystallization kinetics of the polymer. Then, Fourier Transform Infrared Spectroscopy (FTIR) is used to study the changes in the polymer architecture due to the oxidative reaction. From the DSC analysis, the crystallization rate was found to increase with the oxidation due to the presence of additional nucleation sites, but at the same time the oxidation decreased the max crystallinity developed. The results suggest that oxidative cross linking act as a nucleating agent that speeds up the crystallization process. However, the increase in crystallization rate inhibits the growth of large crystals which decreases the final crystallinity level of the material.

Effect of Conveying and Distributive Mixing Elements on Breakage Phenomenon in Twin Screw Granulation

Presentation ID:
MP-19

Room:
ARMS Atrium

Keywords:
Twin-screw granulation, Dynamic yield strength, Material property

Jiayu Li, Shankali U Pradhan, and Carl Wassgren
Purdue University

Twin screw wet granulation (TSG) is gaining more attention and becoming an important process in the pharmaceutical industry. The process is widely implemented because of its flexibility, short residence time, and small equipment footprint. Past studies have shown that screw elements can have a significant impact on the performance of the TSG process. In addition, these studies identified that breakage of wet mass is a significant step in the process. Currently there is no literature that focuses on the effect of each screw element on the breakage process. In this work, experiments have been designed to isolate the breakage process and study the different breakage effects between distributing mixing elements (DMEs) and conveying elements (CEs) in TSG. Cylindrical pellets were made using different model materials having a wide range of dynamic yield strength. The pellets were fed into the twin screw granulator, which then passed through the different screw elements. Pellet breakage probabilities were measured for each screw element configuration. As the strength of the pellets increases, the breakage probability in the CEs decreases. The breakage probability in the DMEs remains the same and shows 100% breakage, independent of the material strength. The experiments have aided in the understanding of the different breakage processes using CEs and DMEs. The breakage in CEs shows a strong dependence on material dynamic yield strength whereas the breakage in DMEs is not a function of the strength.

Rare Earth Elements Purification Using Ligand-Assisted Displacement Chromatography

Presentation ID:
MP-20

Room:
ARMS Atrium

Keywords:
*REE,
Separation,
Chromatography,
Ligand-assisted displacement chromatography*

Yingyi Liang, Hoon Choi, and Nien-Hwa Linda Wang
Purdue University

Rare Earth Elements (REEs) including the lanthanide series, Yttrium, and Scandium play a critical and essential role in various industries such as electronics, power, and defense. Traditional methods have difficulties in separating REEs due to their high similarities in chemical and physical properties. With increasing demand of REEs, current industrial techniques of REE extractions, two phase liquid-liquid extraction, are not efficient enough to meet the market’s need without causing serious environmental problems. Specifically, two phase liquid-liquid extraction uses a large number of mixer-settler units in series and parallel for purification of REEs. This method consumes excessive solvents and chemicals that are environmentally hazardous. Spedding and Powell studied ligand-assisted displacement chromatography of REE recovery in 1950’s, which showed high yields and high purity but low productivity. Their process was designed based on trials and errors and was not optimized. The first goal of this study is to develop and test a systematic design and optimization method to increase sorbent productivity and reduce separation cost. The second goal is to understand the dynamic separation mechanism using rate model simulations. We will test the design method experimentally using three REEs, Nd, Sm and Pr. Ammonium citrate will be used as a ligand displacer. Frontal tests will be used to estimate the various parameters corresponding to adsorption, reaction and mass transfer. Rate model simulations will be conducted to verify experimental data. Experiments are in progress. The design aims to achieve an average yield of each product of 97% with a purity of 99%, and sorbent productivity an order of magnitude higher than that of Spedding and Powell.

Nanotechnology I

ARMS Atrium, 11:00 AM – 12:15 PM

Generalizing the Quantum Dot Lab Towards Arbitrary Shapes and Compositions

Presentation ID:
MP-21

Room:
ARMS Atrium

Keywords:
Quantum dots, Generic structures, Strained crystalline, Amorphous

Matthew A Bliss, Prasad Sarangapani, James Fonseca, and Gerhard Klimeck
Purdue University

As applications in nanotechnology reach the scale of countable atoms, computer simulation has become a necessity in the understanding of new devices, such as quantum dots. To understand the various optoelectronic properties of these nanoparticles, the Quantum Dot Lab (QDL) has been created and powered by NEMO5 to simulate on multi-scale, multi-physics bases. QDL is easy to use by offering choices of different QD geometries such as shapes and sizes to the users from a predefined menu. The simplicity of use, however, limits the simulation of general QD shapes and compositions. A method to import generic strained crystalline and amorphous dot structures into the QDL has been created here. Users can now analyze electronic structure effects in both effective mass and 10-band sp3d5s* tight-binding models. Implementation has been successful through a restructuring of the user interface as well as the alteration of the primary bodies of Tcl code that interpret input and pass them on to NEMO5 for precision computation. With this new development comes the ability for researchers, educators, and students alike to peer into uncharted areas of quantum technology and gain new insight through a high-level of simulation plasticity.

Effect of Aggregation and Particle Size on the Thermal Conductivity of Nickel Epoxy Nanocomposite

Presentation ID:
MP-22

Room:
ARMS Atrium

Keywords:
Heat transfer, Nanocomposites, Thermal conductivity, Aggregation, Nanoparticles

Jacob M Faulkner, Xiangyu Li, and Xiulin Ruan
Purdue University

Microprocessor advancements have been stunted in recent years by inadequate means of heat dissipation as power continues to grow and size continues to shrink. One way to increase thermal conductivity while maintaining electrical insulation is to add metal nanoparticles to a polymer matrix. This cheap material has become a popular thermal interface for this reason. However, optimization of the interface is dependent upon a number of factors including particle size, shape, orientation, and aggregation. Various theoretical models and numerical approximations have been developed to find the effective thermal conductivity of such nanocomposites, but none has been able to fully incorporate each factor, specifically aggregation, due to the complexity of heat transfer in multiple dimensions without idealistic assumptions. In order to address this issue, nickel nanoparticles spread throughout an epoxy matrix were tested using the 3ω method to determine how particle size and aggregation influence effective thermal conductivity. Viscosity, the limiting factor to nanoparticle concentration in solution, was also measured and recorded. It was determined that the thermal conductivity was higher than predicted by previous effective medium approximations or EMA models and thermal conductivity increased with decreasing particle size. A two-level EMA model was developed in order to account for both particle size and aggregation. The higher thermal conductivity is caused by the effect of aggregation, and the presented EMA model accounts for this effect by using local concentration as a fitting parameter.

Atomistic Configuration Interaction Simulation Tool for Semiconductor Based Quantum Computing Devices

Presentation ID:
MP-23

Room:
ARMS Atrium

Keywords:
Quantum computing, Semiconductor, NEMO, Configuration interaction

Jingbo Wu, Archana Tankasala, Jim Fonseca, Rajib Rahman, and Gerhard Klimeck
Purdue University

As the data size and dimensions was growing larger and larger, the demand of more powerful computation tool is arising. Among those solutions quantum computing devices are one of the most promising candidates because quantum computing is not only suitable for large scale data processing, but also suitable for many other specific problems like prime number factorization and optimization. Thanks to its long coherent time, semiconductor-based quantum computing is very promising. In order to have a better understanding of the physical structure of semiconductor-based solid-state quantum computer, in our discussion, A very accurate method, full configuration interaction (FCI) was implemented to solve the Schrodinger equation.

Quantum Dot Lab : Incorporation of Alloys in the Capping Layer of Multi-layer Quantum Dot

Unmesha U Kale, Prasad Sarangapani, Jim Fonseca, and Gerhard Klimeck
Purdue University

Presentation ID:
MP-24

Room:
ARMS Atrium

Keywords:
Quantum Dot Lab, Alloy distribution, Simulations

Quantum dots have enhanced the performance of several optoelectronic devices. Designing and obtaining optimal quantum dot structures requires intensive simulation. Quantum Dot Lab on nanoHUB provides such a simulation platform. The simulation is fully parallelized and depending on the structure, the tool decides the computational resource which is to be used for the simulation. To obtain accurate predictions of quantum dot structures it is essential to provide a variety of simulation parameters to the user. In this research, a user interface was created where the user can simulate alloys by Random distribution and by Virtual Crystal Approximation(VCA) type distribution in the capping layer of a multi-layer quantum dot. Future work includes alloy distribution in other layers of the multi-layer quantum dot namely the substrate, the wetting layer and the quantum dot.

Measurement of Hydrogen Peroxide Influx Into Cells: Preparation For Measurement Using On-Chip Microelectrode Array

Hannah R Kriscovich[1], Sarah M Libring[2], Siddarth V Sridharan[3], James K Nolan[3], Jose F Rivera[3], Jenna L Rickus[3], and David B Janes[3]
[1]Georgia Institute of Technology, [2]Rutgers University - New Brunswick/Piscataway, [3]Purdue University

Presentation ID:
MP-25

Room:
ARMS Atrium

Keywords:
Hydrogen peroxide, Biosensors, Microelectrode arrays (MEA), Real-time flux, Astrocytes

Hydrogen peroxide (H_2O_2) is commonly known as a toxic reactive oxidative species (ROS) for cells. Recent studies have found evidence that H_2O_2 is also an important cellular signalling molecule. Quantifying cellular influx of H_2O_2 will contribute to researchers' understanding of the role H_2O_2 plays in healthy cells and cells involved in the progression of cancers and degenerative diseases, such as Alzheimer's. This work utilizes an assay kit and fluorescence techniques to compare different cell lines and conditions used to create measureable rates of H_2O_2 consumption by cells. Pancreatic beta cells (MIN6) and astrocytes were cultured and placed in 10 μM and 20 μM H_2O_2 solutions for up to 5 hours. The consumption of H_2O_2 by these cell cultures over time was measured using an Amplex Red Hydrogen Peroxide/Peroxidase Assay Kit (Molecular Probes/Invitrogen). Human astrocytes exposed to 20 μM of H_2O_2 displayed the fastest rate of H_2O_2 consumption (1.092 nmol H_2O_2/min/10^6 cells), and the rate of consumption for all cells increased with increasing H_2O_2 concentrations. In the future, a micro-electrode array (MEA) on a chip platform will be used for real-time electrochemical experiments to measure influx of H_2O_2 by astrocytes with spatio-temporal resolution that the current techniques lack. The results from the electrochemical experiments will be compared to results from the assay kit to determine the ability of the MEA to accurately measure H_2O_2 concentration and flux. The MEA can be extended to a wide array of environments with groups of cells or single cells for analysis of real-time biological events.

Effect of Particle Concentration and AC Field Strength on Particle Trapping in Rapid Electrokinetic Patterning (REP)

Sixuan Li, Avanish Mishra, and Steve Wereley
Purdue University

Presentation ID:
MP-26

Room:
ARMS Atrium

Keywords:
Optical tweezers, Electrokinetics, Manipulation, Microfluidics, Lab on a chip

Rapid Electrokinetic Patterning (REP) is an optoelectric technique for trapping and translating micro- and nanoparticles non-invasively. It uses a combination of laser-induced AC electrothermal flow and particle-electrode interactions in the presence of a uniform AC electric field. The trapping is governed by laser power, electric field strength, AC frequency and dielectric properties of the particle and the medium. A REP trap has an AC frequency, termed critical frequency, above which particles cannot be trapped. It is expected to be dependent on dielectric properties of the particle and the medium. However, we propose that the particle concentration and AC field strength also influence the critical frequency. In our experiments, we test 1 and 2 μm polystyrene microspheres in REP under the condition of three particle concentrations and two electric field strengths while keeping the laser power fixed at 25 mW. We find that as the particle concentration increases, the critical frequency increases. Besides, by lowering the AC field strength, the critical frequency decreases. To our best knowledge, this is the first study revealing the effect of particle concentration on critical frequency. Based on these results, by selecting proper parameters, we can separate the smaller particles and hold the larger particles in the trap, opposite to what has been achieved by other researchers. The ability to separate smaller particles will make REP a more prominent and powerful particle trapping method.

Modeling & Simulation I

ARMS Atrium, 11:00 AM – 12:15 PM

Modeling of Roll-to-roll Plasma CVD System for Graphene Manufacturing

Presentation ID: MP-27

Room: *ARMS Atrium*

Keywords: *Chemical vapor deposition, Natural convection, Plasma, Graphene manufacturing*

Yudong Chen, Majed A Alrefae, Anurag Kumar, and Timothy S Fisher
Purdue University

Graphene is a 2D carbon material that has extraordinary physical properties applicable for many industrial applications such as electronics, oxidation barrier and biosensors. Roll-to-roll plasma chemical vapor deposition (CVD) has been developed to manufacture graphene in large scale. In the plasma CVD chamber, graphene is grown on a copper foil as it passes through a high temperature plasma region. The temperatures of the gas and the copper foil play important roles in the growth of graphene. So, there is a need to understand the temperatures as well as the gas velocity distributions in the system. The heat generated in the plasma creates temperature distribution that enhances the natural convection inside the system enclosure. The analysis of the temperature and the fluid flow of hydrogen was carried out numerically using FLUENT, a commercial computational fluid dynamics package. A three-dimensional model has been built including the heat source from the plasma, natural convection, radiation and gas mixture. The plasma is generated between two parallel plates that can be placed either vertically or horizontally. The temperature and the flow in the vertical plasma electrodes configuration have higher values than the horizontal configuration due to the increase of the heated plates that interact with the buoyancy-driven flow. Furthermore, it is found that the presence of a copper foil which is used as substrate for graphene deposition decreases the temperature and velocity in the adjacent regions since the copper foil acts as a fin and blocks the fluid flow, respectively. Finally, adding methane as a mixture with hydrogen increases the gas temperature in the plasma region due to the lower thermal conductivity of methane. The numerical results help in understanding the temperature and the flow in the roll-to-roll CVD plasma system that makes it suitable for industrial mass production of graphene.

TFIT Modeling for Subcooled Boiling and Flow Excursion

Presentation ID: MP-28

Room: *ARMS Atrium*

Keywords: *Two-phase flow, Two-fluid model, Subcooled boiling, Flow excursion*

Brachston Grubbs, Krishna Chetty, and Martin Bertodano
Purdue University

Subcooled boiling leading to the development of flow excursion instabilities is common in light water reactors but is more significant in pressure water reactors. Flow excursion causes critical heat flux to occur prematurely and at a lower value than the actual critical heat flux limit. Simulating subcooled boiling with computational fluid dynamics (CFD) will lead to better modeling of excursion trend lines and test mathematical models already developed. This study uses a program called TFIT to simulate two-phase flow using the Two-Fluid Model. The boundary conditions and physical parameters in a physical experiment done by Peter Griffith were inputted into the program. Saturated liquid water was the simulated fluid and the heat flux is uniform over the entire test section. Various other inlet bulk temperatures, heat fluxes, and pipe lengths were simulated. The numerical outputs from the program were plotted on Subcooled Number and Phase Change Number plots and trend lines were observed. The expected results for this project are that the data from simulations should produce trend lines that are similar to mathematical models proposed by Mamoru Ishii. The continued development of better flow excursion modeling will improve the safety analysis within nuclear reactors.

Thermoelectric Properties of Silicon from Ab Initio Calculations

Presentation ID:
MP-29

Room:
ARMS Atrium

Keywords:
Electronic structure, Thermoelectric, Transport coefficients

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As nanoscales become accessible to experimentalists, atomistic simulations of materials are becoming increasingly important for the prediction and design of materials properties. Recently, the search for energy efficient materials has driven the development of new theoretical methods, such as the Landauer-Datta-Lundstom (LDL) generalized transport model, to explore thermoelectric properties of materials based on their electronic structure and lattice dynamics. The Landauer Transport Properties (LanTraP) tool, currently available in nanoHUB, allows the computation of thermoelectric transport coefficients from a full-band electron dispersion; however, generating such electron band structures from *ab initio* methods is a convoluted process. The aim of this project is to automate the generation of electron band dispersions using density functional theory (DFT) as implemented in the DFT materials properties simulator (DFTMatProp) nanoHUB tool. The new feature will produce the full-band electron dispersion of any material in a format suitable for use with LanTraP.

A Fast Model for the Simulation of External Gear Pumps

Presentation ID:
MP-30

Room:
ARMS Atrium

Keywords:
External gear pump, Numerical simulation, Fluid power system

Zechao Lu, Xinran Zhao, and Andrea Vacca
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External gear pump is an important category of positive displacement fluid machines used to perform the mechanical-hydraulic energy conversions in many fluid power applications. An efficient numerical simulation program is needed to simulate the system in order to provide a direction for design purpose. The model consists of a lumped parameter fluid dynamic model and a model that simulates the radial micro-motions of the gear's axes of rotation. The system consists of a set of ordinary differential equations related to the conservation on mass of the internal control volumes of the pump, which are given by the tooth space volumes of the gears. Flow connections between the control volumes are introduced, as laminar or turbulent orifices to model the displacing action and the internal leakages of the unit. In order to optimize the numerical solution, the whole system is described in C++ and the ODEs are solved using linear multistep methods. The results of the simulation successfully match the experimental results as well as the predictions of a previously developed simulation tool. The results detail several features of the model, such as its capability of predicting the instantaneous tooth space volume pressure, the micro-motion of the gears and the outlet flow oscillations. The simulation model can be utilized in future research on external gear pump, as well as for design purposes. In particular, with its simulation swiftness the model is particularly suitable for virtual prototyping within numerical optimization procedures.

Design Optimization of a Stochastic Multi-Objective Problem: Gaussian Process Regressions for Objective Surrogates

Presentation ID:
MP-31

Room:
ARMS Atrium

Keywords:
Gaussian process, Multi-objective optimization, Regression, Uncertainty

Juan S. Martinez[1], Piyush Pandita[2], Ilias Bilionis[2], and Rohit Tripathy[2]
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Multi-objective optimization (MOO) problems arise frequently in science and engineering situations, where a set of multiple quantities of interest (QoI) of a certain system are to be maximized or minimized. The objective of the optimization problem is to find the set of input parameters that generate the set of optimal outputs, mathematically known as the Pareto front. Solving the MOO problem is a challenge for many applications involving complex systems since expensive experiments can be performed only a constrained number of times and there is a limited set of data to work with, *e.g.* a roll-to-roll microwave plasma chemical vapor deposition (MPCVD) reactor for manufacturing high quality graphene. The current state-of-the-art techniques, *e.g.* evolutionary algorithms, particle swarm optimization, require a large amount of observations and are not applicable. Fortunately, recent extensions of Bayesian global optimization (BGO) are able to tackle the problem. BGO replaces expensive objective functions with surrogates trained with few input-output pairs that are cheap to evaluate. These probabilistic surrogates provide prediction error bars that correspond to the epistemic uncertainty induced by limited data, which quantify the improvement that a hypothetical experiment could contribute to the state of knowledge of the Pareto front in the MOO problem. This allows us to sequentially select the designs that maximize this enhancement. In this work we developed a NanoHUB tool that enables experimentalists to use BGO-based MOO in their daily activities. We verified the tool through synthetic examples and we used it in the challenging task of optimizing the manufacturing of high-quality graphene using an MPCVD reactor.

Energy

ARMS Atrium, 11:00 AM – 12:15 PM

PhotonicsTD-2D: Modeling Light Scattering in Periodic Multilayer Photonic Structures

Presentation ID:
MP-32

Room:
ARMS Atrium

Keywords:
Nanophotonics, Plasmonics, Negative refraction, Metamaterials, Computational electrodynamics

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Efficient modeling of electromagnetic processes in optical and plasmonic metamaterials is important for enabling new and exciting ways to manipulate light for advanced applications. In this work, we put together a tool for numerical simulation of propagation of normally incident light through a nanostructured multilayer composite material. The user builds a unit cell of a given material layer-by-layer starting from a substrate up to a superstrate, splitting each layer further into segments. The segments are defined by width and material --- dielectric, metal or active medium. Simulations are performed with the finite difference time domain (FDTD) method. A database of common plasmonic materials is available either within the tool, or the user can describe a custom medium with the parameters of a Drude-Lorentz dispersion model. Active medium is described with a four-level system. Thus, a single layer can incorporate any of these material kinds or blend them together via segments, for example, to simulate gain assisted compensation of ohmic losses in metals. This is a typical phenomenon that tends to limit the scope of applications of materials with negative refraction. Multiple layers then can be stacked on top of one another leading to a wide range of subwavelength engineered effective media (metamaterials) with new optical properties. This multilayer can represent a hyperbolic metamaterial or a photonic crystal with potential applications in imaging beyond diffraction limit, high optical absorption, low surface scattering in photovoltaic devices, and surface enhanced spectroscopy and sensing. Predictive modeling tools for plasmonic structures with gain pave the way for developing efficient nanolasers and spasers. Results of each simulation may include absorption, transmission, reflection spectra of the scattered beam, and time-resolved evolution of populations of the four-level gain system. Material geometry, the results and the input parameters are available for export and import back into the tool.

Exploring the Effects of Aromatic Molecules in Chemical Enhanced Oil Recovery

Presentation ID:
MP-33

Room:
ARMS Atrium

Keywords:
Enhanced oil recovery, Surfactant flooding, Phase behavior, Ultra-low interfacial tension

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Purdue University

Chemical enhanced oil recovery (cEOR) methods are being used as a viable contributor to the world's growing energy demands. Due to the complex chemical composition of crude oil, attempting to optimize the surfactant concentration and salinity of formulations is done empirically. This process can be very time intensive due to the wide variety of surfactant structures available for cEOR. Surfactant selection is typically done by matching the average chain length of the oil with that of the surfactant. In this study, we are trying to understand how aromatic structures present in Illinois Basin crude oil interact with surfactants. This will potentially help guide the process of surfactant selection. For this experiment, we used four model oils: dodecane, dodecane + 10% toluene, dodecane + 35% toluene, and dodecane + 25% toluene + 5% xylene + 5% decylbenzene. We performed phase behavior testing with two anionic surfactants at a variety of salinities with the model oils. One surfactant is an alkyl propoxy sulfate and the other is alkyl benzene sulfonate. Measurement of the interfacial tension (IFT) between the oil and surfactant dissolved in an aqueous solution provides a quantitative measure of how efficiently the surfactant interacts with the oil. The lower the IFT, the more effective the surfactant. So far, we have observed significant differences in the micro emulsions when the model oil contains aromatics. The results suggest that surfactants containing aromatics play an important role in interacting with the aromatic groups present in the oil. It is anticipated that these results will provide mechanistic insight about the contribution of aromatic structures in surfactant selection.

Fluid Flow Thermometry Using Thermographic Phosphors

Presentation ID:
MP-34

Room:
ARMS Atrium

Gabriel J Fenoglio[1], Humberto J Detrinidad[2], Aman Satija[1], Alex D Casey[1], Robert P Lucht[1], and Terrence R Meyer[1]
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Keywords:
Phosphor thermometry,
Fluid flow,
Zinc oxide,
Laser diagnostics

Phosphor thermometry is a non-intrusive thermometry technique that allows for spatially and temporally resolved surface temperature measurements. The thermographic method has been employed in a number of applications that include combustion, sprays, and gas flows. In the current work, we investigate the implementation of thermographic phosphors in liquid flows, which is of interest in a wide range of applications in heat transfer, fluid mechanics, and thermal systems. Zinc oxide doped with Zinc (ZnO:Zn) was the phosphor employed for experimentation due to its high emission intensity and insolubility. In order to explore this application, the phosphor powder was uniformly dispersed in water using a magnetic stirring rod. The phosphor was excited by the third harmonic 355 nm output of a Nd:YAG laser, and the luminescence was examined using a fiber-coupled spectrometer. Analysis of the spectral data showed a significant redshift as the temperature approached boiling point. Further characterization of effects of temperature and experimental parameters such as ZnO:Zn concentration on the luminescence signal was performed.

Amine-Thiol Solution Route Method for Fabricating $Cd_xZn_{1-x}S$ Thin Film Solar Cells

Presentation ID:
MP-35

Room:
ARMS Atrium

Preston D Fernandez, Xianyi Hu, Carol Handwerker, and Rakesh Agrawal
Purdue University

Keywords:
Thin film solar cells,
CdZnS,
Solution route,
Amine thiol

Cadmium zinc sulfide, CdZnS, is a promising material for the buffer layer of thin film solar cells because the alloy is considerably more cost effective and more optimizable than pure cadmium sulfide, CdS, in terms of band gap. The current fabrication methods of the buffer layer often require expensive equipment or produce undesirable impurities in the alloy. This study investigates a cost effective and scalable solution route method to synthesize the CdZnS buffer layer. Molecular precursors of CdZnS were dissolved in varying molecular ratios of cadmium and zinc in a mixture of hexylamine and propanethiol. The resulting alloys produced were characterized by XRD and UV-VIS spectroscopy to determine the crystallinity and band gap of the CdZnS alloy samples as a function of composition. The results from this investigation show that increasing concentrations of zinc in the precursor solutions and the resulting films increase the band gap of the material. The findings of this study support the feasibility of this solution route to synthesize a $Cd_xZn_{1-x}S$ buffer layer, and provokes a need for further investigation and optimization of this method.

Dynamic Modeling of Contact-Mode Triboelectric Generators by Lagrange's Equations

Presentation ID:
MP-36

Room:
ARMS Atrium

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Keywords:
Electret,
Lagrangian,
Triboelectric generators,
Energy harvesting,
Dynamic modeling

Electret based energy scavenging devices utilizes electrostatic induction to convert mechanical energy into electrical energy. Uses for these devices include harvesting ambient energy in the environment and acting as sensors for a range of applications. These types of devices have been used in MEMS applications for over a decade. However, recently there is an interest in Triboelectric generators/harvesters, *i.e.*, electret based harvesters that relies on triboelectrification as well as electrostatic induction. The literature is filled with a variety of designs for the latter devices, constructed from materials ranging from paper and thin films; rendering the generators lightweight, flexible and inexpensive. However, most of the design of these devices is ad-hoc and not based on exploiting the underlying physics that govern their behavior, the few models that exist neglect the coupled electromechanical behavior of the devices. Motivated by the lack of a comprehensive dynamic model of these devices this manuscript presents a Lagrangian formulation electromechanical equation for a lumped parameter dynamic model of an electret-based harvester. The formulation is robust, capturing the effects of traditional MEMS devices as well as triboelectric generators. Exploiting numerical simulations the predictions are used to examine the behavior electret based devices for a variety of loading conditions simulating real-world applications such as power scavengers under simple harmonic forcing and in pedestrian walking. Finally, the predictions from these models are compared with prototypes of paper-based generators.

Developing a Cu-As-Se Thin Film for Use in Solar Energy Conversion

Presentation ID:
MP-37

Room:
ARMS Atrium

Keywords:
Photovoltaics, Solar cells, Thin films, Nanoparticles, Nanocrystals

Jordan Thomas Grommet, Joseph Andler, Scott McClary, Carol Handwerker, and Rakesh Agrawal
Purdue University

Thin film solar cells have gained popularity in recent years because of their flexibility, low relative cost, and scalability. Cu-As-Se films have the potential to be used as effective solar cell absorber layers due to theoretical estimates of their absorption coefficients and band gaps being similar to materials used in successful solar cells. While some thin films comprised of annealed and sintered Cu-As-Se nanoparticles have been created in the past, none have been designed for solar energy conversion applications. The development of these thin films will allow for further improvements in solar cell design and performance as well as in their use in possible thermoelectric applications. Cu-As-Se thin films were developed through the alteration of preceding Cu-As-Se nanoparticle synthesis procedures in order to produce nanoparticles for use in denser and more uniform thin films. The synthesized nanoparticles were coated onto substrates and underwent heat treatment experiments to determine the best conditions for uniform grain growth. To characterize the nanoparticles and thin films after heat treatment, techniques such as Raman spectroscopy, X-ray diffraction, scanning electron microscopy and transmission electron microscopy were used. The results of the experiments allowed us to create and characterize Cu-As-Se thin films, and the characterization of these thin films will expand this research area and contribute to the growing solar cell research field, as well as help illuminate the applications of Cu-As-Se based materials.

Performance of TF-VLS Grown InP Photovoltaic Cells

Presentation ID:
MP-38

Room:
ARMS Atrium

Keywords:
Photovoltaics, Compact model, Solar cells, Photoluminescence, Nanotechnology

Junyan Shi, Yubo Sun, and Peter Bermel
Purdue University

A grand challenge of photovoltaics (PV) is to find materials offering a promising combination of low costs and high efficiencies. While III-V material-based PV cells have set many world records, often their cost is much greater than other commercial cells. To help address this gap, thin-film vapor-liquid-solid (TF-VLS) grown Indium Phosphide (InP) PV cells have recently been developed, which both eliminate a key source of high costs and offer a direct bandgap of 1.34eV with potential to approach maximum theoretical efficiencies. However, the unanticipated phenomenon of open circuit voltage (V_{oc}) degradation has prevented TF-VLS grown InP PV cells from achieving their theoretical efficiencies, which appears to be caused by effective bandgap narrowing in certain portions of the cells. To address this issue, we have developed a 3D model for these PV cells in Xyce, a SPICE-like free circuit modeling software. Our model quantifies lateral variation of TF-VLS grown cells observed in photoluminescence (PL) images with two sets of unit cell parameters. It turns out that the PL intensity correlates to PV cells of different bandgaps (E_g). Based on user-defined cutoffs, we are able to categorize the expected bandgap and reduced bandgap cells. With the addition of an appropriate shunt resistance, it is possible to explain most of current-voltage relationship with this model. Finally, we are building a web-enabled tool to allow users to upload their own heterogeneous PV cell data into our model, using a graphical user interface on nanoHUB.org, an open-access science gateway for cloud-based simulation tools and resources for research and education in nanoscale science and technology.

Sensing & Controls

ARMS Atrium, 11:00 AM – 12:15 PM

Development of a Diode-Laser Absorption-Spectroscopy Sensor for Real-Time Control of Combustion Systems

Rahul P Balla and Christopher S Goldenstein
Purdue University

Tunable diode-laser absorption spectroscopy (TDLAS) sensors are widely used for measuring gas properties. These sensors offer several advantages including: small footprint, affordability, applicability to harsh environments, rapid time response, and calibration-free operation. As a result, diode-laser sensors can be integrated into control-systems and have previously been used to control gas-turbine combustors. In this study, high-frequency sine waves were generated continuously by a LabVIEW program to simultaneously scan and modulate the wavelength and intensity of a diode laser. The modulated laser light was transmitted 20 cm through the air and measured on a photodetector. Custom-built lock-in software was used to acquire the photodetector signal and extract the corresponding 1st- and 2nd-harmonic wavelength-modulation absorption spectroscopy signals (WMS-1f and -2f) resulting from H_2O absorption. The WMS-2f/1f signal was then calculated to enable calibration-free monitoring of gases in real time. During future work, newly developed WMS signal-processing techniques will be used to convert the measured WMS-2f/1f signals into measurements of temperature and H_2O concentration, thereby enabling monitoring and control of real combustion systems.

Presentation ID:
MP-39

Room:
ARMS Atrium

Keywords:
Tunable diode lasers, Absorption spectroscopy, Wavelength modulation spectroscopy

A Compact System for Photon Counting Based on Silicon Photomultiplier

Youngwoo Cho, Youngkee Jung, and Euiwon Bae
Purdue University

A compact and portable detection system is necessary to measure the amount of pollutant from environmental sample by detecting and quantifying the light emitted by bioluminescent reporters. This silicon photomultiplier based project is hoping to acquire even more accurate data at a far lower light level than previously developed smartphone based system. After pre-amplification and comparator, the signal is separated from the internal noise present in the overall circuit. Next, the microcontroller counts the number of pulses generated by the comparator in a set amount of time and transfers the data to the Bluetooth module for the smartphone to receive it. Currently, each component of the system has been placed on a printed circuit board and works as designed; including the proper amplification, fast discrimination of signal and optimized pulse counting program with Bluetooth communication. With this compact system, many future experiments can be carried out in order to determine the effectiveness of different bioluminescent reporter strains on the detection of environmental pollutant contents or food-safety related analytes such as pathogenic bacteria. Future work should focus on the complete integration of all the developed components and the silicon photomultiplier to deliver its maximum performance.

Presentation ID:
MP-40

Room:
ARMS Atrium

Keywords:
Photon counting, Bioluminescent reporter, Pollutant, Silicon photomultiplier

Real-Time Temperature and Heat Flux Measurements for Lyophilization Process Design and Monitoring: Part 2

Nicholas J Huls, Evan T Liechty, Andrew D Strongrich, and Alina A Alexeenko
Purdue University

Lyophilization is a sublimation drying process that is often used in the pharmaceutical and food industry to make products more stable and increase shelf life. The lyophilization process is very temperature and pressure sensitive so close monitoring is required to ensure the final product quality. New wireless temperature sensors are designed to monitor the product's temperature *in situ* effectively to ensure cake stability. The sensors were tested in Wheaton 6R vials simultaneously with the wired thermocouples using solutions of 5% w/v sucrose in ultra-pure water. The data collected from each of the experiments were used to model the heat flux through the vials. We intend to compare the experimentally determined data with results produced by the numerical model, in order to gauge the accuracy of the numerical model. We also aim to evaluate whether the wireless temperature sensors can accurately and reliably monitor the product temperature and develop approaches for sensor applications in lyophilization process research.

Presentation ID:
MP-41

Room:
ARMS Atrium

Keywords:
Wireless temperature sensors, Lyophilization, Heat flux

Detecting Trace Explosives with Organic Electronic Devices

Presentation ID:
MP-42

Room:
ARMS Atrium

Keywords:
*Pentacene,
Explosives sensing,
Organic field-effect transistors (OFETs),
Organic semiconducting materials*

Elizabeth A Jergens, Jennifer S Laster, and Bryan W Boudouris
Purdue University

Trinitrotoluene (TNT) is a commonly used explosive and poses a significant risk to security arenas across the globe. The use of organic electronics for the detection of explosive residues allows for large scale, solution-processible, and environmentally stable devices with a high selectivity for TNT detection. Currently, fluorescence-based sensors are used in TNT detection, but the synthesis of the fluorescent molecules can be complicated and costly. Hence, we introduce a new design paradigm to overcome this limitation. Specifically, organic field-effect transistors (OFETs) were created using 6,13-bis (triisopropylsilylethynyl) (TIPS) pentacene as the active material to collect a baseline mobility and the on current to off current ratio (ON/OFF). Then, blends of TIPS-pentacene and varying concentrations of TNT were used in OFETs, and the change in the ON/OFF and charge carrier mobility were evaluated. With the introduction of TNT, the ON/OFF increases in value and it was observed that the concentration of the TNT in the film blend has an effect on how much the ON/OFF and hole mobility increases. The measured change in the ON/OFF were used to create a calibration curve that shows the dependence of the TNT concentration. A device that incorporates the TIPS-pentacene FET could eventually be used to sweep an area or surface for the presence of dangerous explosives through a change in an electrical signal in the device and interpretation of the calibration curves.

Exploring How Haptics Contributes to Immersion in Virtual Reality

Presentation ID:
MP-43

Room:
ARMS Atrium

Keywords:
*Virtual reality,
Haptics,
Athletics,
Leap motion,
Google VR,
Actuator,
Simulation*

Dimcho Zhelyazkov Karakashev and Hong Z. Tan
Purdue University

Virtual Reality (VR) has been around for more than fifty years but the technology hasn't reached practical usability until very recently. With the current head-mounted display (HMD) technology and an abundance of investment in VR startups, we have finally reached at the point where it is possible to simulate complex virtual environments that feel immersive. A major problem with virtual reality is that everything looks real but you can not touch and feel virtual objects. We are focusing on developing a device that will allow users to feel what they touch in VR. We developed a hand-held interface and an android app as a test environment. Commercially-available solutions such as the leap motion developer's kit were used to track the position of a user's hand. The actual touch sensation was delivered by a broad-band actuator. Informal testing suggests that being able to feel a virtual object, such as a virtual football, in the hands can enhance user immersion, enjoyment and performance in VR. Future work will improve hand tracking accuracy and range of touch sensations for a more realistic user experience.

Infrastructure

ARMS Atrium, 11:00 AM – 12:15 PM

Developing Methods to Characterize Cured-in-Place Pipe (CIPP)

Presentation ID:
MP-44

Room:
ARMS Atrium

Keywords:
*Water,
Air,
Pipe*

Emily N Conkling, Mahboobeh Teimouri, and Andrew Whelton
Purdue University

Cured-in-place pipe (CIPP) is quickly growing as a method to repair aging water pipes. It's an attractive option for states' Departments of Transportation, as CIPP doesn't require any long term or invasive construction. The exact composition of CIPP is poorly understood, even though CIPP leaching is assumed to be the cause of algal blooms, fish kills, and some human illnesses. The goal of this study was to develop methods to characterize what chemicals are present in uncured and cured CIPP resin and at what magnitude. An exhaust capture system was designed, and the condensate collected from this was extracted using dichloromethane and hexane. Additionally, a photoionization detector was used during field sampling to detect styrene, a major component of CIPP. Preliminary results indicate that the chemicals in the CIPP resin and the exhaust dispersion pattern are highly complex and require further study.

Strength of Reinforced Concrete Beams with High-Strength Steel

Presentation ID:
MP-45

Room:
ARMS Atrium

Brian C Rogers, Aishwarya Puranam, and Santiago Pujol
Purdue University

Structures are commonly made of reinforced concrete, which is a composite material made of concrete and steel reinforcement. Using high-strength steel, with yield stress larger than 100 ksi, could help reduce the quantity of steel required in structural members, thus reducing costs and improving constructability. The hypothesis being tested is that smaller quantities of high-strength steel reinforcement (HSSR) can be used in place of conventional steel in reinforced concrete beams while maintaining similar strength and deformation at failure. Two reinforced concrete beams with two different types of longitudinal steel reinforcement were constructed. The beams were 18 in. wide, 30 in. deep and 58.5 ft long. The beam with HSSR had approximately half the quantity of longitudinal reinforcement leading to reduced material costs and simpler construction. Numerical analyses indicate that the two beams will have comparable strengths and deformation capacities indicating that conventional steel can be replaced by HSSR.

Keywords:
Reinforced concrete,
High strength steel,
Beams,
Strength,
Grade 120,
Grade 60

Passive Visual Analytics of Social Media Data for Detection of Unusual Events

Presentation ID:
MP-46

Room:
ARMS Atrium

Kush Rustagi and Junghoon Chae
Purdue University

Now that social media sites have gained substantial traction, huge amounts of un-analyzed valuable data are being generated. Posts containing images and text have spatiotemporal data attached as well, having immense value for increasing situational awareness of local events, providing insights for investigations and understanding the extent of incidents, their severity, and consequences, as well as their time-evolving nature. However, the large volume of unstructured social media data hinders exploration and examination. To analyze such social media data, the S.M.A.R.T system provides the analyst with an interactive visual spatiotemporal analysis and spatial decision support environment that assists in evacuation planning and disaster management. S.M.A.R.T fetches data from various social media sources and arranges them in a perceivable manner, which is visually appealing. This in turn is a huge aid in finding and understanding abnormal events. Introducing a passive mode makes the tool more efficient, where it automatically detects idle time and gives a summary of all the anomalies encountered in the inactive period as soon as the analyst resumes monitoring. Using the tool, the analyst can first extract major topics from a set of selected messages and rank them probabilistically. The case studies in the past show improved situational awareness by using the methods mentioned before.

Keywords:
Social media,
Threat detection,
Visual analytics,
Spatio-temporal data analysis,
Probability

Structures & Nanomaterials

ARMS Atrium, 11:00 AM – 12:15 PM

High Strength Steel in the Reinforced Concrete Structures: Serviceability

Presentation ID:
MP-47

Room:
ARMS Atrium

Alan Kanybek, Aishwarya Puranam, and Santiago Pujol
Purdue University

The use of high-strength steel (yield stress larger than 100 ksi) in reinforced concrete structures can provide an effective alternative to using conventional steel (yield stress up to 80 ksi). The goal of this study is to investigate if elements with reduced quantities of high-strength steel reinforcement meet the serviceability criteria. Instantaneous and long-term deflections in slab specimens with conventional steel and reduced amounts of high-strength steel were studied. Two sets of 14 ft. long, 30 in. wide reinforced concrete slabs were built. The depth, the quantity, and the type of longitudinal reinforcement were varied between specimens in each set. The first set of slabs consisted of a 4in. thick specimen with conventional steel (Gr. 60) and a 6 in. thick specimen with high-strength steel (Gr. 120). The longitudinal reinforcement ratios were 0.7% and 0.2% respectively. The second set consisted of a 5 in. thick specimen with Gr. 60 steel and an 8 in. thick specimen with Gr. 120 steel. The longitudinal reinforcement ratios were 0.5% and 0.1% respectively. The slabs were designed such that the theoretical deflections at service loads were similar for the specimens within each set. The slabs will be loaded until the working strains are reached in the reinforcement, and then will be tested under this constant service-load.

Keywords:
High strength steel,
Reinforced concrete,
Serviceability,
Deflection,
Slabs

Expression and Site-Directed Mutagenesis of Type III Polyketide Synthases in S. coelicolor

Presentation ID:
MP-48

Room:
ARMS Atrium

Keywords:
Polyketide, Biosynthesis, Ketosynthase

Logan R Richards[1], Odessa Goudy[2], Lee M Stunkard[1], Aaron B Benjamin[1], Bethany P Manning[1], and Jeremy Lohman[1]
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Natural products are a well-established source of drugs, and evolution has yielded polyketides such as leinamycin and iso-migrastatin that have demonstrated anti-tumor activity. Polyketides are large metabolites with a high degree of chemical variability and are commonly produced by soil bacteria. Polyketide synthases (PKS) exist as three different archetypes, and the reaction mechanisms of ketosynthases from all archetypes is not understood. Type III PKSs exist as an independently functioning ketosynthase (KS), which primarily use coenzyme A (CoA), with some exceptions, for the biosynthesis of polyketides. We elected to focus our studies on ketosynthases, because they are responsible for forming the carbon-carbon bonds seen in polyketides. To study these Type III PKS KS, we expressed *Streptomyces coelicolor* germicidin synthase (Gcs) and tetrahydroxynaphthlene synthase (THNS) in *E. coli* and mutant versions where the catalytic active cysteine was changed to a serine or glutamine. In previous studies, serine slowed the overall progress of the reaction, and glutamine abolished carbon-carbon bond formation but promoted malonyl-CoA decarboxylation. We verified our mutations using a third party organization's fluorescent sequencing by dye termination services, as well as confirmed that an acceptable level of expression of our protein is occurring in our BL21 cell lines using SDS-PAGE and Fast Protein Liquid Chromatography (FPLC). Now that we have successfully expressed and mutated our protein, we can move forward and use substrate mimics in conjunction with our mutants to further understand the catalytic mechanism of ketosynthases.

Biochemical and Structural Characterization of Cdc14 Phosphatases from Pathogenic Fungi

Presentation ID:
MP-49

Room:
ARMS Atrium

Keywords:
Cell division cycle 14 (Cdc14), Mitosis, Cyclin-dependent kinase (Cdk)

John Whitney, Kyle Wettschurack, Mark Hall, Jeremy Lohman, Aaron Benjamin, and Lee M Stunkard
Purdue University

Cyclin-dependent kinases (Cdk) drive cell cycle progression and reversal of Cdk phosphorylation is essential for mitotic exit. Cdc14 is a widely conserved family of protein phosphatases that reverse Cdk phosphorylation. Recently, Cdc14 was also found to be essential for pathogenicity of some fungal plant pathogens. Fungal pathogens, like *Ustilago maydis*, decrease agricultural crop yield costing global agriculture by some accounts $60 billion per year. Since Cdc14 is absent in plants, a fungi specific Cdc14 inhibitor could be made to reduce the pathogenicity of *U. maydis* and other fungal plant pathogens to increase crop yields. To guide inhibitor development, a three-dimensional structural model of fungal Cdc14 is needed. Therefore, we recombinantly expressed *Ustilago maydis* Cdc14 (UmCdc14) and a catalytically inactive substrate trapping mutant (UmCdc14$_{C318S}$) with N-terminal hexa-histidine tags in *E. coli*. Recombinant UmCdc14 and UmCdc14$_{C318S}$ were successfully purified using immobilized metal affinity chromatography. We screened the purified proteins by sitting drop crystallography. Two conditions yielded small crystals for UmCdc14. One condition yielded a crystal for UmCdc14$_{C318S}$. These conditions were used for large scale crystal growth by hanging drop crystallography. If ideal conditions are found, UmCdc14$_{C318S}$ will be crystallized bound to a peptide substrate to capture the molecular binding determinants that will help guide inhibitor design. Wild-type UmCdc14 will be crystallized bound to small molecule inhibitors identified by a previous high throughput library screen. In the future, we will also explore crystallization of Cdc14 orthologs from other plant pathogens.

AFTERNOON ORAL PRESENTATIONS

AO

Energy II

ARMS B071, 1:30 PM – 2:45 PM

Temperature Dependent Surface Modification of Tungsten Exposed to High-Flux Low-Energy Helium Ion Irradiation

Antony Q Damico, Jitendra Tripathi, Theodore J Novakowski, Gennady Miloshesky, and Ahmed Hassanein
Purdue University

Presentation ID:
AO-1

Room:
ARMS B071

Keywords:
Nuclear fusion, Ion irradiation, Tungsten, Scanning Electron Microscopy, X-ray Photoelectron Spectroscopy

Nuclear fusion is a great potential energy source that can provide a relatively safe and clean limitless supply of energy using hydrogen isotopes as fuel material. ITER (international thermonuclear experimental reactor) is the world first fusion reactor currently being built in France. Tungsten (W) is a prime candidate material as plasma facing component (PFC) due to its excellent mechanical properties, high melting point, and low erosion rate. However, W undergoes a severe surface morphology change when exposed to helium ion (He^+) bombardment under fusion conditions. It forms nanoscopic fiber-form structures, *i.e.*, fuzz on the surface. Fuzz is brittle and can easily contaminate the plasma, and therefore preventing the fusion chain reaction. In this study, we report on the effect of temperature on the surface morphology evolution of W coatings under low energy He^+ ion irradiation, relevant to fusion conditions. Submicron thickness W films have been deposited on Si (100) at room temperature using RF sputtering deposition technique. Several samples were cut from the same wafer and exposed to 100 eV He^+ ions having a constant flux of 1.2×10^{21} ions m^{-2} s^{-1} (total fluence of 4.3×10^{24} ions m^{-2}) at several temperatures in the range of 1073--1273 K. During each ion irradiation experiments the applied sample temperature were constant throughout that experiment. Post ion-irradiation samples (including pristine) were characterized using field emission scanning electron microscopy (FE-SEM), X-ray photoelectric spectroscopy (XPS), and optical reflectivity measurements for monitoring the changes in surface morphology, chemical composition, and surface roughness/optical properties, respectively. Our analysis shows a *sequential enhancement in W fuzz density, sharpness, and protrusions from the film surface, with increasing sample temperature, during helium ion irradiation. Ex-situ XPS study shows the evidence of W_2O_3 phase formation due to natural oxidation of W fuzz in the open atmosphere, for all irradiated samples.* The study is significant in the understanding processes of fuzz formation on high-Z refractory metals for fusion applications. In addition, the observed W_2O_3 fuzz structure may have potential applications in solar power concentration technology and in water splitting for hydrogen production.

Fluence Dependent Surface Modification on Tungsten Coatings Using Low Energy Helium Ion Irradiation at Elevated Temperatures

Presentation ID:
AO-2

Room:
ARMS B071

Keywords:
Nuclear fusion, Ion irradiation, Tungsten, Scanning Electron Microscopy (SEM), X-ray Photoelectron Spectroscopy (XPS), Optical reflectivity

Cheng Ji, Jitendra K Tripathi, Theodore J Novakowski, Valeryi Sizyuk, and Ahmed Hassanein
Purdue University

Nuclear fusion is the most promising renewable energy source for the near future. It can provide a large amount of energy using a very small amount of fuel, as compared with that of the coal, oil, or nuclear fission. The chain reaction in nuclear fusion produces the energy and fuel, from hydrogen isotopes available in see water. Tungsten (W) is a leading candidate material for the plasma-facing component (PFC) in nuclear fusion reactors such as ITER (international thermonuclear experimental reactor), because of its high melting point, high yield strength, low erosion and low hydrogen isotope retention. Recent studies showed deeply convoluted fiber-form nanostructures (fuzz) formation on W surface under high-flux low-energy He^+ irradiation relevant to fusion conditions. The fuzz greatly degrades the mechanical, thermal, and optical properties of W. The significant enhanced surface area, and fragility of such fuzz, raise several serious concerns for its usefulness as PFC materials in fusion reactors. The fuzz can also be easily eroded and is a major concern for plasma contamination and short lifetime. In this study, we report on the effect of helium ion irradiation on the surface morphology evolution of W exposed to low energy He^+ ions at constant elevated temperature. Submicron thickness W films were deposited on Silicon (100) at room temperature using RF sputtering deposition technique. Several samples were cut and were exposed to 100 eV He^+ ions having a constant flux of 1.2×10^{21} ions m^{-2} s^{-1} and sample temperature (1173 K). The fluence was varied in the range of 4.3×10^{24}--1.7×10^{25} ions m^{-2}. Post ion-irradiation samples (including pristine) were characterized using field emission scanning electron microscopy (FE-SEM), X-ray photoelectric spectroscopy (XPS), and optical reflectivity measurements for monitoring the changes in surface morphology, chemical composition, and surface roughness/optical properties, respectively. We observed a sequential enhancement in the W fuzz density, sharpness, and protrusions from the film surface, with increasing helium ion fluence. Ex-situ XPS study shows the evidence of W_2O_3 phase formation due to natural oxidation of W fuzz in the open atmosphere. The study is also relevant to potential applications in solar power technology and in water splitting for hydrogen production.

Dynamic Behavior of a Clamped-Clamped Bi-Stable Laminate for Energy Harvesting

Presentation ID:
AO-3

Room:
ARMS B071

Keywords:
Energy, Harvesting, Bi-stable, Metamaterials, Vibrations, Nonlinear

Ajay V Kumar, Andres F Arrieta, and Myungwon Hwang
Purdue University

Multi-stable laminates have many applications in morphing structures, energy harvesting devices, and metamaterials due to the specific characteristics attributed to the exhibited stable states. Changes between stable states allow for large deflection, on-demand variation of the stiffness of compliant structures embedded within these elements, and control of effective dynamic properties in periodic lattices. These changes in state can be accessed via a snap-through instability triggered by introducing a well-defined activation energy. The resulting oscillations could enable broadband energy harvesting via piezoelectric transduction and resistive circuits. In this paper, a clamped-clamped bi-stable laminate is studied to understand the behavior of the laminate at each stable state and determine energy harvesting capabilities. An FEA model is created to determine the location and shapes of resonant modes. Small amplitude low frequency vibrations are used to excite the laminate at each stable state using a shaker. The laminate is then excited so that inter-well oscillations became present. The resonant modes of each stable state determined via the simulations are verified by the experimentally observed responses. The laminate shows nonlinear dynamics throughout the various resonant frequencies. At higher excitations, a range of frequencies is observed causing chaotic and inter-well oscillations.

Modeling of Ion/Target Interactions in Plasma Facing Components of Fusion Reactor

Presentation ID:
AO-4

Room:
ARMS B071

Keywords:
Nuclear fusion, Plasma-facing components, Diffusion

Nicole Neto Godry Farias, Tatyana Sizyuk, and Ahmed Hassanein
Purdue University

Nuclear fusion is a promising source of clean energy that can be one of the key future suppliers of the world's increasing power demand. One of today's main challenges faced by scientists and engineers regarding nuclear reactors is to design plasma-facing components (PFCs) that can withstand extreme conditions of temperature, pressure, and ions/particles irradiation. Material evolution and damage of PFCs are strongly related to the bombardment and diffusion processes of ions resulting from fusion fuel, *i.e.*, deuterium and tritium and reaction products, *i.e.*, helium. However, work is still needed in order to understand fuel diffusion in the presence of helium effects and damage produced in heterogeneous media of potential PFCs. This study simulates the diffusion of atoms in an alloy of changing solute concentration in an environment similar to that of a nuclear fusion reactor. The diffusion equation was solved numerically while taking into account the "potential diffusion" present in heterogeneous materials, as it was described analytically in recent studies. The solution was implemented in Fortran 90 code using SRIM software as an input generator and taking parameters found in literature. Our results show that heterogeneous membranes can greatly shift the deuterium concentration profile towards or away from the tungsten bulk surface, depending on the direction of the change in potential energy inside the lattice. These outcomes suggest that tungsten alloys with heterogeneous solute concentration distribution should be empirically analyzed in order to understand how these concentration shifts affect material properties and fuel retention.

Investigation of Aluminum Foams and Graphite Fillers for Improving the Thermal Conductivity of Paraffin Wax-based Phase Change Materials

Presentation ID:
AO-5

Room:
ARMS B071

Keywords:
Passive thermal management, Phase change materials (PCMs), Thermal conductivity enhancement, Thermal management of electronics

Javieradrian Ruiz, Amy Marconnet, Yash Ganatra, John Howarter, and Alex Bruce
Purdue University

Passive thermal management with phase change materials (PCMs) has become the one of the most promising methods to cool cell phone processors due to the relatively simple implementation and profound impact on processor temperatures. Enhancing the thermal properties of conventional PCMs, mainly thermal conductivity and latent heat storage, allows for an overall improved thermal management system. This study aims to improve the thermal conductivity of paraffin wax (a typical commercial PCM) by the introduction of an expanded graphite (EG) filler to form a paraffin wax composite, and then infiltration of the EG/paraffin composite into an aluminum foam matrix. The thermal conductivity of the EG/paraffin composites increases respectively to the percentage by volume of expanded graphite. While the thermal conductivity increased, there is no significant impact on latent heat storage compared to pure paraffin wax. The pore size of the aluminum foam matrixes also has a profound impact on both thermal conductivity and latent heat storage of the overall system. These results will allow for improvements in cooling techniques incorporated within cell phones and other mobile devices, allowing for future development of their processors (higher computational power), prolonged reliability, and longer anticipated life cycles.

Modeling & Simulation II

ARMS 1021, 1:30 PM – 2:45 PM

Dynamic Modeling and Validation of micro-CHP systems

Presentation ID:
AO-6

Room:
ARMS 1021

Keywords:
*Dynamic modeling and validation,
micro-CHP,
Thermal energy storage*

Apurva Badithela[1], Neera Jain[2], and Austin Nash[2]
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Micro-Combined Heat and Power (micro-CHP) units locally generate electricity to simultaneously provide power and heat for residential buildings. Apart from the potential benefits of reducing carbon emissions and increasing robustness to brownouts and blackouts, micro-CHP systems can be controlled to meet energy demands. Micro-CHP systems consist of a prime mover that generates electricity, such as a fuel cell, an internal combustion engine, or a Stirling engine, and a waste heat recovery system that enables utilization of heat generated as a byproduct of electricity generation. Often, a thermal energy storage system is integrated with micro-CHP systems, thereby decoupling, in time, the recovery of the thermal energy from its utilization to meet demand. However, in order to effectively meet time-varying electricity and thermal demand through coordinated use of the prime mover and thermal energy storage system, the dynamics of each of these subsystems, and their interactions, need to be modeled. A low order dynamic model is derived for a micro-CHP system with a PEM (proton exchange membrane) fuel cell as the prime mover and a hot water tank as the thermal energy storage unit. Both steady-state and transient data is collected from an experimental micro-CHP testbed to validate the fuel cell and hot water tank models. Validation of the thermal energy storage model is performed for four distinct modes of operation: charging, discharging, simultaneous charging/discharging, and idling. Future work will include validation of the combined fuel cell and thermal energy storage models, as well as model-based control design for micro-CHP systems.

Mechanical Investigation of Phase-Transforming Cellular and Origami Materials

Presentation ID:
AO-7

Room:
ARMS 1021

Keywords:
*Phase transformation,
Cellular materials,
Energy absorption,
Origami*

John M Cleveland, David Restrepo, Yunlan Zhang, Pablo Zavattieri, and Nilesh Mankame
Purdue University

Cellular materials, such as honeycombs and metallic foams, have attracted much attention due to their exceptional ability to absorb and diffuse mechanical energy. These materials have a wide range of applications, such as improving vehicle crash safety and helmet impact resistance. However, many of these materials are rendered unusable after one application. Phase-transforming cellular materials (PXCMs) utilize a reversible bistable mechanism to facilitate energy absorption from one-dimensional impacts and loads. These mechanisms have the added benefit over other cell structures of reusability. In this study, various PXCM designs are discussed and examined to determine their energy absorption capabilities. Three different designs were tested: the common bending straw's ribbed mechanism, the Kresling pattern cylinder, and a sinusoidal beam mechanism. These designs underwent cyclic compression-tension load tests and their force-displacement curves were examined. These tests showed that all three designs exhibit significant energy absorption behaviors. Each design shows promise, warranting further detailed study of their full properties.

Development of Data Analytics Tools for Acoustic Measurement of Positive Displacement Machines

Dan Ding, Monika Ivantysynova, and Paul Kalbfleisch
Purdue University

Presentation ID: AO-8

Room: *ARMS 1021*

Keywords: *Acoustics, Noise, Fluid power, Positive displacement machines, Data analytics*

Noise control is an important factor in evaluating the design of positive displacement machines. This research project aims to develop new tools in MATLAB, with emphasis on visual approaches, to comprehensively characterize the noise generated by positive displacement machines in spatial, temporal and frequency domains. Sound pressure level (SPL), sound intensity level (SIL) and loudness were calculated and plotted on a measurement surface surrounding the pump, which illustrates the spatial distribution of the sound field. In order to highlight the phenomenon within specific frequency bands, Butterworth filters were used to isolate desired frequencies, such that specific harmonic content or 1/3 Octave bands content can be analyzed. In addition to static visualization methods, videos were created by compressing a series of sphere plots in time to illustrate the dynamic characteristics of the measured sound. Corresponding phase plots were generated at the same time to statically illustrate these dynamic characteristics shown on videos. The successful generation of the various methods of characterizing and visualizing pumps generated noise was evaluated on a large sample set of more than 150 measure grids with nearly 30000 individual microphone measurements. The creation of these analytics has already changed the conversation and challenged the state of the art in hydraulic Noise Vibration and Harshness (NVH).

Benchmark for Security Testing on Embedded Systems

Khaled K Saab[1], Abraham Clements[2], and Saurabh Bagchi[2]
[1]Georgia Institute of Technology, [2]Purdue University

Presentation ID: AO-9

Room: *ARMS 1021*

Keywords: *Embedded systems, Cybersecurity, Benchmark*

With the growing popularity of the Internet of Things (IoT), embedded devices continue to integrate more into our daily lives. For this reason, security for embedded devices is a vital issue to address. Attacks such as stack smashing, code injection, data corruption and Return Oriented Programming (ROP) are still a threat to embedded systems. As new methods are developed to defend embedded systems against such attacks, a benchmark to compare these methods is not present. In this work, a benchmark is presented that is aimed at testing the security of new techniques that defend against these common attacks. Two programs are developed that carry three key values needed for a benchmark: realistic embedded application, complex control flow, and being deterministic. The first application is a pin lock system and the second is a compression data logger. A complexity evaluation of the two applications revealed that the pin lock system contained 171 functions and 190 nodes with 252 edges in the control-flow graph, and the compression data logger contained 192 functions and 1,357 nodes with 2,123 edges in the control-flow graph. The current benchmark will be improved in the future by adding more applications with a wider range of complexity.

Visual Analytics Law Enforcement Toolkit

Qian Zhang, Guizhen Wang, Jieqiong Zhao, and David S. Ebert
Purdue University

Presentation ID: AO-10

Room: *ARMS 1021*

Keywords: *Crime information collection, Crime prediction, Police resource allocation*

VALET, visual analytics law enforcement toolkit, is an interactive toolkit developed for law enforcement agencies to explore concerned crime information and make police resource allocation strategies. As a visual analytics toolkit, VALET is coupled with data collection, data analytics and data prediction. The objective of VALET is to assist law enforcement agencies to reduce crime rate by wisely allocating police resource based on the analytics of historical crime records. The program incorporates three steps to generate police patrol route and policeman allocation. The first step is to generate crime hotspots and crime contours of collected crime data. The next step is to analyze historical crime information and predict potential defects. Finally, the program is to compute police patrol routes and allocate police resource based on schedule and specialty. The results from the program allow us to generate risky area for different type of crimes, and evaluate policemen’s performance in dealing with different type of crimes. Thus, police department is able to assign police officers to designed patrol routes that suggested by prediction tool based on policemen’s specialty. This would take advantage of crime prediction and decrease the time of handling criminal activities. With VALET, law enforcement agencies are able to explore concerned crime information intelligently. At the same time, police department is prompted to allocate police resource wisely.

Environment

ARMS B061, 1:30 PM – 2:45 PM

Use of Demographic Faultlines to Predict Teams' Conflict, Satisfaction, and Performance

Marina Pazeti and Isabel Jimenez-Useche
Purdue University

During the past decade, industries and businesses have experienced the formation of a global market place. Current tasks require professionals from different fields and with different backgrounds to work together as a team. The goal of this study is to investigate how diversity in teams may impact perception of conflict, satisfaction and performance, in first-year engineering students. Team diversity is associated with faultlines: the potential to form subgroups based on certain characteristics. The strength and width of faultlines in a team is likely to impact the team's outcomes. In this research, we calculated values of faultlines strength for each team of students, in an introductory engineering class in their first year. Using teams with null probability of forming subgroups as a control group, the remaining teams had faultline strength calculated for each characteristic. The faultline values were separated in low (0 & 0.33) and high (0.6 & 1). Means for each team dynamic's indicator, *i.e*. performance, satisfaction and conflict, were calculated for each characteristic. From the frequency of the faultlines strength, it was possible to identify Ethnicity as responsible for the greatest frequency rate. At the same time, Language had the lowest frequency rate. The results of this research can be used to improve the mechanism of team making to minimize faultline strength. In addition, it's important to continue investigating the impact of multiple experiences working in diverse teams on the outcomes and performance of engineering students, beyond their first semester.

Presentation ID:
AO-11

Room:
ARMS B061

Keywords:
Teamwork,
Diverse teams,
Faultlines,
Heterogeneity

Experimental Testing and Validation of P-band Bi-static Remote Sensing of Soil Moisture in 137-138MHz Range

Xiangyu Qu, Yao-Cheng Lin, and James L Garrison
Purdue University

Remote sensing using readily available communication signal transmitted by ORBCOMM satellites at very high frequency (VHF) range (137--138 MHz) is a promising method for detecting the root zone soil moisture content. The radio wave reflectivity of soil is strongly correlated to soil moisture content. Therefore, if we were able to measure the reflectivity, we might be able to estimate the soil moisture content. In this preliminary study, we analyze direct signal data from the satellites to investigate and verify communication channels in frequency range of interest and their characteristics (bandwidth, pattern, *etc*.). The analysis of direct signal data is also used for calibrating signal collection systems and compensating for the subtle differences of systems. After comparing the satellite geometry and spectrum from raw signal, we verified that ORBCOMM has 13 channels in our frequency range of interest. It was also verified that among these 13 channels, the channel with center frequency at 137.56 MHz is a public channel shared by all satellites and is not suitable for reflectivity computation in that multiple satellites could be in sight by our antenna and the signal reflecting region cannot be determined. In our long duration (~12 hours) analysis, we observed the visible duration and period of the satellites. Conclusively, using ORBCOMM communication signal for sensing the soil moisture is viable. Further study is needed to build up model that relates soil moisture content to reflectivity and a lot of technical issues need to be resolved.

Presentation ID:
AO-12

Room:
ARMS B061

Keywords:
Soil moisture content,
VHF,
ORBCOMM,
Remote sensing

The Role of Habitat Shaping Motion Detection in Two Songbirds

Presentation ID:
AO-13

Room:
ARMS B061

Elena A. Ritschard[1], Luke P. Tyrrell[2], and Esteban Fernández-Juricic[2]
[1]Universidad de Los Andes - Colombia, [2]Purdue University

Double cones of birds are photoreceptors associated with motion perception, and perceiving motion is highly important to detect predators. Predation risks varies between habitats and may impose selective pressures that could affect organisms' traits. There is evidence that birds show interspecific variations in visual system properties, such as the photoreceptor densities (single and double cones) and distribution across the retina. However, little is known about the relationship between the distribution of double cones and predator scanning strategies in birds living in different habitats. The goal of this study was to compare double cones distributions of birds that live in open vs. closed habitats. We measured the density and distribution of double cones in 2 species of the order Passeriformes. These results are important to understand the evolution of predator- prey interactions as we will learn how prey can optimize vigilance strategies in different habitats with different predation pressure.

Keywords:
Double cones, Motion detection, Scanning strategies, Songbirds, Predator-prey interactions

X-ray and Laser Investigation of High Pressure Sprays

Presentation ID:
AO-14

Room:
ARMS B061

Wilbert C Slowman[1], Lane E Shultz[1], and Terence R Meyer[2]
[1]Fort Lewis College, [2]Purdue University

The diagnostics of multiphase flows is important to understand the correlation of parameters such as nozzle geometry, flow velocity, liquid breakup characteristics, atomization, and mass distribution. Investigation of each of these parameters can lead to various improvements on design and optimization, for example, of combustion in gas turbines and rocket engines. For this project, the X-ray and optical diagnostics of multiphase flows in propulsion is investigated for high pressures. Two X-ray tube sources are used to illuminate the spray, and the images are captured on phosphor plates coupled to high-speed cameras. Reconstruction of the mass distribution is accomplished using computer analysis by applying Beer's-Lambert law. High temporal resolution and spatial resolution images were collected of various sprays composed of water and KI solutions for development and characterization of the technique with different window materials typically used in high-pressure vessels. Laser-based fluorescence was tested in vaporized jet-A fuel in a high-pressure vessels. The implications for X-ray and laser analysis of multiphase flows in sprays with high spatial and temporal resolution and high signal to noise ratio are investigated.

Keywords:
X-ray imaging, Multiphase-flow, Beer's-Lambert Law, Kramer's Law, Laser-induced fluorescence

Continuous Ligand-assisted Elution Chromatography Applied to Separation of Rare Earth Elements

Presentation ID:
AO-15

Room:
ARMS B061

Jeremy A Weinstock, David M Harvey, and N.-H. Linda Wang
Purdue University

Rare earth elements (REEs) are metals used to make many valuable products such as magnets and electronics. Following their extraction from larger materials, REEs are to be separated into their individual components as high purity is required for product manufacture. Purification is very difficult because most (15/17) of the REEs are lanthanides (Ln's) and Ln ions have the same valence and similar atomic radii. The current industrial process for purifying REEs involves using toxic solvents to perform a series of liquid-liquid extractions. Ling and Wang (2015) proposed a ligand-assisted batch chromatography process to purify Ln's. The latter approach is a vast improvement over the former in terms of safety, however being a batch process, it is not economical for industrial use. The purpose of this study was to design and test a continuous system based off of Ling and Wang's ligand-assisted elution chromatography process. A titania sorbent was used with a selective ligand, ethylenediaminetetraacetic acid (EDTA). The continuous system utilizes a stepwise elution process and separates a solution of praseodymium (Pr) and samarium (Sm). A Semba Octave SMB chromatography system was used to perform the experiment. Yields and purities greater than 95% were seen for each of the components in solution and the process can be run indefinitely. This continuous process for Ln separation is of interest because safety is increased in comparison to the aforementioned industrial system, sorbent productivity is increased, and it is more robust and simpler to run than the batch process. This continuous system can be scaled up to produce high purity REEs safely and efficiently.

Keywords:
Rare earth elements, Lanthanides, Separations, Chromatography, Fly ash

Biotechnology

ARMS 1103, 1:30 PM – 2:45 PM

Synergy of Cold Atmospheric Plasma and Electroporation for Treatment of Cancer Cells

Arianna M Avellan, Rohil Jain, Prasoon Diwakar, Cagri Savran, and Ahmed Hassanein
Birck Nanotechnology Center, Purdue University

Cancer kills about 1,500 people every day in the United States alone. Treatments for cancer patients like chemotherapy and radiation are invasive, aggressive, expensive, and can sometimes do more harm than good. There is a need for instrumentation and procedures that reduce toxicity to the human body and are more mobile and accessible to cancer and tumor patients. Electroporation and Cold Atmospheric Plasma (CAP) are two methods being explored to treat cancerous cells without affecting the healthy cells through a minimally invasive treatment. This study will focus on the optimization of parameters for both procedures for efficient apoptosis of cancer cells. This study used different cancer cells lines for both procedures in sequence and simultaneously with the goal of understanding the synergy of both techniques. The viability of cells was analyzed through the use of emission spectroscopy, fluorescence, and microscopy. Initial results show that sequential electroporation was successful at leading cells to apoptosis. These results are very encouraging and have the potential of significant advantages over current methods and techniques. Further work and studies are currently in progress to study the synergetic effect of CAP with electroporation.

Presentation ID:
AO-16

Room:
ARMS 1103

Keywords:
Cold atmospheric plasma, CAP, Electroporation, Cancer cells, Spectroscopy

Cold Atmospheric Pressure Plasmas for Food Applications

Michael V Lauria, Russell S Brayfield II, Ronald G Johnson, and Allen L Garner
Purdue University

Successfully distributing shelf food requires treatment to eliminate microorganisms. Current chemical methods, such as chlorine wash, can alter food quality while only being effective for a limited time. Cold atmospheric pressure plasmas (CAPs) can eradicate the microorganisms responsible for food spoilage and foodborne illness. Optimizing CAP treatments requires understanding the reactive species generated and relating them to eradication efficiency. Recent studies have used optical emission spectroscopy (OES) to determine the species generated in a sealed package that would hold food. In this study,we supplement the OES results with optical absorption spectroscopy (OAS) using the same gases (helium, nitrogen, compressed air, humid air) to elucidate plasma chemistry and temperature. We first reproduce previous results using a new setup while assessing the impact of the package and surrounding box on the plasma spectrum. A UV-Vis light lightsource is emitted through a series of lenses placed next to the plasma. Analysis using SpecAir software allows the identification of absorbed peaks and the calculation of rotational, vibrational, and electron temperatures. Results show that the air plasma produces a primary absorbance peak at a wavelength of ~260 nm, demonstrating the diagnostic capability of this technique . Species generation declined dramatically during the first two minutes of treatment with the effect leveling off thereafter. These findings elucidate reactive species generation within the plasma to optimize CAP systems for microorganism decontamination.

Presentation ID:
AO-17

Room:
ARMS 1103

Keywords:
Cold plasmas, Food sterilization, Optical absorption spectroscopy, Dielectric barrier discharge, High voltage

Ball Pressure Correlations with Peak Impact Force and the Potential for Cumulative mTBI when Heading a Soccer Ball

Nicolas Leiva[1], Daniel Shyu[2], Josh Auger[2], and Eric A Nauman[2]
[1]Universidad de Los Andes - Colombia, [2]Purdue University

Soccer is a unique sport in which athletes use their heads as tools for gameplay, which may ultimately cause cumulative traumatic brain injuries. Due to rising popularity of soccer in the United States alongside the increased occurrence of CTE and mTBI in other contact sports, there is a growing concern over how to keep the repetitive forces caused by heading, as low as possible. Different variables that can affect the peak force felt when heading a soccer ball can be simulated and compared with in-game data, however, this has never been properly tested before. In the present study two size five and two size four balls were tested at three different gage pressures (8.5, 12 and 16.2 psi). These were kicked at different velocities towards a force plate, in order to simulate an in game kick, to collect data about the peak force and impulse exerted on a head.

Presentation ID:
AO-18

Room:
ARMS 1103

Keywords:
Soccer, Biomechanics, Traumatic brain Injuries, Velocity, Force

In Vitro Motility of Actin Filaments Powered by Plant Myosins XI

Presentation ID:
AO-19

Room:
ARMS 1103

Keywords:
In vitro motility assay, Myosin, Pentabromopseudilin, Actin, TIRF microscopy

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The actomyosin network is thought to support fundamental processes of plant development and cell expansion such as polarized elongation of root hairs and the diffuse growth of epidermal and mesophyll cells. Inhibition of myosins via pharmacological treatments represents one of the key approaches for understanding of their roles in different cellular processes. However, the use of the standard plant myosin inhibitor, 2,3-butanedionemonoxime (BDM), is questioned as it requires a high concentration and may not be as specific as desired. By testing drugs that inhibit animal and yeast myosins V, the Staiger laboratory previously found pentabromopseudilin (PBP) as a potential inhibitor of plant myosins in vivo. In order to verify PBP as a plant myosin inhibitor in vitro, an actin filament gliding assay powered by chicken Myosin Va (MyoVa) was developed as a positive control using Total Internal Reflection Fluorescence Microscopy (TIRFM). Here, we partially purified a YFP-tagged Myosin XIK from *Arabidopsis thaliana,* and enriched it in the motility assay chamber by an antibody affinity-capture method. The enriched XIK-YFP showed actin binding activity and addition of ATP resulted in detachment of actin filaments (F-actin) from the protein, suggesting that the ATPase domain of the isolated myosin is partially functional. By testing the detachment frequency of myosin-bound F-actin, we demonstrated that PBP could effectively inhibit the ATP-dependent release of F-actin from the isolated XIK-YFP, suggesting that PBP is a potential plant myosin inhibitor.

A Proposal for a Wirelessly Powered, Implantable Pressure Sensor and Neural Stimulator for the Control of Urinary Incontinence

Presentation ID:
AO-20

Room:
ARMS 1103

Keywords:
Urinary incontinence, Implantable devices, Nerve stimulation, Biopotential recording

Robert N Tucker, Christopher J Quinkert, and Pedro P Irazoqui
Purdue University

47 to 53 percent of women over the age of 20 suffer from urinary incontinence, often caused by childbirth-related damage to the pelvic nerve. This uncertainty of when bladder voiding will occur causes social anxiety and can compromise quality of life. This study explores one method to restore the ability to sense the need to urinate and prevent unwanted voiding. We propose a device to measure pressure due to bladder content as the difference between pressure in the bladder and pressure in the abdominal cavity. Integrated circuits, biocompatible packaging, and wireless radiofrequency powering allow for a fully implantable device to process the pressure data, stimulate the pelvic nerve, and stop stimulation on command. The device recognizes pressure spikes similar to those seen in the bladder prior to urinating and stimulates the pelvic nerve in acute surgeries. We hope to chronically implant the device soon to monitor long-term performance and effects of the device *in vivo*.

Materials Science

ARMS 1109, 1:30 PM – 2:45 PM

Coffee Powder Wettability, Flowability and Characterization Thereof

Presentation ID:
AO-21

Room:
ARMS 1109

Keywords:
Wettability, Flowability, Particle size, Roughness, Surface

Natalia Atuesta[1], Afolawemi Afolabi[2], and Teresa M. Carvajal[2]
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The production efficiency and high-quality results in industrial processes usually rely on how well product characteristics are understood as well as how well processes are controlled in order to obtain specific results. Therefore, in a billion-dollar industry as is the case of the instant coffee market, understanding the properties of the compounds produced using different techniques is a very important tool to enhance performance and delivery of high-quality coffee powders. The aim of the present study is to provide a framework of some powder properties such as particle size, shape, diameter, circularity, convexity, aspect ratio and surface energy among others, which govern powder behavior. To do so, five coffee samples were analyzed using Malvern Morphologi 3G ID for particle characterization and Quanta™ 3D FEG scanning electron microscope to visualize surfaces in great detail. Wettability and flowability of all samples were studied under different humidity conditions. Afterwards, in an effort to enhance flowability, flow-enhancing agents were added to the samples that showed the worst flowability. The results revealed that while all the samples presented different particle size distributions, they showed similar circularity, convexity and aspect ratio values. Measurements indicated passable flowability for most of the powders. Even so, they revealed poor flowability and high values of angle of repose for the sample with finer particles as well as no significant improvement when adding flow-enhancing agents. Additional tests showed that at high relative humidity in the environment (RH = 60%) wettability increased. This effect was observed as indicated by low contact angle values, thereby contributing to powder agglomeration and caking. The properties regarded throughout this study provide detailed information and allow the comprehension of the parameters that need to be modified in order to enhance performance and stability in the food industry.

Applications of Additive Manufacturing Techniques in Making Energetic Materials

Presentation ID:
AO-22

Room:
ARMS 1109

Keywords:
Additive manufacturing, Energetic materials

Peter Cattani, Trevor J Fleck, Jeff F. Rhoads, Steven F Son, and I Emre Gunduz
Purdue University

Energetic materials are currently manufactured using methods such as casting, which involves a high level of human interaction. Additive manufacturing has the potential to remove most of the human interaction, and also improve safety, speed, and material quality. Additive manufacturing has transformed many industries, but has not been applied to the manufacturing of energetic materials. This paper reviews two potential methods of additive manufacturing and presents their applications in energetic materials. Using a fused deposition modelling approach(FDM), H3 aluminum and PVDF were mixed and made into filament using a Filabot Original filament extruder. An energetic filament was created for the deposition modelling system composed of 10% Al and 90% PVDF by mass. This filament was not reactive enough to sustain a self-propagating reaction. The second method used stereolithography, with the goal mixing ammonium perchlorate into a curable polymer which solidifies under UV light. To simulate the viscosity, honey and powdered sugar were used to test printing capabilities. The honey and sugar mixture could be printed using a syringe pump when the powdered sugar to honey ratio was 1:2. This results was much less that the desired ratio of 4:1. Both processes need further refinement to produce functional energetic materials. This paper forms a foundation for further development of processes in which additive manufacturing can be safely used to produce energetic materials.

Radiation Tailored Polymers for Detectors, Adhesive-Coatings and Other Industrial Uses

Presentation ID:
AO-23

Room:
ARMS 1109

Anna M Earley, Alex Bakken, and Rusi P Taleyarkhan
Purdue University

The ever growing importance of humans to depend on renewable resources has shifted the focus of consumers, producers, and even politicians to more sustainable answers. Furthermore, pressure on the oil and natural gas industry has elevated the status of biopolymers in this regard. Polylactic acid (PLA) is unique polymer that offers unique abilities for tailored property derivation; thereby, enabling one to replace many engineered polymers and provide a sustainable solution as a nontoxic renewable resource. As a bioplastic, the tailoring of PLA under various conditions is important to the application and integration into current industry uses. After irradiating high molecular weight PLA in increments of 10 to 100 kGy, the molecule changes can be evaluated through viscometry and friability testing to optimize material properties. The change in molecular weight of irradiated samples was evaluated through dilute solution viscometry, and friability was evaluated based upon generation of fine particulates under fixed milling conditions. As the high molecular weight PLA was irradiated from 0 to 100 kGy the relative viscosity (RV) decreased with increasing dose. The initial RV of 3.52 for 0 kGy conditions dropped to 1.62 after a dose of 100 kGy. The decrease in relative viscosity correlated directly with increasing friability and generation of fine powders. Such controlled tailoring of PLA should permit the user to derive a suitable formulation pertaining to its durability in different operational conditions. Food packaging and medical applications are the most likely industries to benefit from this approach.

Keywords:
Polylactic acid,
Ionizing radiation,
Dosimetry,
Polymer degradation

Rapid Grain Boundary Mobility at Ambient Temperatures

Presentation ID:
AO-24

Room:
ARMS 1109

Jarrod M Lund[1], R Adam Bilodeau[2], and Rebecca K. Kramer[2]
[1]Brigham Young University, [2]Purdue University

Understanding and measuring the influence of grain boundaries (planar defects in the crystalline structure of materials) and their motion has become a dominant aspect in materials research, with applications in additive manufacturing, fatigue prevention, and material modeling. However, modeling grain boundaries and grain boundary mobility (GBM) is difficult due to the high temperatures or external stresses, imaging solutions compatible with the material system, and long time-scales required to create measurable experimental results. In this paper, we introduce a novel material system that allows for easy and fast visualization of GBM. A drop of liquid metal eutectic gallium indium (eGaIn) placed on indium foil will penetrate along grain boundaries, decreasing the internal stresses at grain boundary interfaces and enabling rapid GBM on the order of minutes. Due to the low melting temperature of indium, the entire process is observable without requiring special temperature-control equipment. Using a scanning electron microscope, the GBM of several grains of indium can be observed at a high resolution simultaneously. The value of the material choice and visualization process is shown by measuring the motion as a function of curvature for several grain boundaries.

Keywords:
Grain boundary,
Grain boundary mobility,
Grain boundary curvature

Characterizing HMX/AP Cocrystal Propellant Through Planar Laser Induced Fluorescence

Seth M Nielsen[1], Michael S Powell[2], and Steven F Son[2]
[1]Brigham Young University, [2]Purdue University

Energetic cocrystals, or energetic materials that consist of two or more components that form a unique crystalline structure with unique properties, are currently being investigated as a possible method for decreasing the sensitivity of high energy density explosives for use in powerful solid composite propellants. Fuels more powerful than those in current use have not been practical because of their increased safety hazard due to higher sensitivity to being ignited. This has been one of the barriers that has prevented solid composite propellants from seeing significant improvements in performance. This study is an attempt to characterize a cocrystal of HMX and ammonium perchlorate (AP) of 2:3 molar mass ratio. The cocrystal was compared to the equivalent physical mix and baseline propellants of HMX and AP. Planar laser induced fluorescence (PLIF) was performed to measure hydroxyl (OH) concentrations in the propellants' flames. It appeared that the flame structure of the cocrystal was very similar to that of HMX, as well as the distribution of OH concentrations around the flame. The results were inconclusive, and it is believed that the cocrystal's constituents were not sufficiently bonded at the molecular level; thus, the cocrystal was instead more a mixture of smaller individual crystals of HMX and AP. Future research could include cocrystals created by varying methods, and perform cyano (CN) PLIF to characterize these cocrystals, which may display a better defined region of interest in the flame that can be more closely studied and answer more questions.

Presentation ID:
AO-25

Room:
ARMS 1109

Keywords:
*Cocrystals,
Propellants,
Energetic materials,
PLIF*

AFTERNOON POSTER PRESENTATIONS

AP

Biotechnology II

ARMS Atrium, 3:00 PM – 4:15 PM

Role of SUMOylation in Mitochondrial Division in Tetrahymena thermophila

Presentation ID:
AP-1

Room:
ARMS Atrium

Ramya Modi and James Forney
Purdue University

SUMOylation is a post translation modification that involves the addition of a small protein called SUMO, Small Ubiquitin-like MOdifier to a target protein. It is an important mechanism for the regulation of gene expression, the maintenance of genomic stability and in modifying nuclear proteins. More recently evidence has emerged for its importance in regulating mitochondrial fission and fusion in mammalian cells. This study evaluates the parameters for optimal staining of *Tetrahymena thermophila* mitochondria using two different dyes and then examines different cell lines with defects in the SUMOylation pathway. The first staining method uses Mitotracker Green, a vital stain that can only be used with live cells and the second method uses Mitotracker Red, which can be used with live cells and is retained upon fixation. The dyes were used to stain cell lines either deficient in Ubc9 (SUMO-conjugating enzyme) or wild type controls. These stained cells are then viewed under a fluorescence microscope and the mitochondrial morphology was analyzed for different cell lines. Quantitative analysis of mitochondrial size between the Ubc9 deficient cell line and wild type cell line shows that deficient cell lines have mitochondria that are approximately half the size of mitochondria in wild type cell lines. Although these results suggest a role for SUMOylation in mitochondrial morphology, they are not consistent with models developed through studies of mammalian cells in which decreased SUMOylation should lead to increased mitochondrial fusion. Future studies using overexpression of Ubc9 and SUMO will be performed to evaluate these findings.

Keywords:
Tetrahymena thermophila, Ciliates, Mitochondrial division, SUMOylation, SUMO-conjugating enzyme, Mitotracker, Ubc9

Bioconjugation of N-terminal Functionalized Ca^{2+}/Calmodulin-Dependent Protein Kinase II (CaMKII) on Magnetic Beads

Presentation ID:
AP-2

Room:
ARMS Atrium

Benjamin Moy, Aya Saleh, and Tamara L. Kinzer-Ursem
Purdue University

Protein purification is a fundamental step that commonly precedes structural and functional characterization of proteins. Most of the current protein purification methods are laborious and time consuming due to the multistep nature of the process. Searching for alternative methods that are capable of shortening the purification time and simultaneously enhancing the purity of the purified proteins is therefore needed. The method described in this paper entails surface immobilization of the protein of interest on alkyne-functionalized magnetic beads following selective labeling of the protein's N-terminus with an azide tag. The utility of this method was tested using Ca^{2+}/calmodulin-dependent protein kinase II (CaMKII). Four variants of azide-tagged CaMKII were used in our study. The four proteins readily conjugated to alkyne-functionalized magnetic beads. Additionally, conjugated proteins retain functionality comparable to purified proteins. This method can therefore advance the research industry by providing a reliable and easy way to purify proteins and perform rapid enzyme assays. It also allows researchers to focus on the actual work instead of struggling with protein isolation.

Keywords:
Bioconjugation, Click chemistry, Magnetic beads

Bone Tissue Engineering: Scalability and Optimization of Densified Collagen-Fibril Bone Graft Substitute Materials

John G Nicholas, Lauren E Watkins, and Sherry L Voytik-Harbin
Purdue University

Presentation ID:
AP-3

Room:
ARMS Atrium

Keywords:
Engineered bone construct, Bone regeneration, Adipose stem cells, Type I oligomer collagen, Mineralization

Over 240 million people missing teeth worldwide experience lingering problems such as difficulty speaking and eating, undesirable aesthetics, and resorption of bone supporting neighboring teeth. The gold standard of treatment utilizes grafts to attach a function-restoring implant to supporting bone. Current graft materials suffer from problems including autologous donor site morbidity, long resorption time, incomplete integration with the maxillae or mandible, and structural weakness. Patient-specific, cellularized bone grafts may be a solution to these issues by accelerating and improving the quality of regenerated bone. Recently, encapsulation of mesenchymal stem cells within self-assembling type I collagen oligomer matrices has been shown to support rapid mineralization of small-scale bone constructs (cylinders with diameter and height of 6 mm and 1 mm, respectively) *in vitro*. However, this method's volume and geometric constraints for nutrient transport and cell viability are still unknown. In this study, the effects of construct size and medium formulation on mineralization were investigated using conventional static culture methods. To create constructs, human adipose stem cells (hASCs) were embedded in oligomer matrices, allowed to polymerize, and compressed to final cell and fibril densities of $3x10^7$ cells/mL and 50 mg/mL, respectively. Varying construct sizes (maximum diameter and thickness of 11 mm and 0.81 mm) were cultured for 1 week in growth medium or osteogenic medium with varying calcium concentrations. Alizarin red staining was used to detect calcium deposits indicative of cell-induced mineralization. Preliminary data suggests that culture in osteogenic medium supplemented with both 8 mM and 16 mM calcium may induce rapid, uniform mineralization across all sizes tested, and 16 mM calcium supplementation induces greater mineralization. However, additional validation by direct measurement of cell viability and osteogenic differentiation will be needed to better compare bone regeneration as a function of scale.

Using Elastin-Like Polypeptides for Better Retention of Biofuels

Yu Hong Wang, Ethan T Hilman, and Kevin V Solomon
Purdue University

Presentation ID:
AP-4

Room:
ARMS Atrium

Keywords:
Elastin like polypeptides, Biofuels, Inverse temperature phase transition

Elastin-like polypeptides (ELPs) are synthetic molecules that exhibit an interesting property of inverse temperature phase transition; they exist as soluble monomers at low temperatures and form insoluble aggregates at higher temperatures. The transition temperature depends on the pH, salt concentration, and the amino acid sequence of the ELP. This unique and reversible behavior, along with their high biocompatibility has made them a strategic tool for various biomedical applications. However, their hydrophobic properties also make them a prime candidate for biofuel production. As high levels of many commercially important organic solvents are toxic to the cells that make them, ELPs can potentially alleviate the strain on cells by aggregating around the hydrophobic product. ELP's are simply purified by exploiting their phase transition property and through serial centrifugation at different temperatures. The retention of various bio-products and the cell survivability was analyzed for E. coli containing ELPs both in vivo and in vitro. Confocal microscopy and fluorescence measurements were used to verify the results. The present study provides proof of principle that ELPs have high affinity with certain commercially important biologics and can be a strategic tool to increase their yield.

Stimuli Responsive Fluidics Controls on a Paper-Based Bacterial Detection Platform

Siyu Zhao, Elizabeth Phillips, and Jacqueline Linnes
Purdue University

Presentation ID:
AP-5

Room:
ARMS Atrium

Keywords:
Phase changing material, Microfluidic control, Bacterial detection, Valve, Point-of-care diagnostic

Infectious diseases are the leading causes of death around the world. Point-of-care devices using nucleic acid amplification are sensitive enough to diagnose these diseases, however, often require complex and time-intensive sample preparation steps that are not integrated with the detection process. A rapid, sensitive, and integrated sample-to-result diagnostic device will permit disease treatment planning at the point-of-care. Paper-based detection assays are a promising platform to integrate the sample preparation and detection, with minimal infrastructure, equipment, and user involvement. To integrate sample preparation with detection on paper-based assays, timing and delivery of sample fluid flow needs to be controlled. Here we use thermally responsive materials (*e.g.* wax) to create a micro valve on a nitrocellulose membrane in order to automate fluid flow and minimize user involvement. The ease-of-fabrication, lot-to-lot variability and consistency of the dispensing methods are compared. After multiple trials, dispensing the wax material, PureTemp 68X, using a stamp made of polydimethylsiloxane (PDMS) is able to direct the sample flow with the highest consistency. Thermally responsive valves fabricated by stamping PureTemp 68X are found to block the sample fluid to flow for a sustained time when cool. When heated above the melting temperature (68°C), the valve opens and allows fluid flow without interfering with downstream assay binding reactions. These valves can be actuated multiple times simply by heating and cooling again. As a proof of concept, we use the valve to control sample delivery time of nucleic acid amplicons in a lateral flow immunoassay. Amplicons dispensed onto one side of the assay are incubated and bind to gold nanoparticles. They are then released through the valve by applying heat to open the valve. Nanoparticle nucleic acid amplicons will bind to recognition antibodies at the far side of the valve and become visible bands for detection.

Health II

ARMS Atrium, 3:00 PM – 4:15 PM

Mutational and Biochemical Analysis of Isoprenylcysteine Carboxyl Methyltransferase

Sahej Bains, Amy L Funk, and Christine A Hrycyna
Purdue University

Presentation ID:
AP-6

Room:
ARMS Atrium

Keywords:
Protein structure, Ras protein, S-adenosyl-L-methionine, Site-directed mutagenesis

Ninety percent of pancreatic cancers are attributed to mutations in the Ras protein, making it paramount to concentrate on Ras activity. This study focuses on Ras activity by targeting a post-translational modifying enzyme of Ras called Isoprenylcysteine carboxyl methyltransferase (Icmt). Elucidation of the binding site of Icmt will allow the development of therapeutics that effectively inhibit Icmt causing the mislocalization of Ras, and in turn, aid in the treatment of Ras driven cancers. Currently, the hydrophobic substrate binding site of Icmt is unknown. In order to characterize the substrate binding site of Icmt, site-directed mutagenesis was used to design mutations in the yeast homolog of Icmt, Ste14p, and these mutants were tested on substrate specificity. Residues L33, L34, L40, L176, L190, and L195 were mutated to alanine and residue F80 was mutated to tyrosine. Based on previous work, it is expected that these mutated residues will lose activity compared to wild type. This would suggest that these residues are important in substrate recognition. Results from this study could be utilized to elucidate the binding site of Icmt and design more potent and effective drug therapies to minimize Ras signaling in cancer cells.

Assembly of Nucleic Acid-Based Nanoparticles by Gas-Liquid Segmented Flow Microfluidics

Presentation ID:
AP-7

Room:
ARMS Atrium

Keywords:
Microfluidics, Mixing, Nanoparticles, Gene therapy, pDNA

Matthew L Capek, Ross VerHeul, and David H Thompson
Purdue University

The development of novel and efficient mixing methods is important for optimizing the efficiency of many biological and chemical processes. Tuning the physical and performance properties of nucleic acid-based nanoparticles is one such example known to be strongly affected by mixing efficiency. The characteristics of DNA nanoparticles (such as size, polydispersity, ζ-potential, and gel shift) are important to ensure their therapeutic potency, and new methods to optimize these characteristics are of significant importance to achieve the highest efficacy. In the present study, a simple segmented flow microfluidics system has been developed to augment mixing of pDNA/bPEI nanoparticles. This DNA and cationic polymer pair (plasmid DNA and branched poly(ethylenimine)) was chosen due to bPEI's well-known ability to spontaneously condense plasmid DNA. The system fabricated in this project utilizes silastic tubing (1.6 mm ID) as the reaction channels, nitrogen gas as the continuous phase, and the aqueous components as the dispersed phase. Drop flow has been characterized using UV/Vis spectrophotometry, and the relationships between continuous and dispersed phase flow and drop rate and size have been documented. Drops have been successfully formed using two different types of drop generation (cross-flow and co-flow). Physical properties of the nanoparticles were analyzed using dynamic light scattering (DLS) measurements and agarose gel electrophoresis. The nitrogen-to-phosphate (N/P) ratio (5 and 20), flow rate, and flow-path geometry (linear, serpentine, and coiled) have been explored for their effect on mixing and particle uniformity. The results show a significant decrease in nanoparticle size compared with bulk-mixed methods at an N/P ratio of 5.

Production of Porous Alginate Substrates via Membrane Emulsification for Pharmaceutical Applications

Presentation ID:
AP-8

Room:
ARMS Atrium

Keywords:
Crystallization, Polymerization, Membrane emulsification, Pharmaceuticals

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The Food and Drug Administration (FDA) released in 2013 a report that established the pharmaceuticals current good manufacturing practices for the 21st century. This report encourages the creation of new technology in the pharmaceutical industry. Therefore, this research aims to develop a reliable method to produce porous polymers particles to be used in a novel continuous crystallization in porous substrate. The aim of the current work is to create porous polymer microspheres with uniform particle size distribution using a commercially available membrane emulsification system. In the present study, the emulsification was made using a dispersed phase composed of miglyol 840 and 2% w/w of span 80, and the aqueous phase composed of 2% w/w of alginate in deionized water and magnesium sulfate ($MgSO_4$). Membranes of different pore size (20, 40, and 60 μm) and material (stainless steel and nickel) were tested in order to observe the achievable particle size. A Tagushi design was evaluated considering three levels and four factors ($MgSO_4$ concentration, rotation speed, flow rate, and temperature). The particle size and size distribution was obtained through image analysis of the dried particles. The mean size decreased as the rotation speed and flow rate increases. The temperature did not had a direct impact in the particle size but it reduces the time to generate the particles. No direct impact was observed by changing the $MgSO_4$ concentration and the flow rate of the aqueous phase.

Infant Exposure to Resuspended Particles from Carpeted Flooring: Experimental Chamber Study with a Simplified Mechanical Crawling Infant

Presentation ID:
AP-9

Room:
ARMS Atrium

Keywords:
Bioaerosols, Resuspension, Human exposure

Manjie Fu and Brandon E Boor
Purdue University

Airborne particles of biological origin --- bioaerosols --- are present everywhere, including the indoor environment where people spend considerable amounts of time, and exposure to such materials via inhalation can have a number of health implications. Bioaerosol dynamics can occur through a variety of mechanisms, among them resuspension of deposited particles due to human activity. Because the breathing zone of infants is at a much lower height than that of adults, there is reason to suspect that infants are exposed to greater concentrations of bioaerosols resuspended from the floor, though knowledge in this specific area is limited. To investigate, a mechanical infant was used to simulate crawling over carpeting and particle concentrations for varying size groups were recorded using an optical particle sizer (OPS) at heights corresponding to both infant and adult breathing zones. In addition, resuspension tests on the infant breathing zone were repeated following vacuuming of the carpets to observe the effect of vacuuming on exposure rates. Results show that, as a result of infant crawling, concentrations of resuspended particles are significantly higher in the infant breathing zone compared to the bulk air, which is reduced but not quite eliminated by vacuuming. In addition, the mechanisms governing particle concentrations in the breathing zone appears to differ from those of the bulk environment. This study demonstrates that infant crawling causes significant resuspension of particles in the infant breathing zone, making it a prominent contributor to infant bioaerosol exposure worthy of further investigation.

Haptic Foot Feedback for Kicking Training in Virtual Reality

Presentation ID:
AP-10

Room:
ARMS Atrium

Keywords:
Haptics, Virtual reality, Touch, Actuators

Hank Huang and Hong Tan
Purdue University

As means to further supplement athletic performances increases, virtual reality is becoming helpful to sports in terms of cognitive training such as reaction, mentality, and game strategies. With the aid of haptic feedback, interaction with virtual objects increases by another dimension, in addition to the presence of visual and auditory feedback. This research presents an integrated system of a virtual reality environment, motion tracking system, and a haptic unit designed for the dorsal foot. The prototype simulates a scenario of virtual kicking and returns haptic response upon collision between the user’s foot and virtual object. The overall system was evaluated for its tracking accuracy and stimulation strength of the haptic devices. Our results will address the issues associated to yielding rich haptic sensation for the dorsal foot as well as the errors in tracking foot orientation. The study is currently on-going and preliminary results will be discussed.

Using Pupillometry to Characterize Visual Perception in Autistic Mouse Models

Presentation ID:
AP-11

Room:
ARMS Atrium

Keywords:
Pupillometry, Fragile X

Chirag B Patel, Samuel T Kissinger, Alexandr Pak, Nicholas DiCola, and Alexander A Chubkyin
Purdue University

Fragile X syndrome (FXS) is the leading genetic cause of autism. Individuals with Fragile X Syndrome (FXS) commonly display social, behavioral, and intellectual disabilities. Perceptual deficits and their underlying neural activity remain poorly characterized in FXS and other autism spectrum disorders (ASD’s). To explore visual perception in autism, we developed camera based pupil tracking software using OpenCV (an open-source computer vision library) capable of measuring visually evoked changes in pupil area and position in the FXS mouse model (*Fmr1* KO). Changes in pupil area and position are believed to correlate with changes in arousal or visual processing and may serve as an indirect readout of brain state. To explore visually evoked changes in pupil area, head-restrained wild type or Fragile X mice were exposed to visual stimulation consisting of sinusoidal gratings. The average pupil area of Fragile X mice was increased compared to wild type controls. Our results suggest that online pupillometry has a high potential to serve as a diagnostic tool for autism spectrum disorders.

Developing Strategies for Anatomical Characterization of Locus Coeruleus - Cortical Projections

Presentation ID:
AP-12

Room:
ARMS Atrium

Keywords:
Locus coeruleus, Retrograde tracing, Immunohistochemistry, Stereotaxic

Kendra Wang, Qiuyu Wu, and Alexander A Chubykin
Purdue University

The locus coeruleus (LC) is a small noradrenergic nucleus located in the midbrain that releases the neurotransmitter norepinephrine to diverse brain regions. Through it's release of norepinephrine, the LC plays a central role in modulating numerous physiological functions including attention, arousal, and mood and behavior. Although the LC projects to many brain regions, there is limited information about the organization and the afferent projections to the LC that modulates its activity. The goal of this study was to characterize the anatomical projections between LC and cortical areas using a variety of different experimental techniques, including survival brain surgery, stereotaxic injections of fluorescent dyes, trans-cardiac perfusion, and immunohistochemistry. To determine cortical projections from different brain regions to the locus coeruleus, we injected the retrograde fluorescent tracer Fast Blue into the LC. Immunolabeling technique using dopamine-b-hydroxylase antibody allowed for detection of norepinephrine neurons and their extensive projections. The results from the experiment after microscopic imaging of the histology slices do not reveal a direct projection from the visual cortex to the locus coeruleus.

Materials Science II

ARMS Atrium, 3:00 PM – 4:15 PM

Characterization of Superabsorbent Polymers in Aluminum Solutions

Presentation ID:
AP-13

Room:
ARMS Atrium

Keywords:
Superabsorbent polymers, Ionic absorption, Aluminum, Hydrogels

Nicholas D Macke, Matthew J Krafcik, and Kendra A Erk
Purdue University

Over the past few decades, super absorbent polymers (SAPs) have been the topic of research projects all around the world due to their incredible ability to absorb water. They have applications in everything from disposable diapers to high performance concrete. In concrete, aqueous cations permeate the polymer network, reducing swelling and altering properties. One of these ions, aluminum, alters SAP properties by creating a stiff outer shell and greatly reducing absorbency, but these effects have not been well characterized. One method of characterizing the effects of aluminum on SAP hydrogels was performing gravimetric swelling tests to determine equilibrium water capacity at different aluminum ion concentrations. Compressive strength was also determined for swollen particles using a rheometer to perform compression tests. Results from this testing show that low concentration solutions take several hours to permeate the polymer network and reduce swelling capacity, while high concentration solutions are able to limit swelling immediately. The compressive strength of the gel was increased greatly in polymers containing mostly poly(acrylic acid), while SAPs containing more poly(acrylamide) did not have their strength as greatly influenced by the aluminum ions. These results help elucidate the negative effects that may be caused by multivalent cations in concrete. Further research will include studying the interactions of aluminum ions with polymer strands using polymer brushes on a quartz crystal microbalance. This will hopefully reveal the mechanism and kinetics of salt absorption in polymer networks.

Evaluation of Strain Distortion Correction Protocol using Scanning Electron Microscopy and Digital Image Correlation

Presentation ID:
AP-14

Room:
ARMS Atrium

Keywords:
Bias correction,
Scanning electron microscopy,
Digital image correlation

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[1]San Diego State University, [2]Purdue University

Scanning electron microscopy in combination with digital image correlation (SEM-DIC) is a useful technique for measuring strain in materials at the micro-scale. In particular, it can be used to identify micro-scale strain localizations that are the precursor to material failure. While SEM produces high resolution images of the microstructure, the images also contain a large amount of distortion that, during DIC, will result in distorted strain values that require correction. In this project, a nickel-based alloy underwent cyclic mechanical fatigue at three different high temperatures to a targeted maximum strain. Scanning electron microscopy imaging was done on a 200x150 μm^2 area sectioned into nine of the specimen before and after testing for digital image correlation, and electron backscatter diffraction (EBSD) was also used to image the grain boundaries within the sample area. Digital image correlation was done using the software Vic-2D, and corrections were done by following the protocol previously developed. The images were then stitched together and the EBSD images were overlaid the strain maps in MATLAB™. Results show that with the use of this protocol, corrected strain measurement are approximately equal to the macroscopic strain values obtained from testing, but allows for spatial strain fields relative to the microstructure. The accuracy with which this protocol is able to correct strain bias due to SEM makes it a useful tool for measuring strain value for this material, and can be used to estimate the strain values at which strain localization begin.

High Strain Rate Experiments of Energetic Material Binder

Presentation ID:
AP-15

Room:
ARMS Atrium

Keywords:
Sylgard,
Kolsky,
Compression

Roberto Rangel Mendoza, Michael Harr, and Weinong Chen
Purdue University

Energetic materials, in particular HMX, is widely used in many applications as polymer bonded explosives (PBX) and rocket propellant. However, when damaged, HMX is known to be an unstable substance which renders it a hazardous material and in some cases unreliable. Finding critical mechanical conditions at high rates that render various forms of energetic materials as unreliable would be vital to understand the effects that vibrations and compression forces have on energetic materials. A better understanding would enable the ability to develop improvements in the manufacturing of PBX and rocker propellant. The method utilized to evaluate the mechanical properties of the material involved a compression Kolsky bar where a projectile hits an incident bar at 5 meters per second. The incident bar then compresses a binding polymer specimen composed of Sylgard 184 at the other end. Strain gauges were applied to the incident bar to measure voltage changes due to strain. In addition, a load cell was placed behind the specimen to measure compression force histories. The specimens studied were varied to evaluate correlation between composition and mechanical behavior. The results from the experiments showed that the binders with a lower mixing ratio of base to curing agent made the bonding polymer stiffer and less prone to elastic deformation. The results also unveiled that the stiffer binder experienced a higher compression stress due to it's limited elastic deformation. The results also show that, at the strain rates studied, none of the binders failed. However, the measured results provide insight to manufacturers to select proper binder for specific loads. Further research of the compression force on HMX within Sylgard 184 is needed to delineate whether a stiff or ductile binder is more reliable for PBX.

Quantification and Characterization of Aluminum Distributions in Commercial Beta and Mordenite Zeolites by Cobalt Exchange

Presentation ID:
AP-16

Room:
ARMS Atrium

Keywords:
Beta,
Mordenite,
Aluminum siting,
Cobalt exchange

Rebecca L Reitzel, Claire T Nimlos, and Rajamani Gounder
Purdue University

The aluminum distribution throughout the zeolite framework determines the structural, ion-exchange and catalytic properties of the zeolite. Several methods have been proposed to control the Al distribution, but in order to accurately assess these methods a procedure is needed to quantify Al distribution in various zeolite frameworks. Co^{2+} ions exchange onto the zeolite framework at Al pairs, and atomic absorbance spectroscopy (AAS) can be used to quantify the number of exchanged Co^{2+} ions and, in turn, the overall number of Al pairs. Each framework exhibits differences in pore size and channel configuration which affect the equilibrium conditions needed for saturation of all paired Al sites with Co^{2+} ions. In order to achieve saturation of the Co^{2+} ions, a reproducible exchange procedure must be developed for each framework of interest. Commercial beta (BEA) and mordenite (MOR) zeolites were subjected to liquid-phase cobalt ion exchange with varying exchange solution molarity, temperature, number of repetitions and time of exchange. The zeolites were then washed and treated in an oxidizing environment at high temperatures before undergoing AAS analysis to determine Co^{2+} concentration and diffuse reflectance UV-Vis spectroscopy (DRUV-VIS) to ensure only bare Co^{2+} ions were present. The BEA framework was found to achieve saturation at the following conditions: 0.50 M $Co(NO_3)_2$ exchange solution, ambient temperature, 1 repetition and 12 hour exchange time. The exchange procedure for MOR zeolites requires a 0.05 M $Co(NO_3)_2$ solution, ambient temperature, 24 hour exchange time and 1 repetition. These procedures will aid in the creation of an accurate catalog of the Al distribution in various commercially available BEA and MOR zeolites, as well as aiding in further synthesis studies to control the Al distribution in BEA and MOR zeolites.

Cartilage Engineering: Optimization of Media for Chondrogenic Differentiation In Vitro

Presentation ID:
AP-17

Room:
ARMS Atrium

Keywords:
Chondrocyte,
Media,
Differentiation,
Type I oligomer collagen,
Adipose stem cells

Evan Surma, Sherry L. Harbin, Hongji Zhang, and Stacy Halum
Purdue University

Lower back pain from intervertebral disc injury affects around 84% of the population at some point in their life, which at its worst may cause total immobilization. This pain can only be temporarily relieved by spinal fusion or intervertebral disc replacement; however, both of these cause loss of natural motion in patients by removing damaged fibrocartilage discs. While these techniques help mitigate pain briefly, no permanent solution exists currently to both relieve pain and preserve natural motion. My work may be a solution by eventually providing patient-specific implants that resemble native tissue in the regeneration process that could be absorbed and remodeled by the body. The purpose of this study is to use tunable type I oligomeric collagen matrices for culturing of patient-derived stem cells to optimize chondrogenic media. Human adipose stem cells (hASCs) were passaged and used in conjunction with oligomer collagen, which was polymerized as cell/oligomer mixtures and plastically compressed to a density of 24.5 mg/mL, with $4.5x10^5$ cells per sample. These cell-matrix constructs were cultured with different media and supplements (namely TGF-β (3) and L-ascorbic-acid-2-phosphate) for 1 week. Safranin-o staining was used to detect sulfated glycosaminoglycans, a direct measure of chondrogenesis. Preliminary results show that supplemented DMEM media has the most chondrogenic potential, but further study is required. These results will be used to further improve the process of chondrogenesis *in vitro* in order to develop fibrocartilage constructs for use *in vivo*, eventually allowing for implantable constructs that both preserve natural disc height and relieve pain more permanently.

Dynamics of Active Particles

Presentation ID:
AP-18

Room:
ARMS Atrium

Keywords:
Janus,
Active particles

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Active Janus colloids in which surface reactions provide fast particle motion and directionality represent a new frontier in colloidal science with potential applications in materials science and drug delivery. Janus particles half-coated with a metal such as platinum or gold are promising active particle systems for targeted drug delivery. Most studies of Janus active particles have been performed on planar surfaces. Active particle motion in curved surfaces such as single and double emulsion drops is yet to be explored and could offer a path for the fabrication of active particle clusters. The aim of this research was to design, fabricate and study two active particle systems that will serve as model systems for future studies of active particles in drops. Janus particles half-covered with either platinum or gold were fabricated by first spin-coating diluted suspensions of 1 μm diameter polystyrene particles on a silicon wafer followed by sputtering and re-dispersion in water. The platinum Janus particles react with hydrogen peroxide while the gold Janus particles react to monochrome light in a mixture of water and 2,4-lutedine. As a preliminary test, the motion of the Janus particles was optically observed in flat capillaries as a function of hydrogen peroxide concentration or light intensity. ImageJ was used to find the particle location as a function of time to calculate their mean square displacement and compare it with established active particle motion models. This work serves as the foundation for future work on the development of active particle clusters for drug delivery applications.

Laser-assisted Microchanneling on PMMA Substrate Utilizing Two-pass Fabrication Method

Presentation ID:
AP-19

Room:
ARMS Atrium

Keywords:
CO_2 laser,
PMMA,
Microchannel

Sijie Zhang and Yung C Shin
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Microchannel is widely used in microfluidic devices for mixing, chemical reaction, detection, particle separation and *etc*. CO_2 laser-based microchanneling of PMMA as a low cost, rapid, noncontact fabrication method has attracted the attention of industry. However, the typical V-shape grooves fabricated by CO_2 laser microchanneling have limitations since the V-shape grooves will affect the flow behavior and heat transfer of the fluid, which are important to the performance of microfluidic devices. A two-pass fabrication method is proposed and investigated in this paper to improve the quality of the PMMA microchannel fabricated by CO_2 laser. It was found that by using this method, a trapezoidal shape groove can be formed. Such a microchannel is of higher quality compared with the V-shape groove microchannel.

Experimental Study of Breakage of Particles under Compression

Presentation ID:
AP-20

Room:
ARMS Atrium

Keywords:
Fracture,
Granular material,
Static compression

Haoze Zhou, Niranjan Parab, and Weinong Chen
Purdue University

Granular materials are used widely and can be seen in natural and industrial applications such as sand bags or pharmaceutical pills. During their manufacturing, processing, transport and use, granular materials are subjected to various kinds of loadings. If the amplitude of the loading is above the strength threshold, particles constituting granular materials may fracture. It is very important to understand the failure of particles under these loading conditions to prevent or control their failure during all stages of their manufacturing and use. Better characterization of the fracture behavior of particles composed of different materials and sizes will allow more precise application and better maintenance of granular materials in commercial usage. The effects of size and material properties on the deformation and fracture behavior of granular particles are studied by investigating particles from three different size ranges for three different materials. The mechanical behavior is characterized by force-displacement and stress-strain plots under quasi-static compression (strain rate = 10^{-2} s^{-1}). Along with the deformation behavior, the strengths of particles are also recorded and Weibull distribution is fitted to the fracture stresses. It was observed that the smaller particles break at lower forces but actually withstand higher stress at fracture. The calculated Weibull moduli for different size range and materials show that the flaw population from the manufacturing process is different for different sizes and materials. This study shows that size and material properties alter the fracture stresses. Future experiment can be performed for the same particles under dynamic compression to better understand effects of strain rate on the fracture of particles.

The Effect of Honeycomb Cavity: Acoustic Performance of a Double-leaf Micro Perforated Panel

Yuxian Huang and Kai Ming Li
Purdue University

A micro perforated panel (MPP) is a device consisting of a thin plate and submillimeter perforations for reducing low frequency noise. MPPs have many advantages compared to traditional sound absorption materials, such as durability and designability, and they can be used in a variety of places such as room interior designs, passenger and crew compartments of aircrafts and combustion engines. The models in this study were designed and fabricated with the latest 3-D printing technology. The transmission loss and sound absorption coefficient of the 3-D printed double-leaf MPPs with honeycomb cavities were studied. According to the established theory, MPPs work well with the help of a backing and a cavity. Earlier experimental and theoretical developments have suggested that the acoustic performance of the MPPs can be improved by partitioning the backing cavity. A Brüel & Kjær type 4206 impedance tube was used for the experiments and the one-load method was implemented for calculating the absorption and transmission coefficients of the MPPs. A honeycomb structure was chosen to be placed in the cavity because it can provide the required partitions between perforated panels so that the overall transmission loss was expected to be higher than those without the cavity partitioning. Measured results indicated that use of the honeycomb structure in the cavity have improve the acoustic performance of the MPPs. The sound absorption coefficient of a double-leaf MPP was similar to that of a single-leaf MPP if the cavity was long enough. Future studies should involve an investigation of the acoustic performance of the MPPs at oblique angles of incidence because the current study only provides the pertinent information at normal incidence since the standing wave tubes were used in the experiments.

Presentation ID:
AP-21

Room:
ARMS Atrium

Keywords:
Acoustics, Micro perforated panels, Transmission loss, Honeycomb, Noise control

Nanotechnology II

ARMS Atrium, 3:00 PM – 4:15 PM

Nanobubbles Provide Theranostic Relief to Cancer Hypoxia

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Purdue University

Hypoxia is a common motif among tumors, contributing to metastasis, angiogenesis, cellular epigenetic abnormality, and resistance to cancer therapy. Hypoxia also plays a pivotal role in oncological studies, where it can be used as a principal target for new anti-cancer therapeutic methods. Oxygen nanobubbles were designed in an effort to target the hypoxic tumor regions, thus interrupting the hypoxia-inducible factor-1α (HIF-1α) regulatory pathway and inhibiting tumor progression. At less than 100nm, oxygen nanobubbles act as a vehicle for site-specific oxygen delivery, while also serving as an ultrasound contrast agent for advanced imaging purposes. Through *in vitro* and *in vivo* studies, it was shown the reversal of 5mC hypomethylation was achieved in the hypoxia-afflicted regions. An obvious increase in the oxygen concentration within hypoxic regions was also observed, implying adequate oxygen dissociation from the nanobubbles to the hypoxic tumor microenvironment. These implications suggest nanobubbles can be used as a means for epigenetic regulation, ultrasound imaging, and cancer therapeutics, thus having a significant impact on new-age cancer treatment methods in oncology.

Presentation ID:
AP-22

Room:
ARMS Atrium

Keywords:
Nanobubbles, Cancer, Epigenetics, Hypoxia, Imaging

Wearable Piezotronic Devices for Heart Rate Monitoring

Presentation ID:
AP-23

Room:
ARMS Atrium

Keywords:
Piezotronic, Pressure sensing, Wearable devices, Flexible, Piezoelectric semiconductor nanomaterials

Adam J Miller, Yixiu Wang, and Wenzhuo Wu
Purdue University

Self-powered multifunctional wearable devices that are capable of human-device interfacing are highly desired. Piezotronic devices utilize piezoelectricity and semiconductor properties to enable devices to have seamless interaction between human and device. One important use for piezotronic devices is for pressure sensing. Pressure sensing devices have been employed in smart skins, biomonitoring, gesture recognition, and many more applications. This study aims to create a flexible piezotronic device, specifically for use in pressure sensing to monitor heart rate. ZnO nanowires are grown on a flexible polymer substrate so that they can be made into wearable devices. A p-n heterojunction is formed by depositing a layer of p-type tellurium nanowire on top of the ZnO nanowires. These wearable devices are capable of performing the above mentioned tasks through the piezotronic effect that effectively modulates the electronic transport through the p-n junction. One function in particular is heart rate monitoring. This could be an extremely useful and minimally invasive way of detecting heart diseases such as arrhythmia.

Development of Micro-/Nano-Architectures for Intracellular Sensing Platform

Presentation ID:
AP-24

Room:
ARMS Atrium

Keywords:
Nanostructures, Intracellular sensing, Photolithography, Metal-assisted chemical etching

Ryan M Preston, Dae Seung Wie, and Chi Hwan Lee
Purdue University

Currently available nanotechnologies are capable of creating various nanostructures in controlled dimensions such as particles (0D), wires (1D), membranes (2D), and cubes (3D) by exploiting “top-down” or “bottom-up” methods. However, there exist limitations to systematically construct hierarchical nanostructures with geometric complexities. This study is focused on developing a novel nanofabrication strategy that can rationally produce a set of hierarchical nanostructures configured with precisely engineered facets, tip shapes, and tectonic motifs. We aim to identify a collection of optimal materials, array layouts, basic components, and nanofabrication techniques for the production of hierarchical nanostructures by exploiting device-grade semiconducting silicon materials. To accomplish this, device-grade silicon was processed by traditional photolithographic methods to create precisely engineered three-dimensional shapes. The three-dimensional structures were then layered with random patterns by exploiting metal-assisted chemical etching, leading to significantly increased surface areas with arbitrary morphological complexity.

Designing an Experimentally Feasible Selective Emitter For a Thermophotovoltaic System

Presentation ID:
AP-25

Room:
ARMS Atrium

Keywords:
Thermophotovoltaics, Selective emitter, Spectral matching, Metallic back reflectors, Efficiency

Namrata V Raghavan, Peter Bermel, Enas Said Attia Sakr, and Haejun Chung
Purdue University

More than 60% of the raw energy used in the US is dissipated as waste heat. Thermophotovoltaics (TPV) provide a means to capture this waste heat into electricity. Inefficiencies in TPV systems are due to various loss mechanisms, particularly a lack of spectral matching between the emission spectrum of the emitter and the absorption spectrum of the photovoltaic cell. This study aims to design a simple structure emitting thermal photons mostly at high energies, which could allow for efficient generation of electricity through a photovoltaic cell. Optical data for the different materials obtained using ellipsometry and previous research is incorporated into a nanoHUB tool, known as the Thermophotonic Selective Emitter Simulator (TPXsim), to compute the expected enhancement of the TPV system efficiency. Changes have been made to the TPXsim tool to incorporate customized top dielectric mirror layers, samarium doped glass cavity and bottom metallic back reflectors. It is seen that a TPV system consisting of a rare-earth wafer emitter at 1573 K plus a cold-side rugate filter at 300 K shows an overall efficiency of around 18%. Previous research on emitter designs with top and bottom layers of dielectric mirror is seen to increase this efficiency at a large number of layers while degrading the performance for a small number of layers. Our research shows that using aperiodic customized multilayer structures and metallic back reflectors improves the efficiency over a bare wafer while maintaining the ease of fabrication of the selective emitter.

Brain Inspired Enhanced Learning Mechanism Based on Spike Timing Dependent Plasticity (STDP) for Efficient Pattern Recognition in Spiking Neural Networks

Presentation ID: AP-26

Sourjya Roy, Gopalakrishnan Srinivasan, and Vijay Raghunathan
Purdue University

Room: *ARMS Atrium*

Keywords: *Spiking neural network, Spike timing dependent plasticity, STDP, Machine learning*

Artificial neural networks, that try to mimic the brain, are a very active area of research today. Such networks can potentially solve difficult problems such as image recognition, video analytics, lot more energy efficiently than when implemented in standard von-Neumann computing machines. New algorithms for neural computing with high bio-fidelity are being developed today to solve hard machine learning problems. In this work, we used a spiking network model, and implemented a self-learning technique using a Spike Timing Dependent Plasticity (STDP) algorithm, that closely mimics the neural activity of the brain. The basic STDP algorithm modulates the synaptic weights interconnecting the neurons based on pairs of pre- and post-synaptic spikes. This ignores the timing information embedded in the frequency of the post-synaptic spikes. We calculated the average of the membrane potential of each column of neurons to give an idea of how it behaved and spiked for the particular output neuron for a particular image in the past .The update of the weights or the synapses are done on the basis of the frequency obtained. The resultant synaptic updates are less frequent and made wisely making the learning process better. With the present algorithm, we are able to achieve an accuracy of 79% for classifying images from the MNIST data set for a network of 400 output neurons. So the model was able to identify 79% of the total images correctly which is greater than the original STDP signifying that slow and sensible updates are definitely having a better impact on the learning process.

Energy Transfer in CdSe Nanoplatelet Superlattices

Presentation ID: AP-27

Kelly Wang, Jordan Snaider, and Libai Huang
Purdue University

Room: *ARMS Atrium*

Keywords: *Exciton dynamics, Energy transfer, Photoluminescence, Two-dimension energy transfer, Semiconductors*

Two-dimension CdSe semiconductor nanoplatelets (NPLs) exhibit unique, highly desirable optical and electronic properties, such as large absorption crossection and bright emission. Förster resonance energy transfer (FRET) between NPLs is responsible for the utility of these NPLs in fields such as lasing, lighting, solar energy, and sensing. Here we study energy transfer processes in NPL superlattices using photoluminescence (PL) and time resolved PL (TRPL) spectroscopic methods. Information on the effect of thickness of NPL is obtained through correlating PL and TRPL spectra of CdSe superlattices with AFM measurements. PL spectrum showed narrow fluorescence and absorption peaks at room temperature corresponding to excitonic transitions. A FRET lifetime of 351 ps was observed. Results suggest that FRET occurs more rapidly in CdSe NPL superlattices than in isolated CdSe NPLs and that FRET lifetimes depend on available energy pathways in the surrounding environment. This is a promising new material in the field of semiconductors and optical applications.

Relative Contributions of Inelastic/Elastic Phonon Scattering to Thermal Boundary Conductance across Solid Interfaces

Presentation ID: AP-28

Mengxi Zhao, Zexi Lu, and Xiulin Ruan
Purdue University

Room: *ARMS Atrium*

Keywords: *Inelastic phonon scattering, Thermal conductance, Molecular dynamics*

The knowledge of inelastic phonon scattering is crucial for the understanding of thermal boundary conductance across solid interfaces. Several traditional theoretical models such as the acoustic mismatch model (AMM) and the diffuse mismatch model (DMM) assume that the elastic phonon scattering drives the thermal transport across the interface. But there are experiments indicating that the inelastic phonon scattering plays an important part in the interfacial thermal energy conduction as well. We use nonequilibrium molecular dynamics (NEMD) to predict the inelastic phonon conductance across Cu/Si interface. Temperature distribution across Cu/Si interface has been obtained from the simulation results, and a temperature drop across the interface is observed. The inelastic phonon scattering is compared to the elastic phonon scattering to demonstrate their relative contributions to the interfacial thermal conductance. The results show that at relatively high temperature, the inelastic phonon scattering can be comparable to elastic phonon scattering, providing an additional energy dissipation channel.

Modeling & Simulation II

ARMS Atrium, 3:00 PM – 4:15 PM

Analyzing Sports Training Data with Machine Learning Techniques

Presentation ID:
AP-29

Room:
ARMS Atrium

Keywords:
*Purdue women's soccer,
Data science,
Unsupervised learning*

Rehana Mahfuz, Zeinab Mourad, and Aly El Gamal
Purdue University

In the sports industry, there has not been enough effort in analyzing the personalized monitoring data of athletes collected during training sessions. This research is an attempt to find meaningful patterns in the Purdue Women's Soccer training data that could help the coach design more efficient training sessions. We are specifically interested in studying this problem as an unsupervised learning problem. Our initial attempt is to cluster the players as well as drills into groups using k-means, c-means and spectral clustering algorithms, combined with feature transformation and reduction steps. These basic algorithms serve as a benchmark to measure performance improvements when suggesting more advanced methods. In spectral clustering, the gaussian kernel similarity function was used, in which sigma and number of clusters were matched using the eigengap method. The Pearson correlation was used to eliminate highly correlated features, and Principal Components Analysis was used to find mutually orthogonal axes with maximum variance. Three features were eliminated with negligible loss in accuracy. Satisfactorily consistent clusters were identified, where by "consistent", we mean the clustering results that we get through multiple algorithms. The next step will be to give the clusters meaningful labels with expert help (in this case, the soccer team's coach). It is hoped that this is a good start in sports performance analysis.

Stochastic Multiple Gradient Decent for Inferring Action-Based Network Generators

Presentation ID:
AP-30

Room:
ARMS Atrium

Keywords:
*Algorithm,
Network,
Multi-objective optimization,
Stochastic optimization*

Qian Wu, Viplove Arora, and Mario Ventresca
Purdue University

Networked systems, like the internet, social networks *etc*., have in recent years attracted the attention of researchers, specifically to develop models that can help us understand or predict the behavior of these systems. A way of achieving this is through network generators, which are algorithms that can synthesize networks with statistically similar properties to a given target network. Action-based Network Generators (ABNG) is one of these algorithms that defines actions as strategies for nodes to form connections with other nodes, hence generating networks. ABNG is parametrized using an action matrix that assigns an empirical probability distribution to vertices for choosing specific actions. For a given target network, ABNG formulates the problem of estimating an action matrix as a multi-objective optimization problem, which in turn requires an algorithm to determine a Pareto set of action matrices that can generate networks statistically similar to the target. We propose using a population based stochastic multiple gradient descent algorithm to estimate this Pareto set. Results showing the properties of networks optimized using the gradient based algorithm are presented. A comparison is also performed with the previous approach used for optimization.

Model Selection Using Gaussian Mixture Models and Parallel Computing

Presentation ID:
AP-31

Room:
ARMS Atrium

Keywords:
*Machine learning,
Gaussian mixture models,
Model selection,
EM algorithm,
Parallel computing*

Tian Qiu, Georgios Karagiannis, and Guang Lin
Purdue University

In recent years, model selection methods have seen significant advancement, but improvements have tended to be bench marked on its efficiency. An effective model selection system requires a robust feature extraction module. A model selection system is developed by using Finite Multivariate Generalized Gaussian Mixture Model, which organize data points to clusters. Clustering is basically to assign data set into different groups based on their similarity. In this model, expectation maximization method is used to calculate the distance from each point to their dummy center point, where center point will be changing with the process of simulation to get the best fitting results. Parallel computing is utilized to accelerate simulation process. The performance of the developed model is studied through experimental evaluation with ten thousands data points and identification accuracy. The system still can be improved by a new algorithm to separate the cluster. Performance evaluations will be investigated and compared.

Computer Modeling of Graphene Field Effect Transistors

Presentation ID:
AP-32

Room:
ARMS Atrium

Keywords:
Graphene, COMSOL, GFET, Modeling

Drew M Ryan and Robert S. Bean
Purdue University

Graphene has been the centerpiece of numerous research projects since its discovery in 2004, greatly due to its multitude of unique properties. Its variable conductivity, relative strength, and electron mobility make graphene a prime candidate for applications in the field of radiation detection. While work has been performed in the past on testing radiation detection using graphene using Graphene Field Effect Transistors (GFET), due to its limited size, fabricating GFETs can be tedious and costly. Therefore, a need arose for a way to test potential GFET designs without the cost and limitations of fabricating GFETs for each test iteration. Using COMSOL Multiphysics, a model of graphene's material properties and a model of a GFET detector were created to simulate the electric responses. The COMSOL simulation in this project provided data on the responses from the detector, as well as potential scaling information for idealized monolayer single crystal graphene. The results from the computer model are promising; however, experimental work is needed to verify the data. While theoretical information is available on the response of the GFET detector, this data is from an idealized environment based on past empirical and theoretical work. Additional work will need to be performed in the future to compare these results to GFETs in realistic environments.

Decelerating I/O Power Management

Presentation ID:
AP-33

Room:
ARMS Atrium

Keywords:
Linux, Power management, Dynamic binary translation

Shuang Zhai and Felix Xiaozhu Lin
Purdue University

System suspend/resume is crucial to energy proportionality of modern computers, from wearable to cloud servers. Ironically, this OS mechanism itself is slow and energy hungry. Through characterizing the Linux kernel on a variety of modern system-on-chips (SoCs), we show the major reason as slow power state transitions of IO, which keeps CPU waiting. Furthermore, we argue that the IO wait can hardly be reduced to a satisfactory level, because most of slow transitions of IO are bounded by peripherals, low-speed buses, or physical factors. Therefore, the kernel execution for suspend/resume should be offloaded to a miniature core that waits more efficiently. To fix this problem, we propose a power management core running novel hypervisor that dynamically translates and executes Power Management functions. This method not only supports offloading a complex kernel subsystem but also provides forward compatibility with a commodity kernel. Based on QEMU, an open source hypervisor, we implement the backend for ARMv7M ISA. We optimize QEMU's translation by directly mapping flag emulation to hardware. In the end, we are able to achieve 100% increase performance compared with QEMU's original version.

Optimization under Uncertainty Tool for Modeling Porous Lithium-Ion Batteries

Presentation ID:
AP-34

Room:
ARMS Atrium

Keywords:
Optimization, Battery simulation, Uncertainty quantification

Lefei Zhang, Salar Safarkhani, and Guang Lin
Purdue University

The motivation of this tool is to optimize the performance of battery based on energy output. During the manufacturing process, several parameters such as cathode thickness, the volume concentration of cathode and radius of negative active materials are subject to uncertainty. To optimize battery performance, it is significant to quantify those uncertainties through electrochemical multiscale computer simulation. Hence, this tool will focus on the optimization of the performance of lithium-ion battery under different currents. This tool will consist of a module on visualized generator of uncertainty input, an electrochemical system simulator, a visualization of output optimization module. First, the uncertainty input generator provides the option for selecting one of several statistical models for the input parameter distributions. The method of moment matching and Gauss-Hermite quadrature formula are used to simulate distribution. Simulations are performed using an existing electrochemical system simulator that in turn uses the data obtained from the uncertainty input generator to simulate energy and power, which can be considered as a black-box function. The simulation results are quantified graphically through error bar plots that visualize the impact of the uncertainties. For the optimization part, the variation and optimization of power and energy densities as a function of current density of the battery electrode are presented using GPy package and the result are obtained and plotted under uncertain input parameters. Bayesian optimization will be utilized to determine the global optimization through the black-box function. Additional work may be needed to include more of the uncertain variables in this framework.

Natural Resources

ARMS Atrium, 3:00 PM – 4:15 PM

Transport Contaminant in Flowing Water for Improving Water Quality

Presentation ID:
AP-35

Room:
ARMS Atrium

Keywords:
Surface water transport, Denitrification, Tracer experiment, Water quality, Nitrate transport

Ghassani Feta Adani, Antoine Aubeneau, Carlo Andrej Alviar, Xuqing Xiong, and Shizhang Wang
Purdue University

Clean freshwater is fundamental to sustain human activities and the aquatic life. However, cities, industries, and agriculture wastes deteriorate water quality. For example, released fertilizer induces excess algal growth. This leads to major ecological problems such as eutrophication of freshwater ecosystems which has not only a great environmental cost impact, but can also affect the health and sustenance living of the people. This project investigates the transport of nitrate, a major plant fertilizer, in flowing freshwater. Streams and rivers can transform nitrate, thus mitigating its impact. Most of the biogeochemical reactions involved in nitrate removal take place where microorganisms usually thrive, at the sediment or water interfaces. We propose to study how the riverbed sediment influences nitrate transport and transformation. At Notre Dame University, our group conducted tracer experiments in artificial streams at the Linked Ecosystem Experimental Facility (LEEF). The experiment was conducted by co-injecting a conservative tracer (NaCl) and a nitrate salt (KNO_3) and measuring their concentration over time at a downstream station. The data shows how their behavior differs as a function of time. Because water flowing through the sediment is much slower than the surface flow, we can make a space for time substitution and attribute longer timescales to travel in the hyporheic zone. As a result, we can attribute reaction rates to specific reactive zones in the stream. Our results show that benthic and hyporheic nitrate uptakes were reflected in the shape of the nitrate breakthrough curves. The benthic zone induced an exponentially decreasing nitrate signal at early times, while the hyporheic uptake was reflected by the truncation of the late time power law tail. We suggest that our analysis should be useful to scientists and managers alike, as we provide a new, spatially explicit, understanding of nitrate fate in flowing systems.

Persistence of Trace Organic Contaminants from a Commercial Biosolids-Based Fertilizer in Aerobic Soils

Presentation ID:
AP-36

Room:
ARMS Atrium

Keywords:
Emerging contaminants, Biosolids-based fertilizers, Persistence, Degradation

Travis A Banet, Jihyun R Kim, and Michael L. Mashtare
Purdue University

Municipal biosolids are recycled as agricultural fertilizers. Recent studies have raised concerns due to the presence of emerging contaminants in municipal biosolids. Previous research suggests that these contaminants have the potential to reside in biosolids-based fertilizers that are commercially distributed. Use of these products in urban/suburban areas may provide a pathway for these contaminants to enter ecosystems and impact human and environmental health. Soils from Purdue University's community garden and MiracleGro Potting Mix were chosen to represent commonly used urban/suburban growth media. Triclosan, triclocarban, and methyl parabens were selected as compounds of interest for this study. A heat treated commercial biosolids-based fertilizer (Milorganite) was applied to growth media at a rate twice the recommended rate. Microcosm aeration and moisture content were monitored weekly and adjusted accordingly. Microcosms were sacrificed in triplicate at 0, 3, 7, 14, and 21 days, though data will continue to be collected up to 112 days. Soils were extracted using a 1:1 methanol:acetone (v/v) mixture, were cleaned up with microcentrifugation, and analyzed via LC-MS/MS. Anticipated results should demonstrate degradation rates and half-lives of biosolids-borne triclosan, triclocarban, and methyl paraben. This study should further our ability to assess risk and assist in guidance towards safer use of biosolids-based fertilizers.

PAH Analysis of Sediments from Pleasant Run Creek adjacent to a Former Manufactured Gas Plant

Presentation ID:
AP-37

Room:
ARMS Atrium

Keywords:
Coal tar,
Polycyclic aromatic hydrocarbons,
Risk assessment

Celeste A. Bronson, Xuda Lin, Amisha D. Shah, and Chad Jafvert
Purdue University

Polycyclic aromatic hydrocarbons (PAHs) are known to be toxic and some are even carcinogenic. A prime source of PAHs is coal tar. Coal tar can be found in soils and sediments near former manufactured gas plants (MGPs) or coking facilities. This study involves characterizing the chemical composition and concentrations of PAHs within stream sediments at a former MGP site by Pleasant Run Creek in Indianapolis, Indiana. To characterize the stream sediments, sediment cores were removed from various locations along the stream and sampled with depth. Sample collection was conducted in partnership with the environmental engineering firm, August Mack Environmental. Samples were taken at 2 feet intervals from the surface (0.5 ft.) to a depth of 8 to 12 feet. Since the study is ongoing, samples continue to be processed in the lab to analyze concentrations of 17 PAHs by gas chromatography-mass spectrometry (GC/MS). A comparison between measured concentrations and published risk-based criteria will be performed to determine if observed concentrations pose an environmental risk. The results are expected to indicate significant PAH weathering (*i.e.*, variable composition) in the sediment, due to the water volume and velocity of Pleasant Run Creek being affected by storm events. The results of this project will be used by August Mack Environmental to evaluate remediation strategies.

Exploring Regional and Telecoupled Land Use Change Impacts from Environmental Shocks

Presentation ID:
AP-38

Room:
ARMS Atrium

Keywords:
Telecoupled,
Environmental shock,
Input-output,
Land use change,
Network analysis

Kevin Hill, Liz Wachs, Brady Hardiman, David Yu, and Shweta Singh
Purdue University

Natural disasters or environmental shocks have the potential to disrupt local agricultural systems as well as distant agricultural systems through cascading effects. In this work we selected two distinct environmental shocks and traced their cascading effects on land use change. Quantifying cascading effects is a salient issue because climate change forecasts indicate an increase in frequency and intensity of global environmental shocks. This study incorporated the concept of telecoupled systems involving interrelating ecological, economic and political/social components. A telecoupled framework involving cascading effects was implemented using three approaches. The first approach involved using bilateral agricultural trade matrix data to analyze time-based production/consumption changes of agricultural systems directly and by using Input-Output. Next, we employed time-based network analysis to identify regions vulnerable to environmental shocks through globalization of agricultural trade. Land use changes associated with environmental shocks that occurred in telecoupled regions were delineated using image processing software to quantify the impacts of affected regions. Based on two selected environmental shocks, empirically-based case studies were developed that provided insight on cascading effects. Case study 1 linked a drought in the US to economic/trade changes that influenced land use changes in Paraguay releasing 128,950.4 Mg of stored Carbon. Case study 2 linked a typhoon in Malaysia to economic/trade changes that influenced land use changes in Colombia releasing 544,212 Mg of stored Carbon. These findings provide implications for future impact assessments of environmental shocks. The ongoing research should focus on quantifying and refining of global land use change impacts attributed to environmental shocks.

GDD (Growth Degree Day) Module for VinSense Visual Analytics System

Presentation ID:
AP-39

Room:
ARMS Atrium

Keywords:
GDD,
Data visualization,
Viticulture

Pradeep K Lam, David Ebert, and Jiawei Zhang
Purdue University

Limited resources and increasing costs require vineyards to develop optimized methods of planting, growing, and harvesting crops in order to ensure max yield and stay competitive in the marketplace. Data from sensors planted within the soil paired with weather reports and observation data from farmers could help develop competitive farming strategies. While automatic computation models are usually a black box that cannot explain how the input data are transformed into output, the farmers require an approach that allows them to interactively manipulate and supervise the computation process. The VinSense project was developed for this purpose. In this paper, we focus on a particular visual analytics module in Vinsense: GDD (Growth Degree Day) prediction module. GDD is calculated based on the aggregated temperature value and can be used to predict different events such as bud breaking and optimal harvesting point. This module not only integrates several prediction algorithms, but also allows farmers to interactively load data of interest and label multiple events for prediction. We use a few case studies to demonstrate the effectiveness of this visual interface.

Effects of Probiotics Feeding Levels on Meat Quality and Lipid Oxidation Stability of Breast Muscles from Heat Stressed Broilers

Presentation ID:
AP-40

Room:
ARMS Atrium

Keywords:
Probiotics,
Heat stress,
Oxidation stability,
Lipid oxidation,
Broilers,
meat quality

Osamudiamen Ogbeifun, Hyun-Wook Kim, Traci Cramer, and Yuan H. Brad Kim
Purdue University

Heat stress has negative impacts on meat quality attributes including oxidation stability. Since microbial probiotics supplementation results in positive impacts on growth performance and antioxidant property, it is hypothesized that this will improve quality of meat from broilers exposed to heat stress. The objective of this study was to determine the effects of probiotics levels on meat quality and oxidation stability of heat-stressed broilers. 336 1-day-old chicks were group-weighed and randomly assigned to 24 pens with three different diets (basal plus 0, 0.5, and 1.0g of PoultryStar [1.0×10^5 cfu/g of feed containing 4 strains of bacteria]). Heat stress began at 8 days up to 42d at 32ºC for 12 hr/day. At 42d, two birds were randomly selected from each pen and harvested. Breast muscles (*M. Pectoralis major*) were removed from carcasses at 24 hr postmortem. Measurements for cook loss, shear force, color, proximate analysis, peroxide value, 2-thiobarbituric reactive substances (TBARS), and phospholipid content were conducted. Probiotics feeding did not affect shear force, cook loss, or color ($P > 0.05$). An increase in probiotic feeding level slightly decreased fat and ash contents of broiler breast muscles ($P >> 0.05$). In terms of lipid oxidation stability, an increase in probiotic levels led to a significant increase in peroxide values ($P < 0.05$), whereas TBARS of breasts from broilers fed probiotic were lower than that of control broilers ($P >> 0.05$). This current study showed feeding probiotics to heat-stressed broilers could decrease fat content of broiler breasts and possibly inhibit formation of secondary lipid oxidation products.

Movement of Hydrocarbon-Degrading Bacteria Near Oil-Water Interfaces

Presentation ID:
AP-41

Room:
ARMS Atrium

Keywords:
Microfluidics,
Environment,
Bacteria

Daniel A Quinkert, Adib Ahmadzadegan, and Arezoo M. Ardekani
Purdue University

Bacteria are found everywhere in nature, including within human/animal bodies, biomedical devices, industrial equipment, oceans and lakes. They can be found in planktonic state within a bulk liquid phase or attached to surfaces with the potential to form biofilms. In this study we are interested in the movement and distribution of bacteria near surfaces. The concentrations and fluid interactions of bacteria were characterized at various distances from a surface. *Psuedomonas putida* F1 was observed in a suspension near a surface. Bacteria movements were visualized with an inverted microscope at 40x magnification. *P. putida F1* exhibited greater density in close proximity to the surface when compared to the bulk. Additionally, the ability to move in a direction normal to the surface was significantly reduced.

Comparing Carbon Dioxide and Water Vapor Fluxes from Tilled and Non-tilled Maize Canopy Fields

Heather Sussman and Richard Grant
Purdue University

Presentation ID:
AP-42

Room:
ARMS Atrium

Keywords:
Greenhouse gases,
Eddy covariance,
Leaf area index (LAI),
Tillage,
Maize stress

Agricultural activities account for approximately 25% of worldwide greenhouse gas emissions. Farm management practices, such as tillage and no-tillage, may contribute more to this percentage than others. The two most abundant greenhouse gases responsible for climate change are CO_2 and H_2O, therefore it is important to determine whether tillage or no-tillage emits less of these gases. Fluxes of CO_2 and H_2O from two maize canopy fields, one with tillage and one with no-tillage, were measured in Indiana during the 2016 growing season. This study utilized the eddy covariance method, which represents flux as a covariance between vertical velocity and gas concentration. Measurements of canopy height and leaf area index (LAI) from both fields were collected since these parameters influence photosynthesis, respiration, and evapotranspiration rates and show differences in the growth of maize. Results showed that the tilled field had a 14% higher maximum CO_2 uptake and a 4% higher maximum H_2O flux to the atmosphere when LAI was 32% larger than the non-tilled field. Previous studies suggest these fluxes should be higher for the tilled field than what was measured. Drought conditions caused the maize to be water stressed, which restricted H_2O loss and caused less CO_2 uptake. These outcomes indicate that while maize canopies with tillage may typically have a higher CO_2 uptake and higher H_2O emissions than with no-tillage, this effect tends to disappear when maize is under water stress.

Earth and Space Science

ARMS Atrium, 3:00 PM – 4:15 PM

Velocity Profiling, Turbulence, and Chlorophyll Concentrations in the Bottom Boundary Layer of Lake Michigan near Muskegon, Michigan

Jonathan M. Benoit, Cary D. Troy, and David J. Cannon
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Presentation ID:
AP-43

Room:
ARMS Atrium

Keywords:
Turbulence,
Lake michigan,
Bottom boundary layer,
Concentration boundary layer,
Quagga mussels

The characterization of water flow and turbulence near lake beds is important for modelling environmental and ecological effects throughout a lake. In Lake Michigan, where invasive filter-feeding Quagga mussels dominate the lake bed, turbulence plays an important role in determining how much of chlorophyll is mixed down to the Quagga Mussels. Deep in Lake Michigan (44 m) near Muskegon, MI, a large tripod was deployed, attached with an Acoustic Doppler Velocimeter, a fluorometer to measure chlorophyll concentrations, and a temperature sensor. Measurements were recorded from late May until early August by sampling velocities every hour in ten-minute bursts at 4 Hz, and sampling temperature and concentration approximately every minute, continuously. Several important turbulent parameters were calculated using the data collected. Chlorophyll data from the site showed that the water column here displayed a Concentration Boundary Layer (CBL), in which the chlorophyll concentration increases as distance from the lake floor increases. The median speed (U = 2.85cm/s) and Turbulent Kinetic Energy (TKE = 2.1×10^{-5} m^2/s^2) were also calculated. All of these results have previously had very little documentation in such deep waters. The observation of a CBL shows that the invasive Quagga Mussels are able to drastically alter chlorophyll concentrations near the lake floor, an important result for future modeling efforts. The quantification of turbulence parameters will be useful in further studies to find causation between various turbulence levels and concentrations.

Development of Functional Requirements for a High-capacity Airspace System

Presentation ID:
AP-44

Room:
ARMS Atrium

Keywords:
State-based model, Air transportation system, Airspace capacity, Quality measures

Noel J Colon[1], Jeongjoon Boo[2], and Steven J Landry[2]
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NASA along with other researchers visualizes a future where more aircraft will transport passengers or goods around the world. Thus, they envision increasing air capacity from 10 to 100 times more than the current system without any reduction in efficiency or safety. Many models are being proposed that comply with the necessary requirements to form part of the method needed. However, knowing which of the proposed methods have the most desirable characteristics, such as efficiency and safety, are yet to be determined. For this reason, a standardized method to compare and assess them has to be developed, since is not possible to apply them all. An approach to this issue is establishing functional requirements, which are a set of standards that assess and compare performances of new models. Thus, this research is focused on identifying quality measures, which are measures of the requirements, in order to establish functional requirements. As for the first step, measures regarding air transportation system were collected and analyzed by literature review and surveys to determine the potential candidates. As a result, the final potential quality measure candidates were obtained that lead us to determine the ideal measures of the functional requirements and three types of quality measures were discovered. These measures of the functional requirements will constitute a standard to assess new models being proposed and determine the most desirable results.

iFly: Code Development for an App to Support Automating Entomological Data Collection

Presentation ID:
AP-45

Room:
ARMS Atrium

Keywords:
Entomology, Forensics, iFly, iOS, Data

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We are developing a prototype entomological data-collection application called "iFly," which runs on a field-capable iPad device. In this phase, we tackled refining screens and introducing a database manager to streamline operations as info is entered, stored, retrieved and delivered. We used SQLite3 database in Apple's Xcode Integrated Development Environment (IDE). Xcode gives mixed programming results. Apple's iOS environment ensures functional and fairly error-free apps can be built. But the sophisticated Xcode IDE requires specialist developers and valuable project time is spent as new programmers learn key techniques. The iFly prototype was advanced with improved database integration; however, more work is needed. For this software to successfully empower researchers in entomology/forensic science, funding is needed for the prototype to move out of the lab and into the field for real-world testing feedback to guide design refinement. Further, we've yet to exploit the full range of iPad data-entry capabilities.

Particle Swarm Transport in Porous Media

Presentation ID:
AP-46

Room:
ARMS Atrium

Keywords:
Porous media, Micro-particle transport, Fluorescent imaging

Alison R Hoe and Laura J Pyrak-Nolte
Purdue University

In recent years, interest in particulate transport in the subsurface has increased with the increased use of micro-particulates in consumer products. In this research, we study particulate swarm transport through porous media that depends on the complexity of the flow paths, on the size and shape of the particles and on the physical interactions among the particles, fluids, and matrix. Specifically, we investigate the effect of pore geometry and grain wettability on swarm evolution under gravity. Swarms were composed of 3 micron polystyrene beads in either water or water with KCL (%). Two types of grains are used to simulate a porous medium: (1) hydrogel spheres that are hydrophyllic and (2) 3D printed PMMA spheres that are hydrophobic. We found that a hydrophillic matrix resulted in a wider transport path and caused an increase in bifurcations when compared with the hydrophobic PMMA. We also observed that as the swarms increased in volume the number of bifurcations increased. Bifurcations occurred around the beads creating a more widespread dispersed transport path. The potential spread of particulate contaminants by swarms will depend on the hydrophobicity or hydrophilicity the grains, yielding either increased dispersion or more highly localized concentrations.

Sustainability

ARMS Atrium, 3:00 PM – 4:15 PM

Increasing Maize Tolerance to Drought and Flood with Seed Coating Treatments

Presentation ID:
AP-47

Room:
ARMS Atrium

Keywords:
Field stress, Germination, Seed coatings, Seed corn

Jacob E Bennett, Achint Sanghi, and R. P. Kingsly Ambrose
Purdue University

The lack of irrigation in regions prone to drought, and flooding due to high rainfall or lack of drainage affects seed viability and the subsequent germination and crop establishment. Seed treatment in the form of coatings shows promise as an effective method to preserve the viability of corn (*Zea mays*) seeds in drought and flood conditions. Chemical formulations may help improve the seed corn vigor under these stressed conditions. This study examined the efficacy of *β*-aminobutyric acid [BABA] and N-isopropylacrylamide [NIPA] in inducing drought resistance, as well as the ability of lanolin and linseed oil to provide flood tolerance for seed corn. Germination rates and linear shoot growth measurements were used as indications of seed vigor. Uniform coatings of the treatments were applied to untreated seed corn, and treated seed performance was compared to an uncoated control batch of seeds. Water imbibition, moisture, and temperature were manipulated to replicate drought, flood, and optimal growth conditions. The preliminary results of these experiments indicate that these coatings did not significantly increase the viability during short-terms of stressed conditions. At suboptimal temperatures, uncoated control seeds displayed significantly higher seed vigor and growth rates. Manipulation of coating thickness and/or testing at more intense stress levels may be necessary for coating treatments to exhibit positive effects on corn seed resistance to drought and flood.

Effects of Internal EGR on Modern Diesel Engines Internal Equipped with VVA at Idle

Presentation ID:
AP-48

Room:
ARMS Atrium

Keywords:
Diesel, Engines, VVA, EGR, NO_x

Erik R. Santini, Dheeraj B. Gosala, and Gregory M. Shaver
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Vehicle emissions regulations are continuing to grow more challenging requiring near-zero levels of pollutant emissions. Nitric oxide (NO_x) emissions are heavily regulated with the emission limit expected to become 1/10th of its present limit by 2021. In order to meet the new regulations, improvements in both the engine and the exhaust aftertreatment system are required. Exhaust gas recirculation (EGR) is used to reduce the NO_x produced by the engine while the aftertreatment system converts most of the engine-out emissions to safer gases before releasing them to the atmosphere. One of the main challenges with the aftertreatment system is that it requires to operate at a certain minimum temperature before it is effective. Variable valve actuation (VVA) can be used to improve the thermal management of the aftertreatment system- first to accelerate the warmup following a cold start and then to maintain its temperature economically. Using VVA, negative valve overlap (NVO) was looked at as form of internal EGR, where exhaust gas is trapped inside the cylinder. Experiments showed a 70°C increase in exhaust gas temperature while maintaining engine out NO_x. A literature survey was performed on exhaust gas re-induction as another means of internal EGR. Internal EGR has potential to be an effective means of reducing NO_x and improving aftertreatment thermal efficiency in future diesel engines.

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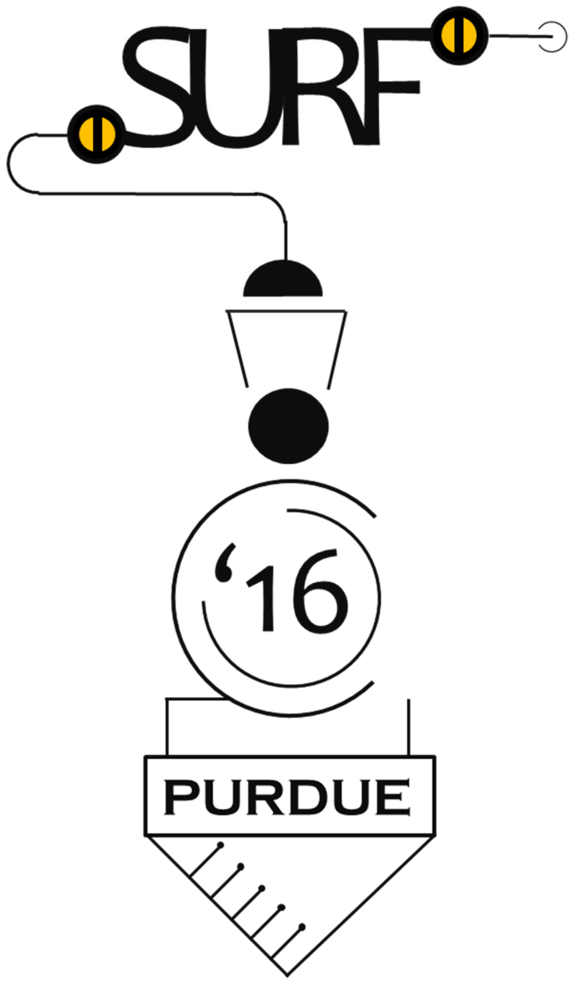

2016 SURF T-shirt Logo
(Designed by Paula Sarmiento)