ENGINEERING GRADUATE RESEARCH SYMPOSIUM 2014
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**BAE-01 Enhanced Land Treatment Of Food Processing Wastewaters**  
*Authors*: Niroj Aryal; Dawn Reinhold

**Abstract**: Land application of high-strength food processing wastewater can result in anoxic and anaerobic soil environments. Under these conditions, metals like manganese, iron, and arsenic can leach, pollute ground water, a major source of drinking water. On the other hand, nitrate pollution may occur under aerobic conditions due to nitrification of ammonium and organic nitrogen. Poplar plantations could reduce both metals and nitrate problems while allowing increased rates of land application of food processing wastewater. This experiment used field and column studies to identify underlying processes that contribute to the potential of poplar trees to reduce metal and nitrate leaching.

Results show that poplar tree growth is not hindered by application of wastewater at the rate of 1-2 times highest current application rate in Michigan. Poplar plants significantly removed more water from soils than evaporation alone with a crop factor of 3.86 ±0.6, indicating decreased soil moisture, decreased reducing conditions in soil, and increased allowable rates of wastewater application would be expected for poplar plantations (as compared to existing land application sites). Carbon treatment was enhanced by poplar trees likely due to rhizostimulation. While microbial and soil redox data is under analysis, initial results in metal mobilization showed that metal (including arsenic) concentrations in stems and leaves of trees irrigated with food processing wastewater were significantly greater than that in trees irrigated with waters. Consequently, poplar trees demonstrate great potential for enhanced land treatment of wastewaters.

*This work was supported in part by Michigan Department of Agriculture and Rural Development, Project GREEEN*

**BAE-02 Effect Of Saturation On Nutrient Removal And Drought Resilience In Stormwater Treatment Systems**  
*Authors*: Rebecca Bender; Dawn Reinhold

**Abstract**: Constructed wetlands and bioretention systems are widely accepted as stormwater best management practices. These systems are designed to retain water and reduce the effects of nonpoint pollution through retention and remediation with infiltration, filtration, sorption, and biological activity. However, the optimal water content for pollutant removal has yet to be identified in a quantifiable manner. Likewise, the resilience of these ecological systems to drought and their recovery time to maximum performance should be studied methodically. In controlled columns and in five field-scale systems, parallel systems of varying water content will be evaluated for stormwater treatment performance (including removal of sediment, total phosphorus, total nitrogen, nitrates, nitrite, ammonia and pH change). Ecological resilience will be monitored in regards to plant health and insect diversity. Once established, the systems will undergo a drought simulation and then a monitored recovery period until remediation performance is reestablished. Similar vegetation, soil composition, and pollutant loading will isolate the effect of saturation on system performance and contribute to knowledge of system design and management. Such qualitative and quantitative analysis is an important part of justifying and promoting use of wetlands and bioretention for stormwater best management.

**BAE-03 Optimization Of A Torrefied Pellet Plant To Reduce Production And Supply Costs**  
*Authors*: Li Chai; Christopher M. Saffron

**Abstract**: Torrefaction is a preprocessing technology that upgrades biomass to a form with improved physical and chemical properties. In torrefaction, heat is added in the absence of oxygen to perform a mild pyrolysis of the structural components of biomass. The advantages of torrefied biomass versus untreated biomass include: 1) reduced transportation costs due to densification, 2) improved storage stability due to increased hydrophobicity, and 3) reduced grinding costs due to increased friability. Because of these benefits, torrefaction is being considered to produce a drop-in replacement for coal. Decentralized torrefaction involves the regional deployment of relatively small facilities near the area of biomass harvest. A trade-off exists between economies of scale and economies of transportation. Smaller scales benefit transportation but more capital investment is needed to process a given amount of biomass. Small scales are also prone to higher risks due to issues with biomass storage. A techno-economic model was formulated to examine the costs and benefits of decentralized torrefaction systems. The optimum plant capacity was determined using economic metrics as objective functions.
BAE-04  Evaluating Environmental Justice Model Performances At Different Census Levels  
Authors: Fariborz Daneshvar; A. Pouyan Nejadhashemi; Zhen Zhang; Georgina M. Sanchez; Geoffrey Habron; Sandra Marquart-Pyatt; Ashton Shortridge; Matthew R. Herman

Abstract: This study considers both stream health and socio-economic data to develop a predictive model for water quality by using socio-economic data variation. The Saginaw River watershed, which is the biggest six digit Hydrologic Unit Code watershed in Michigan, was selected as the study area. Socio-economic data from 2010 US census was collected at three levels (county, census tract, and block group) for the study area and four stream health indicators including the Index of Biological Integrity (IBI), Hilsenhoff Biotic Index (HBI), Family IBI, and total number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa, were used to evaluate stream health condition. The Conditional Autoregressive (CAR) model was used to predict stream health indicators using sixteen socio-economic parameters at three resolutions while considering multi-level interaction. Results obtained from the block group level analysis, were significantly different from the county level. Therefore, socio-economic and eco-environment model developed with county level resolution can be misleading. In general, spatial dependence needs to be considered for a model development, especially at fine scales. Finally based on the results obtained from this study, multilevel interactions will further improve model prediction accuracy.

BAE-05  The Effectiveness Of AGIS Process On Fats, Oil And Grease Using A Septic Drain Field  
Authors: Younsuk Dong; Steven Safferman

Abstract: Fats, oil, and grease (FOG) are in animal meat, cooking oil and dairy products. When FOG is discharged to sewers, it builds up over time and clogs the sewer pipes. Blocked pipes can create overflows and backups that cause odor and the surfacing of untreated wastewater. Sustainable Environmental Technologies, Inc., (SET) developed the Advanced Grease Interceptor System (AGIS) to manage FOG. The AGIS uses aeration equipment, baffles and a one-time inoculum in a standard septic tank to microbiologically partially breakdown FOG. The remaining FOG easily flows through the sewer without causing clogging. The effect of the decomposed FOG in a drain field is not understood and is being evaluated in this research. To investigate, simulated drain fields were constructed with moisture sensors to detect the progress a flow through the soil. Five different conditions are being tested including representative wastewater samples with and a without AGIS treatment to determine clogging potential. In addition, the research will measure the triglyceride components before and after treatment with the AGIS. FOGs are composed of triglycerides, which are formed by 3-fatty acid bound to an ester composed of a glycerol. Many triglycerides have a characteristic of stickiness which results in sewer pipe clogging. In order to test triglyceride, solid phase extraction of FOG within the wastewater is the first step, followed by high performance liquid chromatography (HPLC) to identify each component.

This work was supported in part by Sustainable Environmental Technologies; Michigan Corporate Relations Network; MSU Bioeconomy Institute i6 Green Proof of Concept Center

BAE-06  Data Management Practices For Low And Negative Plate Counts Affect The Confidence Intervals Of The Estimated Parameters Of Microbial Reduction Models  
Authors: Francisco Garcés-Vega; Bradley Marks

Abstract: Experimental limits of detection (LOD) affect data for developing microbial reduction models. To deal with this, published approaches include: considering only positive values (Y+), or replacing negative results by: the LOD, one divided by the LOD, or a random number between 0 and the LOD. Recent results show that these practices significantly affect accuracy of estimated parameters. Our objective was to quantify the effect of data management practices on confidence interval sizes (CIS) for resulting model parameters. Simulated microbial reduction data sets (n=100), were synthesized (YOBS). The low-count data management practices described above were applied. Log-linear and Weibull models were fit to the resulting data sets. The CIS of the parameters were estimated, and then compared by ANOVA and Tukey. The ranking of CIS among data management practices varied among data and model types. The Y+ approach, previously shown to be the most accurate, often had the largest CIS, as double (P<0.05) those for YOBS. For the other approaches, the CIS fell below those of YOBS and Y+. 22 out of 30 cases yielded CIS greater (P<0.05) than those for YOBS. These suggest that the application of low-count data management practices affects the accuracy and uncertainty of the model parameters. The fact that the CIS of Y+ were most often the largest indicated that predictions based on these results, even if more accurate, are also more uncertain. This could influence model selection and utility in risk assessments and food safety management.

This work was supported in part by Colciencias-Fulbright scholarship (2012)
**BAE-07  Biomass Fast Pyrolysis And Electrocatalysis For Liquid Fuel Production And Value Addition**  
**Authors:** Mahlet Garedew; Zhenglong Li; Chun Ho Lam; James E. Jackson; Christopher M. Saffron

**Abstract:** The production of liquid hydrocarbon fuels from biomass is needed to replace fossil fuels, which are decreasing in supply at an unsustainable rate. Renewable fuels also address the rising levels of greenhouse gases, an issue for which the Intergovernmental Panel on Climate Change implicated humanity in 2013. In response, the Energy Independence and Security Act (EISA) mandates the production of 21 billion gallons of advanced biofuels by 2022. Biomass fast pyrolysis (BFP) uses heat (400-600°C) without oxygen to convert biomass to fuels offering an alternative to fossil fuels and a means to meet the EISA mandate. The major product, bio-oil, can be further upgraded to liquid hydrocarbon fuels, while biochar can serve as a solid fuel or soil amendment. The combustible gas co-product is typically burned for process heat. Though the most valuable of the pyrolysis products, bio-oil is highly oxygenated, corrosive, low in energy content and unstable during storage. As a means of improving bio-oil properties, electrocatalytic hydrogenation (ECH) is employed to reduce and deoxygenate reactive compounds.

In this study, model compounds representative of bio-oil components are subjected to ECH under mild conditions using ruthenium on activated carbon (Ru/ACC) as a catalytic cathode. To date, model monomers (guaiacol, syringol and phenol) and model dimers (4-phenoxynaphol) have successfully been reduced using this method. Further work in this area focuses on pyrolysis and electrocatalysis of lignin. As lignin comprises up to 30% of the mass and 40% of the energy stored in biomass it offers great potential as feedstock for BFP.

*This work was supported in part by Great Lakes Bioenergy Research Center*

**BAE-08  Evaluation Of Feedstocks For Achieving Michigan State University's Energy Transition Plan Goals With Torrefied Biomass**  
**Authors:** Kristen Henn; Christopher M. Saffron; Raymond O. Miller; Richard E. Baker

**Abstract:** Michigan State University's Energy Transition Plan (ETP) sets a goal of 15% renewable energy production by 2015. Anaerobic digestion, wind, solar power and alternative fuels currently contribute to 8% of the total energy portfolio. The T.B. Simon Power Plant also combusts raw biomass accounting for a small portion of the 8%. Another electric power source is required to meet the ETP goal. Raw biomass is not desirable for efficient combustion due to high moisture content, low energy density and poor grindability. However, biomass can be thermally upgraded by torrefaction; a process that converts biomass into a product that is a drop-in coal replacement. During torrefaction, the properties of biomass are upgraded to form an energy dense, friable, hydrophobic, biologically stable and easily combustible solid fuel.

Historically, electricity production from torrefied biomass has a higher cost than coal or natural gas. Therefore, selecting feedstocks that can readily be converted to “drop-in” form is necessary to reduce costs. While the effects of torrefaction operating conditions have been extensively studied, the dependence of torrefied biomass properties on raw biomass composition is not well understood. Closing this knowledge gap requires connecting feedstock and product properties using advanced multivariate analysis (MVA). The observations generated by MVA will be used to understand the mechanisms of biomass conversion during torrefaction. The dependence of torrefied biomass properties on feedstock composition will be discussed.

**BAE-09  A Review Of Macroinvertebrate And Fish Stream Health Indices**  
**Authors:** Matthew Herman; A. Pouyan Nejadhashemi

**Abstract:** The focus of this review is to discuss the current use and development of macroinvertebrate and fish indicators for stream health. Macroinvertebrates and fish are commonly used indicators of stream health, due to their ability to represent degradation occurring within local regions (macroinvertebrates) and within the entire river system (fish). The next section of the review discusses several types of common components, or metrics, used in the creation of indices. Following this discussion of common metrics, the review will focus on the different methods used for macroinvertebrate and fish collection, in both wadeable and non-wadeable aquatic ecosystems. With the basics of macroinvertebrate and fish indices discussed, emphasis will be placed on the application of indices and the different regions for which they are developed. The final section will do a brief summary of the benefits and limitations of macroinvertebrate and fish indices.
**BAE-10 Impact Of Inoculation Procedures On Thermal Resistance Of Salmonella In Wheat Flour And Associated Repeatability Of Results**

**Authors:** Ian Hildebrandt; Bradley Marks; Elliot Ryser; Rossana Villa-Rojas; Juming Tang; Sarah Buchholz

**Abstract:** Investigation of Salmonella inactivation involves artificial inoculation of a food matrix. However, most studies focus on the effects of the treatment variable, neglecting to consider the influence of inoculation procedures. The objective was to quantify the impact of inoculation methodology on thermal resistance of Salmonella in wheat flour, and repeatability in a two-laboratory comparison study. Batches of wheat flour (100 g) were inoculated with Salmonella by five methods: (A) high-concentration, low-liquid volume (HCLV) broth, (B) HCLV suspended lawn, (C) pelleted and resuspended lawn, (D) direct contact with a lawn, and (E) fomite transfer of a lawn. Afterwards, samples were equilibrated to ~0.45 aw in a controlled-humidity chamber, subjected to isothermal (80°C) treatments in aluminum cells in a water bath, immediately cooled, diluted, plated, and enumerated. D-values were computed from the resulting log CFU/g data by linear regression. Post-equilibration and post-come-up Salmonella populations ranged from 8.7 to 6.3 and 7.7 to 3.7 log CFU/g, respectively. Method A yielded the largest population decline during equilibration (~3 log) and come-up (~2.5 log), and the highest D-value (504.9 s), compared to the other methods (P < 0.05). The MSU-generated D-values for methods B, C, and D were clustered (250.9, 285.9, and 226.7 s, respectively), but were statistically different. Based on these findings, careful consideration should be given to the inoculation method, which can significantly impact thermal resistance of Salmonella in low-moisture foods, and the uncertainty, which can significantly affect utility of models.

*This work was supported in part by USDA – NIFSI*

**BAE-11 Correlating Maize Cell Wall Properties To Their Response To Alkaline Pretreatment And Enzymatic Hydrolysis**

**Authors:** Muyang Li; Dan Williams; David Hodge

**Abstract:** Maize (Zea mays L.) stover has the largest production area in the United States as a bioenergy feedstock. The environmental and agronomic factors such as maturity, nutrients and genetics may impact the maize cell wall properties, which results in differences in pretreatability, ruminant digestibility, and cellulosytic enzyme hydrolyzability. Alkaline treatments, which are well-suited to the monocot grasses, have been utilized in this study to test the response between diverse maize towards alkali pretreatment. The cell wall composition and hydrophobicity of the lignified grasses cell wall have been altered by alkaline pretreatment and those properties are related with the enhanced enzymatic digestibility. In this study, water retention value (WRV) representing porosity and hydrophilicity and the other grasses cell wall properties including lignin, xylan and p-hydroxyphenylcinnamic acids, were determined for a maize diversity set containing 27 maize lines. The correlation between these cell wall properties have been cluster analyzed, and their contributions to the enzymatic hydrolysis yield have been compared by multivariate modeling. Additionally, high-throughput analysis techniques including pyrolysis molecular beam mass spectrometry (py-MBMS) was utilized in combination with chemometric models to both predict the cell wall properties including lignin content, p-coumaric and ferulic acids content, and hydrolysis yields.

*This work was supported by the Department of Energy through GLBRC project: BER DE-FC02-07ER64494*

**BAE-12 Effect Of Product Structure On Thermal Resistance Of Salmonella Enteritidis PT30 On Whole Almonds, In Almond Meal And In Almond Butter**

**Authors:** Pichamon Limcharoenchat; Bradley P. Marks; Ian Hildebrandt; Nicole Hall

**Abstract:** Almonds can be contaminated with Salmonella in the production environment. Subsequent valued-added processes change product structure, but the impact on pathogen thermal resistance has not been reported. The objective was to quantify the effect of product structure on thermal resistance of Salmonella Enteritidis PT30 inoculated onto whole almonds subsequently ground into meal and butter.

Almonds were inoculated with Salmonella Enteritidis PT30 (~10^8 CFU/g) and equilibrated to ~0.4 aw. After equilibration, almonds were ground in a food processor (45 s) to produce almond meal sized between U.S. standard sieves #20 and 80. Almond butter was produced by further milling almonds for 15 min, with dry ice added. All products were re-equilibrated. Inoculated almonds were individually vacuum-packed in thin layer plastic bags, and meal and butter samples were packed in aluminum test cells. Samples were heated in an isothermal water bath (~80°C), with almonds pulled every 10 min for 1 h, and others pulled every 15 min for 2.5 h; all were cooled immediately in an ice bath, diluted in peptone water, and plated on mTSA to enumerate survivors.

Initial Salmonella populations and sample water activities were not significantly different (P>0.05) after grinding and milling. However, D80°C values, determined by linear regression of the survivor curves, were greater (P<0.05) in almond meal (58.8 min) and almond butter (62.9 min) than on the whole almonds (17.9 min).

Changing the product structure significantly impacted Salmonella thermal resistance. Therefore, it is extremely important to use product-specific inactivation parameters when validating pasteurization processes.

*This work was supported in part by The U.S. Department of Agriculture, National Institute of Food and Agriculture, Award No. 2011-51110-30994.*
Abstract: Anaerobic Digestion (AD) is practical and efficient in utilizing various organic wastes, such as animal manure, municipal sludge, and food wastes, for production of biogas - an important energy alternative. However, liquid effluent from AD (Liquid AD effluent) remains high in biological oxygen demand (BOD), chemical oxygen demand (COD), as well as unpleasant smell and other nutrients (nitrogen and phosphorus). Appropriate treatments of liquid AD effluent are thus needed. To address this need, a multiple-stage AD effluent treatment and utilization process was developed to simultaneously reclaim the water from liquid digestate, and generate value-added algal biomass. The system starts with an optimization of electrocoagulation (EC) process, in regards of mass nutrients removal and turbidity improvement. An algal cultivation unit was then carried out using the EC effluent with significantly improved clarity to strengthen TN removal performance and accumulate algal biomass. This study integrated water reclamation from AD effluent, and algae cultivation to systematically address challenges of anaerobic digestion technology and advance its industrial applications.

This work was supported in part by DQY Agriculture Technology CO, LTD, China

Abstract: Prior work has suggested that bacterial transfer from produce to contact surfaces during slicing is affected by surface roughness, relative contact speed, distance, and normal force. However, mathematical models of these relationships have not been well developed, as prior studies typically tested overall transfer results, but did not elucidate single-variable effects. The objective was to quantify the effect of four physical variables on Salmonella transfer to stainless steel during slicing contact with potatoes used as the model product. Peeled potatoes were cut into 3-cm cubes, spot-inoculated with Salmonella Typhimurium LT2 (~6 log CFU/cm2), and then pulled (using a controlled speed-force machine) across a 304 stainless steel plate with variations in surface roughness (brushed vs. mirror finish), sliding speed (2, 5, 8 mm/s), total contact distance (20, 30, 180 cm), and additional mass placed on the product (30, 60, 90 g) to obtain different normal forces. After contact, Kimwipe® samples collected from the potato/stainless steel contact path were appropriately diluted and plated on modified trypticase soy agar to quantify Salmonella. Bacterial populations along the contact path were analyzed via a repeated measures statistical analysis. Greater transfer (P < 0.05) was seen to mirror-finished stainless steel. Overall, normal force did not significantly affect transfer, except at long contact distances; however, contact speed and distance impacted cumulative transfer (P < 0.05) for certain cases. For example, greater cumulative transfer (P < 0.05) occurred over 30 cm of contact at 5 mm/s than at 2 mm/s (420,000 vs. 190,000 CFU total). Quantifying the effects of individual physical variables is critical to the future development of bacterial transfer models and the refabricating/redesigning of fresh-cut processing equipment and related produce-handling operations to minimize cross-contamination.

Abstract: The rheological properties of saliva show large variation between individuals due to several factors such as age, dental status and type of food consumed. Differences in saliva viscosity may have an impact on food digestion when the food reaches the stomach, reducing mass transport of gastric acid into the bolus. The objective of this study was to determine the uptake of acid into rice boluses formed with saliva of varying viscosity. Simulated saliva viscosity was modified using guar gum (0%, 0.5% and 1%) and was mixed with white medium grain rice during a simulated mastication step. The bolus was introduced into a plastic syringe with one side opened and the other sealed, and incubated in simulated gastric juice at 37°C. Bolus acidity was measured by titration after 2 to 60 hours of incubation (6 time points). Acidity values for boluses with 0% 0.5%, 1% guar gum were 0.18±06, 0.27±0.09, and 0.31±0.09 mg HCl/g dry matter after 2 hours, respectively. After 60 hours, boluses made with saliva with 0%, 0.5% and 1% guar gum had an acidity of 5.17±0.54, 5.37±0.27, 4.95±0.27 mg HCl/g dry matter, respectively. The overall acidity was significantly influenced by time (p < 0.0001), and the time x guar gum interaction (p = 0.0015). The level of guar gum did not significantly influence the overall acidity (p<0.0842). Although saliva viscosity did not significantly influence mass transport of gastric acid, future studies need to be done to determine the role of gastric juice viscosity during digestion.
**BAE-16 Recovery of Bacillus Anthracis Spores From HVAC Filters Using Two Quantification Techniques**  
**Authors:** Bharathi Murali; Jade Mitchell;

**Abstract:** Understanding the ability of microorganisms to adhere on fomite surfaces is an important component in modeling their recovery and ultimately the risk they pose. For example B. anthracis, the endospore forming Category A biothreat agent that is frequently found in nature, can pose a high biological threat in indoor air and on surfaces. The spores have been found to be extremely resistant to environmental stresses, and are stable over decades. Microbial recovery of spores from HVAC filters, an example of a porous fomite media, which can capture a significant quantity of microorganisms when there is an attack of bioterrorism, is investigated. Since these filters have been found to become distribution conduits in the entire building, in the event of a bio-attack, experimental studies can help identify appropriate recovery factors which may subsequently inform studies on persistence. This study specifically investigates the recovery of B. anthracis over time with culture-based and molecular-based quantification techniques. Twofold quantification was found to be significant when considering recovery efficiency to distinguish between the live and dead counts. Further research on the recovery of Bacillus spores could explain the differences in factors that affect adhesion on porous surfaces. Our analysis demonstrates the importance of understanding the variability in recovery over time and the selection of quantification methods for studies measuring persistence.

Keywords: Bacillus anthracis, anthrax, biothreat agents, microbial recovery

*This work was supported in part by the Center for Advancing Microbial Risk Assessment (a jointly funded Center of Excellence by the U.S. EPA and the Department of Homeland Security)*

**BAE-17 Climate-Smart Agriculture For Enhanced Food Security**  
**Authors:** Melissa Rojas-Downing; A. Pouyan Nejadhashemi

**Abstract:** There is a need to increase agricultural production by 70 percent by 2050 due to projections of population growth. In addition, rapid urbanization threatens the existing agricultural lands. Meanwhile, several estimates indicate that climate change could significantly reduce agriculture production, especially in the most food insecure regions of the world. Therefore, there is need to increase agricultural production on less land and under less reliable and harsher climatological conditions. In addition, in order to promote sustainable agriculture and food production there is a need to use less energy, fertilizer, and pesticide without invading the most sensitive ecosystems and protecting water quality. In 2009 the Food and Agriculture Organization defined “Climate Smart Agriculture” as “agriculture that sustainably increases productivity, resilience, reduces or removes Greenhouse Gases, and enhances achievement of national food security and development goals”. The goal of this study was to evaluate the existing methods and technologies for producing more food on less land, using less water, energy, fertilizer and pesticides while protecting the environment. Comprehensive literature-review was performed in different area of concerns including land management, integrated nutrient management, pest control, water conservation, and energy use efficiency. Each practice was evaluated based on productivity impacts, climate adaptation benefits and greenhouse gas emissions mitigation criteria. Overall the performance of different techniques varies on different regions. Under application of the most sustainable techniques, dry areas present more resilience and humid areas show higher mitigation potential to climate change, while the impacts on yield will vary by adopted techniques.

**BAE-18 Microbial Lipid Production From Combined Corn Stover Hydrolysate By Oleaginous Fungus For Advanced Biofuel Production**  
**Authors:** Zhenhua Ruan; Michael Zanotti; Wei Liao; Yan Liu

**Abstract:** A combined hydrolysis process, which first mixed dilute acid- and alkali-pretreated corn stover at a 1:1 (w/w) ratio, directly followed by enzymatic saccharification without pH adjustment, has been developed in this study in order to remove steps of neutralization, detoxification, and washing during the process of lignocellulosic biofuel production. The oleaginous fungus M. isabellina was selected and applied to the combined hydrolysate as well as a synthetic medium to compare fungal lipid accumulation. Fungal cultivation on combined hydrolysate exhibited comparable cell mass and lipid yields with those from synthetic medium, indicating that the integration of combined hydrolysis with oleaginous fungal lipid fermentation has great potential to improve performance of advanced lignocellulosic biofuel production.
BAE-19  Effect Of Rapid Desiccation On Thermal Resistance Of Salmonella In Wheat Flour
Authors: Danielle Smith; Bradley P. Marks

Abstract: Salmonella is able to survive in low moisture environments, and has been shown to become more resistant to heat as the water activity (aw) of the product decreases. However, it is unknown how rapidly the resistance changes if the product water activity is rapidly altered. Wheat flour was inoculated with Salmonella Enteritidis PT30 then divided into three treatment groups. Groups A and B were equilibrated over ~4 d in controlled-humidity chambers to 0.6 and 0.3 aw, respectively. Group C was equilibrated to 0.8 aw, then rapidly dried to 0.3 aw (< 4 min), using desiccated room temperature air in a small fluidized bed drying system. Samples then immediately (within ~1 min) were isothermally treated (80°C) in aluminum test cells, immediately cooled in ice water, serially diluted, and plated on modified trypticase soy agar with yeast extract for enumeration of survivors. D-values were calculated and compared via ANOVA. The rapidly desiccated group (C) and the group initially equilibrated to 0.3 water activity (B) were not significantly different (P > 0.05), but both were significantly greater than for the group initially equilibrated to 0.6 water activity (P < 0.05). Salmonella in the rapidly desiccated flour (0.3 aw) was as thermally resistant as that which previously had been equilibrated to 0.3 aw. These results suggest that the observed enhanced thermal resistance of Salmonella at lower aw is a state function that requires negligible adaption time.

This work was supported in part by USDA-NIFSI

BAE-20  Impacts Of Climate Change On Stream Ecosystem Integrity
Authors: Sean A. Woznicki; A. Pouyan Nejadhashemi; Yaseen Hamaamin

Abstract: Anthropogenically-driven climate change is projected to alter water resources and aquatic ecosystems. Changes in the hydrological behavior of streams and increased magnitudes of nonpoint source pollution concentrations negatively impact ecological components of streams, such as fish and macroinvertebrates. While it is important to understand the consequences of climate change on aquatic ecosystem health, it is imperative to identify the quantitative risk of these consequences. By recognizing the risk of adverse impacts to aquatic ecosystem health locally and regionally, adaptation strategies can be prioritized. This study examines the potential impacts of changing climate on aquatic ecosystem integrity by coupling climate models, a watershed/water quality model, and ecological models. Statistically downscaled daily climate data from ten coupled atmosphere-ocean general circulation models (AOGCMs) driven by four IPCC SRES storylines (A1F1, A1B, A2, and B1) are used with a high-resolution Soil and Water Assessment Tool (SWAT) to develop information on projected future hydrology and water quality for the River Raisin Watershed in Michigan. In-stream hydrological and water quality data were then used to predict fish and macroinvertebrate measures of stream health based on biological sampling data. Ecological model development was performed using adaptive neuro-fuzzy inference systems (ANFIS). Best models were selected by prediction of stream health measures at biological sampling locations and extended to all streams in the watershed. Through the use of several AOGCMs, emissions scenarios, and stream health measures, we develop multiple projections for the risk of deteriorating aquatic ecosystem integrity due to climate change at local stream and watershed scales.

BAE-21  A Self-Sustaining Advanced Lignocellulosic Biofuel Production By Integration Of Anaerobic Digestion And Aerobic Fungal Fermentation
Authors: Yuan Zhong; Zhenhua Ruan; Steven Archer; Yingkui Zhong; Yan Liu; Wei Liao

Abstract: Microbial biodiesel production from lignocellulosic materials has gained intensive attention in recent years. However, the high energy input, particularly during the aerobic fungal fermentation stage, is hindering the development and application of the technology. Renewable energy sources from organic wastes could be a good solution to satisfy the energy demand and sustain the microbial biodiesel production. Anaerobic digestion (AD), a biological conversion process to convert organic residues into renewable energy, was applied in this study to convert organic wastes into bioenergy to power microbial biodiesel production. Besides providing the required energy, anaerobically digested fiber (AD fiber), a major output stream in AD process, has been proven to be a promising feedstock to be mixed with other lignocellulosic materials for biodiesel production. In this study, corn stover, dairy manure, and food wastes were used as feedstocks for both anaerobic digestion and aerobic fungal fermentation to sustainably produce biodiesel. Dairy manure and food waste were anaerobically digested to produce energy and AD fiber. AD fiber and corn stover were then processed by a combined alkaline and acid hydrolysis followed by a fungal fermentation to produce biodiesel. Based on the experimental results, a comprehensive mass and energy balance was also conducted and a self-sustaining lignocellulosic biodiesel production process was concluded.

This work was supported in part by Strategic Environmental Research and Development Program (SERDP), United States Department of Defense
CHE-01  
**Toughening Of Aromatic Epoxy Polymers For Fiber Reinforced Composite Matrices Via Aliphatic Epoxy Copolymers**  
**Authors:** Markus A. Downey; Lawrence T. Drzal

**Abstract:** Epoxy polymers play an important role in many modern day applications. Their high strength-to-weight ratio and corrosion resistance make them especially desirable materials for high-performance structural applications in a fiber-reinforced composite (FRP). A significant limitation with epoxy polymers is their inherent low toughness due to the lack of a crack arresting mechanism. While toughening bulk epoxies can be achieved through numerous mechanisms, in order to make the toughening useful for FRP properties such as strength, modulus and glass transition temperature cannot be detrimentally affected. Additionally, the proposed toughening mechanism needs to be compatible with current manufacturing processes, such as resin transfer molding. In this work, the addition of aliphatic epoxy copolymers to the aromatic epoxy was investigated. Both epoxies undergo the same amine reaction to form a highly cross-linked network. The more flexible aliphatic chain of the aliphatic epoxy absorbs more energy prior to fracturing while the stiffer aromatic chain provided high modulus. The resulting aromatic/aliphatic epoxy polymer showed substantially increased impact toughness without major losses in flexural properties. At these low concentrations of aliphatic epoxy, the glass transition temperature is also only slightly reduced. Since these two epoxies form a miscible system, this approach to increasing the toughness should be applicable for FRP produced with all current manufacturing processes and represents an important building block as the matrix for fiber-reinforced composites.

*This work was supported in part by General Electric Aviation*

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CHE-02  
**Composition Dependence Of Glucose Oxidation At Mediated Glucose Oxidase Bioanodes**  
**Authors:** Yira Feliciano; Scott Calabrase Barton

**Abstract:** Research in Enzymatic biofuel cells holds significant technological promise for sustainable energy generation by combining renewable catalysts with fuel flexibility. In the past decade, research interest has grown due to potential applications such as biosensors, portable electronics, and implantable power. However, the limitations of enzymatic biofuel cells for such applications are low stability of the electrode and low current density. Our previous work describes the optimization of mediator redox potential for a laccase-catalyzed oxygen reduction electrode. This result leads us to our current research, focused on composition dependence of the electrode structure, in terms of the balance between loadings of enzyme and mediator. The electrode under study is a modified with a film consisting of glucose oxidase with poly(N-vinyl-2-pyrrolidone)[Os(bpy)2Cl]+/2+. An optimum glucose conversion current density is found at 40 wt% GOx, where the catalytic and electron transport properties are balanced. A mathematical model is used to estimate the limits of current density. This model incorporate film thickness, which is one of the important parameter that affects the performance of the redox polymer mediated enzyme electrodes by affecting the mobility of the redox active centers and the species transport. The outcome of this study will be improved quantitative understanding of mediated enzyme electrode behavior, applicable to engineering of biofuel cells.

*This work was supported in part by Sloan and the U.S. Dept. of Education GAANN fellowship.*

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CHE-03  
**Correlating Surface Properties To Nonspecific Binding: GFP As A Tag In Lignocellulosic Biofuel Production**  
**Authors:** Carolyn Haarmeyer; Tim Whitehead

**Abstract:** The deconstruction of lignocellulosic plant matter into fuels like alcohols is an important area of renewable energy research. To produce fuels from plant mass, lignocellulosic biofuel production includes pretreatment, which breaks down plant cell walls, enzymatic hydrolysis, which uses enzymes to convert carbohydrates into simple sugars, fermentation, which converts these sugars into alcohols, and downstream purifications. Lignocellulosic biofuel production can be made more cost efficient by increasing the recyclability of the cellulases that hydrolyze cellulose into sugar. These cellulases nonspecifically adsorb to lignin, a biological polymer that reinforces plant cell walls. This adsorption step irreversibly inactivates these cellulases. To understand why this nonspecific binding occurs, we will correlate a quantifiable surface property of proteins (like these cellulases) to lignin binding. As a model system, we have chosen to use enhanced green fluorescent protein (eGFP) as a proxy for these cellulases, as eGFP readily adsorbs to lignin, and it can readily be quantified in solution by visible fluorescence. Mutant eGFP variants from these libraries will be selected based on surface properties and will be characterized for their binding affinity to lignin. Comparisons of experimental results to theoretical predictions like DLVO theory will be made. This unprecedented wealth of information will be used to design new cellulases that resist lignin-mediated inactivation.

*This work was supported in part by National Science Foundation*
CHE-04  **Graphene Nanoplatelet Based Polymeric Nanocomposites With Enhanced Barrier Properties**  
*Authors:* T. Honaker-Schroeder; F. Vautard; L. Drzal; L. Sui

**Abstract:** Polymer matrix nanocomposites are gaining increased interest because of their ability to add or enhance a variety of different properties when compared to the base polymer matrix, including mechanical, electrical, thermal, and barrier properties. A particular nanoparticle that shows promise in enhancing all four of those properties at a low concentration is a Graphene nanoPlatelet (GnP). GnP can be produced with diameters ranging from 0.3 to 25 microns, and thicknesses between 2 and 6 nanometers. If GnP is added to a cost effective polymer matrix such as high density polyethylene (HDPE), the large aspect ratio of the GnP can form a tortuous path that is impermeable to the transport of small molecules. This GnP nano-composite could be used for the manufacture of structures such as gas tanks and fuel lines in motor vehicles, also potentially reducing the weight of the vehicles.

In this study, concentrations of GnP from 0.2 to 15 percent weight in HDPE have been investigated for three different nanoplatelet diameters between 0.3 and 15 microns. Additionally, two processing methods have been employed, melt mixing and microlayer co-extrusion. It was found that the addition of GnP greatly improved the barrier properties of HDPE, along with increasing the stiffness of the material. While the ultimate strength remained similar for all concentrations, the impact resistance decreased with increasing GnP concentration. The thermal stability of the composite was also improved but the percolation threshold was not achieved due to limited dispersion of the platelets yielding no increase in electrical conductivity.

*This work was supported in part by Hyundai-Kia America*

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CHE-05  **Nano-Scale Homogenization Of Bio-Based PLA/Cellulose Composites In One-Step Emulsion Process**  
*Authors:* Shaowen Ji; Jue Lu; Ankush Gokhale; Anna Song; Jason M. Thompson; Ilsoon Lee

**Abstract:** Cellulose fibers from renewable bioresources have been widely studied as one of the natural-organic fillers for the development of bio-based polymer composites, due to their impressive physical and mechanical properties as well as the biodegradable nature. In the green composite field, the use of nano-sized fillers is gradually replacing for traditional micro-sized ones, which leads to significant improvement of final properties. The major obstacle for the fabrication of these bio-composites is the difficult dispersion and poor interfacial adhesion of hydrophilic nanomaterials from renewable bioresources in the organic solvent or hydrophobic polymer matrix. Our technology has been developed to improve the production of bio-based polymer composites (e.g. PLA) with the uniform dispersion of hydrophilic nanomaterials and enhanced performance in the nano-scale by manipulating the old fashioned emulsion process. The key is to form water-in-oil-in-water type multiple emulsions instead of conventional oil-in-water ones via a fast dynamic nano-mixing process based on the single emulsion method. By utilizing the inner aqueous space, hydrophilic nanoparticles or molecules can be encapsulated in the polymer matrix. The production of PLA micro/nano-particles with controlled size and shape can be well achieved by this technology in a much reduced time of up to 2 min and mild operation conditions. The emulsion method is one of the oldest industrial processes and abundant experience for scale-up and commercialization can be used for reference from existing manufacturing productions.

*This work was supported in part by MIIE, URC*

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CHE-06  **Interlaminar Reinforcement Of Glass Fiber/Epoxy Composites With Graphene Nanoplatelets (GnP)**  
*Authors:* Nicholas T. Kamar; Mohammad Hossain; Al Loos; Lawrence T. Drzal

**Abstract:** Incorporation of carbonaceous nanomaterials into fiber-reinforced/epoxy composites (FR/EP) has been shown to improve a variety of intralaminar mechanical properties. Our research investigated the ability of graphene nanoplatelets (GnP) to improve the interlaminar properties of glass reinforced multilayer composites. We developed a novel method for the inclusion of GnPs into plain-weave glass fabric fiber-reinforced/epoxy composites processed with vacuum assisted resin transfer molding (VARTM). Pristine GnPs are dispersed in a solvent solution of diglycidyl ether of bisphenol A epoxy resin and then uniformly coated onto the surface of glass fabrics at different concentrations prior to laminate stacking. The sizing/GnP combination adheres to the glass fabric and allows full resin infusion using a conventional VARTM processing method. Subsequently, four-point bending test results on the cured laminate produces a 29% improvement in flexural strength with the addition of only 0.25 wt% GnP compared to the pristine glass FR/EP. At the same loading, mode-I fracture toughness testing revealed a 25% improvement. Significant improvements were also obtained in low velocity drop-weight impact properties. Analysis of the composite samples after impact testing with ultrasonic c-scans and dye penetration tests showed less damage resulted in the composite. The c-scan images revealed that both interfacial and through-the-thickness damage decreased with addition of GnP contents. Interestingly, dye penetration tests indicated that impacted surface damage decreased, but back surface damage increased with addition of GnPs. The mechanisms by which the GnP improves the impact properties of the multilayer composites will be discussed.

*Abstracts of the 2014 Engineering Graduate Research Symposium, Michigan State University*
Abstract: Comprehensive sequence-function mapping can be used to optimize enzyme catalysis and protein binding. Next-generation sequencing of mutant libraries provides millions of sequencing reads. Comparing how often a given mutant appears before and after selection provides a measure of that mutant’s fitness. This method has previously been limited to mapping short stretches of amino acid sequence [1]. Here we extend this method to allow mapping of entire protein sequences through the use of a modular, universal PCR amplification method. We have extended the deep sequencing derived sequence-function maps to proteins of arbitrary size. Both growth and yeast display systems can be used to select for mutants with enhanced functionality. Analytical solutions to normalize data over separate populations allows for the multiple mutant protein libraries to be independently selected. Because of this, we can map the sequence-function space for proteins 800 residues using a single 150 bp PE MiSeq sequencing reaction. We are no longer limited by the length of the protein but rather by the amount of sequencing data we can obtain.


This work was supported in part by National Science Foundation under award No. CBET-1254238

Abstract: Proton exchange membrane fuel cells (PEMFCs) have long been thought of as an alternative to internal combustion engines in the transportation industry, but cost, particularly of precious metal catalysts, has impeded commercialization. Catalysts based on pyrolyzed metal/nitrogen/carbon (MNC) compounds are one less expensive alternative. These non-precious metal catalysts generally require higher mass and volume loadings. In this work we explore the impact of these higher loadings by modeling key transport phenomena within the cathode catalyst layer of a PEMFC with a non-PGM catalyst. A gas/liquid transport system that takes into account hydrophobicity, porosity, and evaporation is coupled with kinetics and conductivity to model the transport phenomena within the cathode. The gas/liquid transport system is treated via a two-phase porosity model that calculates saturation, liquid permeability, and effective diffusivity as a function of liquid pressure and constituent fluxes within the cathode. The combination of the various transport phenomena impact the kinetics via a Tafel model, and the various impacts of water, oxygen, proton, and electron transport on performance can be calculated. The model captures key experimental parameters that have been shown to influence electrode performance, and will be used to explain experimental observation and guide further optimization.

This work was supported in part by the U.S. Department of Energy (EERE), under a Non PGM Catalyst development effort (Contract no EE 0000459) led by Northeastern University (Sanjeev Mukerjee, P.I.).

Abstract: We previously developed the alkaline peroxide pretreatment catalyzed by copper-diimine complexes, which significantly increases the enzymatic digestibility of a range of herbaceous and woody feedstocks including switchgrass, prairie cordgrass as well as hybrid poplar. Under mild operation conditions (room temperature and ambient pressure), the maximum efficacy of the pretreatment can be achieved with less than one hour of reaction time. Mechanistic studies of the catalytic oxidation reveal disruption of cell wall layers, which is associated with lignin removal and cellulose oxidation. We optimized the key parameters during pretreatment and enzymatic hydrolysis, which produces hydrolysate from recalcitrant hammer-milled hybrid poplar with >80% yield of monomeric sugars. Fermentation studies indicate that the hydrolysate from hybrid poplar can easily be fermented to ethanol, regardless of the toxicity from the residual copper catalyst in the hydrolysate. The severity of the toxicity can be alleviated by a simple process of catalyst recovery prior to fermentation, or by using lower amount of an improved less-toxic catalyst during pretreatment. LCMS analysis of the hybrid poplar hydrolysate has demonstrated the presence of monomeric lignin fragments including vanillin, syringic acid and p-hydroxybenzoic acid, which as aromatic by-products add to the overall profitability of the biorefinery process. Further investigations of the lignotoxins in the hydrolysate have provided more important information on hydrolysate toxicity as well as valuable guidance for the future optimization of yeast strains.

This work was supported in part by Department of Energy Great Lakes Bioenergy Research Center (DOE BER Office of Science DE-FC02-07ER64494)
Effect Of Static Pre-Stretch Induced Surface Anisotropy On Orientation Of Mesenchymal Stem Cells

Authors: Chun Liu; Jungsil Kim; Seungik Baek; Christina Chan

Abstract: Mechanical cues in the cellular environment play important roles in guiding various cell behaviors, such as cell alignment, migration, proliferation, and differentiation. Numerous studies have shown that mechanical cyclic stretch can induce cells to align perpendicular to the stretch direction, while relatively fewer studies focus on static stretch. However, almost all of the previous studies of static stretch were post-stretch, which means the cells were first seeded to allow attachment and then the substrate subsequently stretched. In contrast, we create a static pre-stretched anisotropic surface in which the cells are seeded after the substrate is stretched. The results show that cells align in the direction of pre-stretch, which is induced by the anisotropy that can be predicted by the theory of finite elasticity.

The experimental results agreed with a “Cell mechano-active sensing” model, which suggests that the cells can sense and respond to surface anisotropy by orienting in the direction of maximal effective stiffness. In this study we employed a theory of “small deformation superimposed on large” to predict the anisotropy induced by the uniaxial pre-stretch. After a 10% uniaxial pre-stretch, the effective stiffness that the cells sense in the stretched direction is 1.33 times of that in the perpendicular direction. Next, we explored the impact of pre-stretch magnitude on cell orientation angle distribution. Cells (mesenchymal stem cells or primary neurons) seeded on poly-L-lysine coated PDMS membrane surfaces with 10%, 20%, or 30% pre-stretch were quantified after 4 days of culture for their cell orientation angles. The results showed that the ratio of cells that orient parallel (within ±10°) increased with the magnitude of the stretch.

In summary, we demonstrated that cells aligned on static pre-stretched anisotropic surface, and the number of cells that aligned in parallel orientation increased with the pre-stretch magnitude. Besides alignment of MSCs, we investigated the impact of pre-stretched surface on axonal growth and orientation. The results showed that axonal alignment also increased with the pre-stretch magnitude and a larger pre-stretch can promote thicker and longer axonal growth.

This work was supported in part by the National Science Foundation (CBET 0941055), the National Institute of Health (R01GM079688, R01GM089866).

Separation Of Perchlorate Ions By Polyelectrolyte Multilayer Membranes

Authors: Oishi Sanyal; Anna Sommerfeld; Ilsoon Lee

Abstract: Perchlorate ion has been recently identified as a harmful contaminant in drinking water. It competes with iodine ion during its uptake by the thyroid gland thereby inhibiting the formation of thyroid hormone. In average its maximum allowable concentration is 6 ppb. Being a monovalent ion the most effective membrane operation which is suitable for its rejection is reverse osmosis (RO). A major disadvantage of desalination processes is the extreme high pressure requirement which is due to the inherent low flux offered by such membranes. We therefore modify a nanofiltration (NF) membrane such that its rejection is similar to that of desalination membrane but the flux remains higher than the latter. The surface modification technique used is called the layer-by-layer (LbL) assembly. This technique involves the deposition of alternately charged polyelectrolytes on a surface to form polyelectrolyte multilayers and allows the formation of nanothin films. Layering of such nanothin films on the surface of NF membrane helps in reduction of porosity of the membrane which in turn leads to size-based exclusion of ions. The performance of the modified membrane has been tested against a commercial RO membrane under cross flow conditions. The perchlorate concentration of the feed and permeate samples are measured using LC-MS/MS technique in order to evaluate the membrane rejection. The effects of various conditions on these membranes which include transmembrane pressure and cross flow velocity are currently being tested. This work is primarily focused on perchlorate ion but it can be extended to several other monovalent ions.

This work was supported in part by DOD SERDP

Investigation Of Na2/3[Ni1/3Ti2/3]O2 As A Layered Electrode Material For Na-ion Batteries And The Effect Of Manganese Substitution On The Electrochemical Properties

Authors: Rengarajan Shanmugam; Wei Lai

Abstract: Na-ion batteries have emerged as promising low cost, alternative rechargeable battery chemistry, currently being targeted towards large-scale electrical energy storage that is critical for increased penetration of renewable energy sources and stabilizing the power grid. Na-ion batteries essentially work on the principle of storing charge by ion intercalation into host materials, like Li-ion batteries. Sodium chemistry is more attractive because of wide availability of inexpensive sodium mineral resources. We have demonstrated the reversible sodium intercalation/de-intercalation in a new class of layered oxide materials with composition Na2/3[Ni1/3Ti2/3]O2 using a non-aqueous electrolyte. This material can be used as a bi-functional electrode using Ni2+/3+ and Ti4+/3+ redox couples that have average $E_0$ values of 3.6 and 0.7 V, respectively. Studies are underway to investigate the effect of partial manganese substitution, in the ‘2a’ sites of the transition metal layer, on the intrinsic electronic conduction and the electrochemical properties.
**CHE-13 Influences On Hemicellulose Dissolution And Enzymatic Hydrolysis Yield After The Soda Pulping Of Hardwoods**  
**Authors:** Ryan J. Stoklosa; David Hodge

**Abstract:** The development of an economical and sustainable biomass conversion industry is inherently tied to the transportation logistics of the feedstocks, capital equipment costs for processes, and high titer yields of sugar for conversion. As a way to decrease the costs associated with commercialization, the pulp and paper industry can offer an already developed infrastructure with regards to feedstock transportation and process equipment. This research evaluated alkali impregnation followed by soda pulping of three hardwoods and the associated effect on the dissolution of hemicellulose, and the yields of monomeric sugars from enzymatic hydrolysis after pulping. Soda pulping trials were conducted in a pressurized digester at 170°C for one hour for all three hardwoods. The severity of the pulping trial was quantified with the H-factor relationship where time and temperature are combined into a single variable to express the rate of delignification. Two other severity conditions were applied to a hybrid poplar feedstock (Populus nigra x maximowiczii cv. NM6) to see if temperature or time during pulping can contribute to higher sugar yields from enzymatic hydrolysis. The dissolution of hemicellulose increased during the heat up phase of the pulping trial, but at the start of the constant temperature phase the hemicellulose amount decreased; this was attributed to polysaccharide degradation to saccharinic acids. High yields of glucose (> 80%) were achieved after enzymatic hydrolysis for all pulped feedstocks. Sugar yields were also compared based upon enzyme loading and particle size of the pulped substrate.

*This work was supported in part by Northeast Sun Grant Initiative*

**CHE-14 Engineering Delivery Vehicles For SiRNA Therapeutics**  
**Authors:** Daniel Vocelle; Georgina A. Comiskey; Olivia Chesniak; Stephen Lindeman; Sean Norton; Amanda Phillips; Christina Chan; S. Patrick Walton; Milton R. Smith

**Abstract:** Given the limitations of small molecule and protein based drugs, new therapeutic approaches are needed for treating disease-associated proteins. One potential candidate, short interfering RNA (siRNA) therapeutics, is capable of highly specific targeting for a wide range of proteins. With the assistance of target specific delivery vehicles, siRNAs are transported from an extracellular environment into the cytoplasm of eukaryotic cells. Utilizing the RNA Interference (RNAi) pathway, siRNA degrades sequence specific messenger RNA (mRNA) and reduces target protein expression. siRNA therapeutics have been developed for cancers, genetic disorders, and infectious diseases, but currently are still awaiting FDA approval. siRNA therapeutics are currently limited by their dependency on inefficient delivery vehicles. Within in vivo models, vehicles are restricted by poor delivery, in addition to issues of toxicity and immunogenicity. While many types of delivery vehicles have been developed, there is little consensus regarding the mechanisms or characteristics essential for delivery. Using silica nanoparticles, delivery criteria can be investigated among four main categories: siRNA binding affinity, membrane translocation, biodistribution, and protein suppression. Wherein, the effects of vehicle size, structure, charge, and functionalized surface can be characterized. Our current data indicates an optimal binding affinity and the presence of dextran facilitates active silencing. Particle endocytosis exhibits preferential accumulation within the lysosome, causing complex dissociation, particle degradation, and eventually exocytosis. While achieving silencing comparable to those of commercially available reagents, dextran functionalized silica nanoparticles have an increased rate and onset of silencing, a 10 fold increase in the amount of siRNA delivered to the cell, and no observable toxicity.

*This work was supported in part by the National Institutes of Health (#GM079688, #RR024439, and #GM089866), MSU Foundation, National Science Foundation (CBET 0941055), MUCI, and the Center for Systems Biology*

**CHE-15 Cell Wall Hydrophilicity Impacts On Enzymatic Digestibility For Alkaline Hydrogen Peroxide Pretreated Grasses**  
**Authors:** Dan Williams; David Hodge

**Abstract:** Treatment of biomass with alkaline hydrogen peroxide (AHP) can be used as a chemical pretreatment or alternatively as a post-treatment. This work will present research results of AHP pretreatment used as a post-treatment for liquid hot water (LHW) pretreatment as a delignifying step. The effect of AHP on the carbohydrate and lignin compositional changes after pretreatment and fiber swelling behavior of corn stover and switchgrass will be shown as a function of hydrogen peroxide loading as well as the formation of potential fermentation inhibitors. We hypothesize that the digestibility improvement resulting from AHP pretreatment may be attributed to mild oxidation or solubilization of the lignin remaining in the cell wall and, for grasses, destruction of ferulate crosslinks between cell wall polymers which would have the net effect of increasing the hydrophilicity to allow improved water and enzyme penetration into the cell wall. To test this hypothesis, we will correlate the hydrophilicity of the cell wall as measured indirectly by lignin and cell wall carboxylic acid content to water swelling capacity, water activity at limiting free water, and digestibility.

Abstracts of the 2014 Engineering Graduate Research Symposium, Michigan State University 14
Abstract: Biofilms are notorious for their strong immune defense, high tolerance to antibiotic treatment and difficulty in clearance. It has been found that biofilms are responsible for about 65% of infections happened in hospital, leading to more than 500,000 deaths, 17 million infections and $94 billion medical expense annually in the United States alone. Recently, a series of novel benzimidazole molecules have been developed as anti-biofilm compounds (ABCs). Thus, new types of anti-biofilm coatings can be designed with the incorporation of ABCs. Polyelectrolyte multilayers (PEMs) have been considered as a versatile platform for antibacterial surface design. In order to create anti-biofilm coatings and achieve controlled release, porous poly(acrylic acid) (PAA)/poly(allylamine hydrochloride) (PAH) multilayers have been fabricated. 5-methoxy-2-[(4-methylbenzyl) sulfanyl]-1H-benzimidazole (named ABC-1) molecules were incorporated into the porous multilayers via evaporation method since ABC-1 can be dissolved in ethanol. During the evaporation, ABC-1 molecules were condensed and diffused into the porous multilayers at the same time, leading to an optimization of ABC-1 loading. The porous structure of the multilayer is critical to the amount of ABC-1 incorporated and the release profile. Completely different porous structures can be achieved by adjusting pH for porous treatment, using different cross-linking methods, and changing molecule weight of PAH. By tuning the porous structure, the release of ABC-1 can be controlled. It has already been found about 99% of V. cholerae biofilm formation was suppressed by this type of anti-biofilm coatings.

Abstract: Luminescent solar concentrators are regaining attention as low-cost solar harvesting systems around the building envelope. However, the visible absorption and emission of previously demonstrated chromophores result in highly colored systems that hamper their widespread adaptability in many applications including solar windows. Here, we demonstrate transparent luminescent solar concentrators (TLSC) that employ ultraviolet (UV) or near-infrared (NIR) absorbing lumiphores for selective light harvesting that creates an entirely new paradigm for power-producing transparent surfaces. In the first configuration, we have designed systems composed of metal halide phosphorescent luminophore blends.[1] these nanoclusters enable selective harvesting of UV photons with absorption cutoff positioned at the edge of visible spectrum (430nm) and massive-downconverted emission in the near-infrared (800nm) with quantum yields for luminescence of 75%. Through experiment and modeling, we show that this architecture can be scaled up to areas > 1 m2 with a power conversion efficiency of 1-2% due to the massive luminescent downconversion. We have also developed transparent luminescent solar concentrators employing fluorescent organic salts with both efficient NIR absorption and emission that allow for efficiencies > 4-5%. The moderately low Stokes shift of these systems is overcome by embedding spatially segmented solar cell arrays throughout the waveguide, leading to minimal reabsorption losses. We will discuss the photophysical properties of both classes of luminophores, the impact of ligand-host control, and optimization of the TLSC architectures.

This work was supported in part by National Science Foundation (CAREER award, CBET-1254662).
CE-01  **Evaluating Residual Capacity Of Reinforced Concrete Beams Exposed To Fire-An Approach**  
**Authors:** Ankit Agrawal; Venkatesh Kodur  

**Abstract:** Reinforced concrete (RC) structural members exhibit high fire resistance due to relatively low thermal conductivity, high thermal capacity, and slower degradation of mechanical properties of concrete with temperature. Also, owing to advancements in active fire protection systems and fire-fighting strategies, complete collapse due to fire is rare. In most cases, RC structural members retain much of their structural capacity after a fire incident. However, this does not ensure safety of the building for immediate reoccupation after fire is extinguished. Unlike fire induced spalling, which is a visible sign of damage, structural deterioration due to degradation of mechanical properties at elevated temperatures and redistribution of stresses within the member is not too apparent. Thus, it is imperative to ascertain the residual capacity of structural members through rational engineering methods. Such an assessment would be indispensable for subsequent retrofitting strategies as well. This study is aimed at developing an approach for assessing residual capacity of fire exposed reinforced concrete beams. For this purpose, response of normal strength concrete (NSC) beams 3.96 m in span and of rectangular cross section has been simulated using finite element package ABAQUS under standard and design fire scenarios. Data from the numerical studies is being used to develop a simplified approach based on maximum experienced rebar temperatures and post fire residual deformations that can be applied in practice to evaluate residual capacity of fire exposed RC beams.

CE-02  **Intelligent Structural Damage Detection Using Data From Self-Powered Wireless Sensor**  
**Authors:** Amir H. Alavi; Hassene Hasni; Nizar Lajnef; Karim Chatti  

**Abstract:** In the last decade, significant attention has been devoted to the utilization of new sensing technologies for structural health monitoring. The complexity of analysis of the valued information offered by such smart sensor technologies implies the necessity of developing robust interpretation approaches. This study presents a new methodology for the structural damage detection based on the simulation of the compressed data stored in memory chips of self-powered wireless sensors. An innovative data interpretation system integrating finite element method and probabilistic neural network based on Bayesian decision theory is developed for damage detection. Several features extracted from the cumulative limited static strain data are used as damage indicator variables. Another important contribution of this study is to define effective indicator variables that simultaneously take into account the effect of array of scattered sensors. This enables the method to detect damage at any location in a structure with a sparse distribution of the sensors. The performance of the proposed approach is evaluated for the case of U10 gusset plate of the I-35W Bridge in Minneapolis, Minnesota at the time of the bridge collapse. The gusset plate is analyzed as a 3D FE model utilizing the ABAQUS computer software. A detailed uncertainty analysis is performed through the contamination of the damage indicator features with different Gaussian noise levels. The results indicate that the proposed method is efficiently capable of detecting different damage states in spite of high-level noise contamination.

CE-03  **Effect Of High-Temperature Creep On Response Of Reinforced Concrete Structures**  
**Authors:** Saleh Alogla; Venkatesh Kodur  

**Abstract:** Concrete structures when exposed to high temperatures undergo significant deformations due to the development of mechanical and thermal stresses. Thermal stresses play a major role in changing the deformation behavior of concrete since they induce thermal and transient strains, and amplify creep and load induced mechanical strains in concrete and steel reinforcement. It is hypothesized that creep strains primarily govern the failure of concrete structures when exposed to high temperatures above 500 °C commonly encountered in fire. While the characterization of thermal and mechanical strains is well established for different concrete types, there are limited studies on high-temperature creep and transient strains. Available concrete creep and transient strain models have numerous drawbacks and indicate significant variability. Furthermore, most of the creep models are based on tests conducted in 1970’s and 1980’s, and do not represent current concrete mixes used in practice. To overcome these limitations, experimental studies are currently underway to characterize high-temperature creep and transient strains of different concrete types. Data from uniaxial compression tests on concrete cylinders is being utilized to develop constitutive models for high-temperature creep of concrete. This paper presents a comparison of different high-temperature creep and transient models available in literature for concrete. Through this comparison the variability of creep and transient strains in current models will be illustrated and the factors which lead to this variability will be discussed. Also, the need for reliable creep models for evaluating fire response of reinforced concrete structures is highlighted.
CE-04  A Fracture Mechanics-Based Approach For Quantifying Delamination Of Spray-Applied Fire-Resistive Insulation From Steel Moment-Resisting Frame Subjected To Seismic Loading
Authors: Amir Arablouei; Venkatesh Kodur

Abstract: This article presents a numerical approach based on fracture mechanics theory for evaluating crack initiation, propagation and delamination of fire insulation at the interface of spray-applied fire insulation and steel surface of a moment resisting frame under the action of earthquake loading. Progression of delamination at the fire insulation-steel interface during cyclic loading is simulated through contact interaction analysis in which Cohesive Zone Model is adopted to model the interface damage and softening. The developed 3D finite element model is validated by comparing predictions from the model, namely crack initiation, crack propagation pattern and the extent of delamination of insulation, against test data generated both at material and structural levels. The validated model is applied to quantify the effects of cyclic damage accumulation at SFRM-steel interface through a parametric study in terms of interfacial critical fracture energy. The influence of local buckling occurring in flange on the extent of delamination is considered in the analyses. Results from the parametric studies indicate that critical fracture energy at steel-insulation interface has significant influence on the extent of damage accumulation over the plastic hinge zone. Further, flange local buckling can substantially enhance the development of tensile stresses at the crack tip leading to delamination over a larger surface area.

CE-05  Experimental Behavior Of Steel Bridge Girders Under Fire Conditions
Authors: Esam Aziz; Venkatesh Kodur

Abstract: In the current practice, no special measures are applied for enhancing structural fire safety of steel bridge girders. Further, there is very limited information and research data in the literature on the fire resistance of structural members in bridges. Experimental study was carried out to evaluate the fire response of uninsulated composite steel-concrete bridge girders. In the experimental work, the critical factors that influence fire resistance, namely fire scenario, load level, web slenderness ratio, web/stiffeners aspect ratio, composite action arising from steel-concrete interaction are investigated. Results from experimental work show that fire resistance in steel bridge girder could be as low as 35 minutes. Furthermore, the web slenderness and web/stiffeners aspect ratio can alter the failure limit state from flexural yielding to shear web buckling.

This work was supported in part by National Science Foundation

CE-06  Statistical Validation Of 3D Finite Element Models For Reinforced Concrete Bridge Columns And Their Use For Predicting Damage Limit States For Performance-Based Seismic Design
Authors: Ata Babazadeh; Rigoberto Burgueño

Abstract: Performance-based seismic design of reinforced concrete (RC) bridges requires precise knowledge about the onset of intermediate damage states on the columns at different demands. Large-scale experiments have been traditionally the only source to obtain these limit states. Finite element (FE) simulations provide the opportunity to study the performance of columns in detail and predict limit states for new designs in lieu of experimental data. However, model validation and data extraction are critical steps for their appropriate use. It is well accepted that visual validation methods through graphical comparison of experimental data and simulation results by means of overlaid plots provide little information about the reliability of the models. In contrast, quantitative methods of validation are less subjective ways to find the extent of confidence in FE simulations. Being validated through rigorous hypothesis testing and determining the confidence level, the applicability of FE simulations for determining damage limit states in flexure-dominated ductile RC bridge columns is presented. The work is shown within the context of six large-scale RC columns units, which were experimentally tested and simulated using 3D FE models. Results from the FE simulations were further analyzed to extract responses at local and global levels. Damage limit states were determined based on these data and compared to experimental measurements. Damage states of onset of yielding, initiation and significant growth of spalling of the cover concrete were found to be predicted with adequate accuracy using FE simulations.

This work was supported in part by NSF under Grant CMMI-1000549
Abstract: The deployability of structural health monitoring self-powered sensors relies on their capability to harvest energy from signals being monitored. Many of the signals required to assess the structure condition are quasi-static events which limits the levels of power that can be extracted. Several vibration-based techniques have been proposed to increase the transferred level of power and broaden the harvester operating bandwidth. However, these techniques require vibration input excitations at frequencies higher than dominant structural response frequencies which makes them inefficient and not suitable for ambient quasi-static excitations. Therefore development of new devices capable of harvesting energy at very low frequencies is needed. This research proposes a technique to harvest energy at very low frequencies (less than 1 Hz) using the snap-through behavior between multiple equilibrium positions of postbuckled elastic elements. When the quasi-static load reaches a certain threshold, a sudden snap-through transition occurs generating a high-rate motion. These sudden transitions excite piezoelectric scavengers that are attached to the elastic elements with high-rate input accelerations, generating then electric power. Extractable energy levels depend on the piezoelectric properties and the accelerations generated within the transitions. Therefore number, spacing and accelerations of snap-through transitions of elastic elements have to be controlled for enhanced power management. The main objectives are to develop energy harvesting devices capable to harvest energy efficiently under quasi-static excitations using snap-through transitions between equilibrium positions of elastic elements, model the postbuckling behavior of the elastic elements and essentially the sudden transitions and finally control the behavior by tailoring geometry and material properties of the buckled elements or stacking them into system assemblies.

This work was supported in part by Michigan Department of Transportation

Abstract: The local calibration of the performance models in the mechanistic-empirical pavement design guide is a challenging task, especially due to the lack of needed data. The data requirements for the selected set of pavement sections from the PMS for local calibration include (a) a wide range of inputs related to traffic, climate, design and material characterization, (b) a reasonable extent and occurrence of observed performance data over time. This paper highlights the process for local calibration of performance models. Statistical sampling concepts were used to determine the adequate number of pavement sections for robust calibrations. The next step was to identify candidate projects in the PMS database based on the pavement type, age, geographical location, and number of performance data collection cycles. Subsequently, the final set of pavement projects were selected based on the distress magnitude over time. It is important to categorize the selected projects based on the measured performance (i.e., poor, normal and good performing pavements) because the locally calibrated models are typically used to predict normal pavement performance at the design stage. For the selected projects, the as-constructed input variables were collected from the construction records. However, when such input information was unavailable, the best estimates were used to represent MDOT pavement design and construction practices. Lastly, the typical steps for local calibration i.e., verification, calibration and validation were executed for the rigid pavement performance models. The above mentioned process is demonstrated with the help of examples and discussed for cracking and IRI models in the paper.

This work was supported in part by U.S. DOT

Abstract: The potential of nuclear magnetic resonance (NMR) as a powerful and convenient tool for comprehensive condition assessment of the concrete-based infrastructure was demonstrated. Non-destructive and supporting destructive test methods and data analysis procedures were developed. A first-generation portable unilateral NMR system was designed and fabricated. The capabilities of this system in non-destructive monitoring and quantification of concrete structure and strength development over time, assessment of the depth profile of concrete moisture content, field evaluation of concrete transport properties, and assessment of the concrete microcrack conditions were demonstrated.

This work was supported in part by U.S. DOT
CE-10  **Tailoring The Elastic Postbuckling Response Of Thin-Walled Cylindrical Composite Shells Under Axial Compression**  
**Authors:** Rigoberto Burgueño; Nan Hu; Annelise Heeringa; Nizar Lajnef;  

**Abstract:** The buckling of cylindrical shells has long been regarded as an undesirable phenomenon but increasing interests on the development of active and controllable structures open new opportunities to utilize such unstable behavior. In this paper, approaches for modifying and controlling the elastic response of axially compressed laminated composite cylindrical shells in the far postbuckling regime are presented and evaluated. Three methods are explored: (1) varying ply orientation and laminate stacking sequence; (2) introducing patterned material stiffness distributions; and (3) providing internal lateral constraints. Experimental data and numerical results show that the static and kinematic response of unstable mode branch switching during postbuckling response can be modified and potentially tailored.

CE-11  **Micro-Structural Evaluation Of The Interaction Mechanisms Of Crumb Rubber And Asphalt Binders**  
**Authors:** Anas Jamrah; M. Emin Kutay  

**Abstract:** Several studies have been conducted evaluating the properties and characteristics of Crumb Rubber (CR) modified asphalt blends. Despite the improved performance of the modified asphalt blends, the mechanisms of interaction between different asphalt binders and CR have not been fully understood. This study is aimed at effectively quantifying the stiffening and rheological effects of modifying asphalt binders with CR at the microscale. The material behavior at this scale is important due to the fact that asphalt coating thickness of aggregates is in the order of a few microns. An experimental approach was taken to investigate the mechanisms of interaction between different asphalt binders and different CR (engineered and raw) particles. Asphalt binders were mixed with CR particles at elevated temperatures (130, 160, and 190°C), and then drained such that no rubber particles were present in the residual asphalt binder. The residual material was then tested for the rotational viscosity, creep compliance ($D(t)$), and the main rheological property; complex shear modulus ($|G^*|$) of the asphalt binder. The characteristics obtained were used to quantify the changes in the asphalt rheology and stiffness due to the absorption/diffusion of the light fractions (aromatic oils) of asphalt binder into CR particles. To fully understand the interaction between rubber and asphalt binders, a 3D Finite Element (FE) based micromechanical model of the $|G^*|$ test is being developed using the commercially available ABAQUS software. The FE model will provide insight on the relationship between the microscale and macroscale material behavior, in addition to the stiffening and interaction effects of rubber particles on asphalt binders. In addition to the experimental approach and the FE based analyses, the Atomic Force Microscopy (AFM) technique will be used to investigate the interface between the rubber particles and the asphalt binder. The AFM is an ideal tool for characterizing the behavior within a composite material as it is capable of measuring nano- and micro-scale forces. Once the interaction mechanisms of CR and asphalt binder are fully understood, this will lead to optimized CR-asphalt binder blends, which in turn leads to optimized CR-asphalt mixtures.  

This work was supported in part by Michigan Department of Environmental Quality (MDEQ)

CE-12  **Performance Evaluation Of Post-Buckled Strip Negative Stiffness Damper**  
**Authors:** Pengcheng Jiao; Nizar Lajnef; Rigoberto Burgueño  

**Abstract:** The usefulness of supplementary energy dissipation devices is now well-known in the seismic design and retrofit of civil engineering structures. However, as an effective structural control approach, negative stiffness system has rarely been applied. Therefore, the main objectives of this study are to examine the behavior of negative stiffness damper and evaluate it in seismic structural applications. For this purpose, a two-phase simulation will be elaborated. Firstly, characterization evaluation will be performed on the negative stiffness damper to provide information on the behavior of load vs. displacement, energy dissipation, damping effect, and stability of performance. Secondly, an earthquake simulation is going to carry out on a moment-resisting steel frame with and without the negative stiffness damper-bracing assembly. Simulation results will be compared with published testing results.
Performance Evaluation Of Ground Tire Rubber Modified Hot Mix Asphalt At Macro Scale

Authors: Salih Kocak; M. Emin Kutay

Abstract: The use of sustainable materials has been becoming more and more important, as the consumption of virgin earth materials has increased significantly during last couple of decades. In pavement construction industry, many departments of transportation and local road agencies are looking for ways to cut down costs and the use of virgin materials. Increased use of reclaimed asphalt pavements (RAP) is one approach that is being taken. Furthermore, scrap tires have been becoming a growing environmental problem all over the world. Currently in the U.S., more than 300 million of scrap tire are buried in the landfills and only 12 million of them are being converted into ground tire rubber (GTR) for use in the asphalt pavement applications each year. The researchers and some industry have been working on engineered GTR particles and GTR modified asphalt binders to design long-lasting asphalt pavements and to minimize the initial construction cost. The GTR is typically introduced into asphalt mixture via two processes: i) wet process (i.e., pre-mixing GTR with asphalt binder) and ii) dry process (dry GTR particles added to asphalt mixture as aggregates). Although wet process has been successful in enhancing the reflective, fatigue and thermal cracking resistance, dry process has historically provided limited success. However, in terms of ease of production and economic reasons, dry process is more advantageous.

The objective of this study was to investigate the performance of asphalt mixtures made with different GTR modification methods combined with high percentages of reclaimed asphalt pavement (RAP). High percentages of RAP (40% by weight) were introduced into HMA along with rubberized asphalt using both wet and dry processes. The performances of the mixtures were evaluated via an extensive laboratory testing program that includes the following major tests: i) flow number (FN) for rutting, ii) dynamic modulus (DM) for linear viscoelastic properties, iii) tensile strength ratio (TSR) for moisture damage, iv) indirect tensile strength (IDT) for low temperature (thermal) cracking and v) push pull (PP) for fatigue cracking. Data analysis revealed that the macro scale performance of HMA mixtures including high amount of RAP and GTR along with some polymer modifiers yielded to similar performance results on FN, TSR and PP tests and better performance on low IDT and DM results. This means that the performance improvements typically gained by use of polymer-modified binders can also be achieved with GTR modified binders/mixtures. It is noted that the initial costs of GTR and polymer modified asphalt binders are generally equivalent. Considering the sustainable aspects of GTR (e.g., use of recycled tire), its use may be a better alternative as compared to some polymer modified asphalt mixtures.

This work was supported in part by Michigan Department of Environmental Quality (MDEQ)

Evaluation Of Pavement Treatments Effectiveness

Authors: Gopikrishna Musunuru; Gilbert Baladi

Abstract: After the initial construction, pavements deteriorate due to environmental and traffic factors. At certain pavement conditions, treatments are applied to either restore or extend the service life of the pavement and/or to decrease its rate of deterioration. There are various treatment types that can be applied to a given pavement section. The appropriate treatment type is a function of the pavement surface type and conditions, causes of distress, traffic volume and load, and the environmental conditions.

The effectiveness of a given pavement treatment for a given pavement section is typically measured by short- and long-term benefits. Short term benefits are typically measured by the improvement in the ride quality and the other pavement conditions. Long term benefits include the improvement in the remaining service life of the pavement.

In this study, which is sponsored by the Federal Highway Administration, the long term pavement performance (LTPP) program, short- and long-term benefits of various treatment types of numerous pavement sections were analyzed. Results of the analyses are presented and discussed in this paper.

Data Analysis - Long Term Pavement Performance

Authors: Gopikrishna Musunuru; Gilbert Baladi

Abstract: In this study, which is sponsored by the Federal Highway Administration (FHWA), time-dependent pavement performance data that were collected through the Long Term Pavement Performance (LTPP) program were analyzed. The objectives of the analyses were to assess the longevity of the various pavement section, and to develop pavement performance prediction models. The models can be used where to study the effectiveness of various pavement treatment types that were used by the LTPP program.

Results of the analyses are presented and discussed in this paper along with the definitions of pavement performance and pavement conditions.

This work was supported in part by Federal Highway Administration

Abstracts of the 2014 Engineering Graduate Research Symposium, Michigan State University
CE-16  **Numerical Investigation Of Composite Action On Shear Response Of Fire Exposed Steel Girders**  
*Authors*: Mohannad Naser; Venkatesh Kodur

**Abstract**: In current practice, failure in beams under fire conditions is evaluated based on flexural limit state without any consideration to shear capacity. This is in contrast to ambient temperature design, where a beam is generally designed to satisfy flexural limits state and then checked for shear resistance. Deriving failure in fire exposed beams based on flexural limit state, although valid for most common scenarios, may not be representative in certain situations, such as transfer girders and coped beams where shear forces are dominant or shear capacity degrades at a rapid pace with fire exposure time. In order to further investigate this phenomenon, a three-dimensional nonlinear finite element model is developed using ANSYS. This model takes into account temperature-dependent properties of constitutive materials, sectional instabilities, and composite action arising from steel beam-concrete slab interaction. The developed model is used to evaluate flexural and shear response of composite girders subjected to high shear forces and simultaneous thermal (fire) loading. Results from this analysis show that shear capacity of a steel girder can degrade at a higher rate than flexural capacity in certain scenarios, thus shear limiting state can be a dominant failure mode. Loading pattern, slenderness ratio and composite action are critical factors that influence shear response in steel girders under fire conditions.

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CE-17  **Winter Circulation, Ice Cover And Exchange In The Saginaw Bay – Lake Huron System: Field And Satellite Observations And Numerical Modeling**  
*Authors*: Tuan D. Nguyen; Guoting Kang; Phanikumar Mantha

**Abstract**: We use an unstructured-grid, three-dimensional hydrodynamic model of Lake Huron coupled with ice processes to understand the nature of circulation and the extent of ice cover over the lake during winter seasons and to quantify exchange rates between the Saginaw Bay and Lake Huron in winter. The model used hourly atmospheric forcing data for the years 2009-2010, and 2012-2013. We deployed thermistor chains and bottom-mounted, up-looking acoustic Doppler current profilers (ADCPs) during the winter season and collected hydrodynamic and temperature data to test the numerical models. We also extracted Moderate Resolution Imaging Spectroradiometer (MODIS) data from both Terra and Aqua satellites for ice cover extent with a relatively high spatial resolution of 463 m with daily temporal resolution. Here we present the comparisons between the field data, satellite remote sensing data and model simulations of currents, temperature, and ice cover extent. New estimates are provided for the mean flushing times and residence times for the Saginaw Bay for winter seasons. These novel results are expected to aid in our understanding of how contaminants are flushed out of the bay during winter seasons and how lake processes are changing in this important ecosystem.

CE-18  **A Coupled Recharge And Groundwater Model To Predict Stream Index Flow**  
*Authors*: Xiaojing Ni; Shuguang Li; Huasheng Liao

**Abstract**: The State of Michigan limits groundwater withdrawals by comparing index flow (i.e., the median flow during the summer months) with the expected stream flow removed due to pumping. The current approach for implementing this policy is to predict total streamflow using a regression model based on many hydrologic parameters. While this approach succeeds for predicting large-scale trends of baseflow, it fails in a number of small area studies. The aim of this research is to use process-based numerical modeling as an alternative to predicting baseflow in small watersheds and site studies. The representative small area watershed is in Hillsdale County, MI. In the process-based model, groundwater from/to adjacent cells, from/to sources and sinks and stored in cells will be considered. A water balance is solved to estimate baseflow, which can be considered as streamflow in summer used to calculate index flow. Recharge is a critical source of groundwater and estimated as output from a watershed model. Forty years of climate data including precipitation, maximum and minimum temperature and soil/vegetation data are used as inputs in the watershed model. The groundwater model calibration compares hydraulic head from monitoring wells with simulated water levels and streamflow records from USGS gaging stations with basflow from the model for one known precipitation event. The current model is in the process of calibration and the final results of baseflow will be used to calculate index flow. This index flow can be compared with proposed water withdrawals to assess whether pumping will significantly affect the stream.
CE-19  Relationship Of Pavement Condition To Subgrade Soil Type  
Authors: Michael Prohaska; Gilbert Baladi; Dennis Chase  

Abstract: Understanding the effects of material properties, construction quality, and environmental factors on pavement are all essential to cost-effective pavement management. While the effects of construction quality, environmental factors, and pavement, base, and subbase materials are extensively understood there continues to be an insufficient understanding of the role of subgrade in pavement life. Previous research studies addressed the effects of subgrade soils on pavement design and construction but neglected their effects on the long term pavement performance. To bridge this knowledge gap, a study sponsored by the Federal Highway Administration is being conducted at Michigan State University to relate the time dependent pavement condition data to the type of subgrade soils. The soil types will be based on the AASHTO soil classifications and their effects on four pavement distresses; lateral cracking, longitudinal cracking, alligator cracking, and rut and on the ride quality expressed by the international roughness index (IRI). For each pavement section, the results will be standardized based on the annual average daily traffic (ADT), percentage trucks, drainage conditions, and climatic zone. Results of this study will be presented and discussed in this presentation.  

This work was supported in part by Federal Highway Administration  

CE-20  Prediction Of Frost Heave  
Authors: Pegah Rajaei; Gilbert Y. Baladi  

Abstract: In cold regions, the ground freezes when the temperature drops below the freezing point causing heave in the soil layers. The thickness of the frozen region and the thickness of the ice lenses increase over time and are function of temperature, soil type and capillarity, the availability of water sources, the proximity of the ground water table and the applied load or overburden pressure. Since the 1930s, several models were developed by researchers to estimate the amount of soil heave due to freezing. Unfortunately, none of the model has received universal acceptance. In general, the majority of the existing frost heave models are based on two different theories; capillary theory and frozen fringe theory. The capillary theory has some limitations which result in inaccurate prediction of frost heave. Whereas the frozen fringe theory assumes the existence of a frozen fringe region below the frozen soil where unfrozen water exists at temperatures below the freezing point. This assumption is controversial and is being debated by researchers. In a research study sponsored by the Michigan Department of Transportation (MDOT), the Gilpin Model (Gilpin, 1980) was applied to Road Weather Information System (RWIS) data in the State of Michigan. Frost heaves were calculated based on no frozen fringe and the existence of frozen fringe model. Results of the analyses were compared and a revised model was developed. This paper introduces the modified models along with its advantages and shortcomings.  

This work was supported in part by Michigan Department of Transportation (MDOT)  

CE-21  Macropore Flow Through Earthen Covers  
Authors: Duraisamy Saravanathiban; Milind Khire; M. Emin Kutay  

Abstract: In the U.S., landfilling is the most common means to dispose off municipal solid waste. Earthen cover, composed of compacted clay soil, is constructed once a landfill reaches its capacity and is scheduled for closure in order to impede the flow of water into the waste and to prevent the landfill to be filled with liquid which can be a long term environmental hazard. The formation of large openings (macropores) due to shrinkage, desiccation, freeze-thaw cycles, vegetation root growth and death, rodent holes, and worm holes in earthen covers is one of the major challenges in landfill cover design as it impacts long term percolation during service. The liquid flow in macropores is predominantly downward due to gravity. Presently available water balance models used for designing earthen covers are based on Richards equation that simulates only the flow through microscopic pores (micropores), not the macropores. Hence, there is a need to develop a model capable of simulating flow through micropore as well as macropore to design earthen covers. In this study, evaluation of macropore flow was carried out using a field scale test section constructed at a landfill near Detroit. Also, laboratory test were carried out on intact compacted clay samples and compacted clay samples with macropores. These samples were used to develop digital data of macropores using X-ray CT. A model based on Lattice Boltzmann Method (LBM) that can simulate fluid flow through micropores and macropores is developed. The model was validated using laboratory measured data.  

This work was supported in part by National Science Foundation (Grant No. CMMI-1100020); Waste Management, Inc.; Environmental Research and Education Foundation
CE-22  **Mix Design Procedures Based On Packing Density Models For Ultra-High-Performance Concrete (UHPC) Nanocomposites**  
*Authors*: Libya Ahmed Sbia; Parviz Soroushian

**Abstract**: Ultra-high-Performance concrete (UHPC) mixtures require high-quality aggregates and fillers with particular size distributions, which may not be readily available in many locations. In order to broaden the selections of UHPC raw materials, mix proportioning methods were developed based on packing density models. The blend of all particulate matter (aggregates, cement, supplementary cementitious materials, mineral powder, nanomaterials, etc.) used in UHPC should provide a combined particle size distribution which favors achievement of high packing densities. The purpose of this research is to develop guidelines for proportioning readily available particulate (granular) matter for realizing dense particle packing and desired fresh mix characteristics. The reduced porosity and finer pore size distribution of this matrix would favor improved interactions with nanomaterials and fiber. Models and criteria were developed for selection of particulate materials at different scales (and their blends) with the objective of enabling effective use of nanomaterials. Nanomaterials were found to benefit the packing density of the particulate matter in UHPC, even at very low volume fractions, by extending the particle size distribution into the nano-scale region.

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CE-23  **Behaviour Of Prestressed Concrete Hollowcore Slabs Under Standard And Design Fire Exposure**  
*Authors*: Anuj Shakya; Venkatesh Kodur

**Abstract**: Prestressed concrete (PC) hollowcore slabs are widely used in building floor systems due to numerous advantages, they offer over other types of floor systems. Currently, fire resistance of these slabs is assessed based on standard fire tests, or prescriptive approaches. These fire tests are expensive, time consuming and do not yield realistic fire resistance, as they cover only limited numbers of parameters. To overcome some of these limitations, a numerical model was developed for evaluating fire resistance of PC hollowcore slabs under realistic fire, loading and restraint scenarios. For validating this numerical model, a set of fire resistance tests was carried out on PC hollowcore slabs. This study presents results of fire resistance tests on PC hollowcore slabs subjected to different loading and fire scenarios. Six PC hollowcore slabs, of 4 m in length, 1.2 m in width and 200 mm in depth, were designed according to PCI design specifications. The cores in these slabs were of 150 mm radius and low relaxation prestressing strands, with yield stress of 1860 MPa and diameter of 12.7 mm, were used in these slabs. The test variables included aggregate type, restraint condition, fire scenario and load level. All six slabs developed fire induced cracks, but sustained fire exposure, without failure, for more than 2 hours before undergoing failure reaching limiting temperature on unexposed surface of slab. Hollowcore slabs performed better under design fires than standard fires. Also, slabs with carbonate aggregate exhibited slightly better fire resistance than slabs with siliceous aggregate. In addition, end restraints significantly enhanced the fire resistance of PC hollowcore slabs.

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CE-24  **Development Of Methods For Microbial Gene Quantification**  
*Authors*: Jackson Sorensen; Robert Stedtfeld; Marius Vital; James Tiedje; Syed Hashsham

**Abstract**: The suite of microorganisms present in the human gastrointestinal tract, often called the microbiome, are increasingly believed to play a role in the health of their hosts. Animals free of microorganisms, or "germ free" animals, commonly have developmental abnormalities, suggesting a role for the microbiome in the well being of their host. However, the mode of action that the microbiome utilizes to have this impact on its host is unclear. Many studies on the microbiome center on the presence or absence of certain populations or functions through the sequencing of microbial DNA. While this information is useful, it only indicates the potential of the microbiome to perform certain actions, and does not give a depiction of the functions the microbiome is actively executing. Currently, we are working on methods for the quantification and sequencing of both DNA and RNA of the microbiome present in gnotobiotic mice. Through the utilization of loop mediated isothermal amplification (LAMP), we have been able to absolutely quantify the number of butyryl-CoA transferase(but) genes in the microbial DNA extracted from fecal samples. This methodology allowed for the specific identification and quantification of the microbial species Roseburia intestinalis, Rosburia inulinivorans, and Faecalibacterium prausnitzii. LAMP allows the quantification of this gene in under thirty minutes. To date quantification of RNA using LAMP has proven difficult to reliably and reproducibly achieve. For these issues, RNaseq and directed transcriptomics are being explored to provide a solution.

*This work was supported in part by NIEHS*
CE-25  Development And Mechanical Characterization Of Novel Functionally Graded Open-Cell Al/Cu Hybrid Metal Foam Structures  
Authors: Yi Sun; Rigoberto Burgueño

Abstract: Cellular/foam materials found in nature such as bone, wood, and bamboo usually have a non-uniform density that is distributed in space to optimize the global mechanical performance of the structure. Inspired by such naturally engineered products, many studies have been conducted in the development of functionally graded cellular/foam materials (FGF). However, most of these studies are limited to FGF with one-dimensional property gradient. An approach has been recently demonstrated for fabricating Aluminum/Copper hybrid foams with enhanced and controllable stiffness, strength and energy absorption capacity by reinforcing open-cell aluminum (Al) with nanocrystalline copper (Cu) coatings. The manufacturing process of Al/Cu hybrid foams can be controlled to fabricate engineered foam structures with three-dimensional property gradients. Nano-copper reinforcement patterns were designed to optimize the performance of beam-type foam structures under quasi-static and dynamic flexural demands. The results show that the reinforcement pattern can be designed to modify the deformation and failure mechanisms of foam structures. It is also shown that functionally graded hybrid foam elements can have reduced deformation and damage, and enhanced stiffness, strength and ductility compared to hybrid foams with a uniform coating in both quasi-static and dynamic loading conditions. By providing a strategic distribution of reinforcement in a three-dimensional domain, the approach presented greatly extends the possible design of functionally graded foam structures with superior mechanical performance. The methods and findings from this study provide valuable information for the development of novel high-performance functionally graded cellular materials and structures.

This work was supported in part by National Science Foundation

CE-26  Numerical Modeling Of A Coupled Groundwater And Lake System  
Authors: Yuting Sun; Shu-Guang Li

Abstract: Many lakes in the U.S. are suffering from decreasing water levels likely caused by climate change. Lake augmentation through the input of extracted groundwater or pumped water from the other surface water source is often used to boost water levels in such lakes, but in many cases it is insufficient due lack of knowledge about complex lake and groundwater interactions. The purpose of this research is to use numerical modeling to better understand groundwater and lake interaction and to apply this knowledge to improve management schemes for stressed surface water bodies. Three-dimensional multi-scale modeling of the coupled groundwater-lake system is used because it simplifies the interaction system based on analysis of the sub-model and improved computational scaling. This research will utilize 'transition probability' approach to simulate lithology distribution at regional scale and local scale, and then assign similar material types appropriate hydraulic conductivity values to be used in the hydrologic model. Recharge is calibrated with monitor well data and leakage from several years of dry season lake levels, respectively. Current work focuses on Barron Lake, a Cass County lake without any surface inflow or outflow and a declining lake level. A large-scale model of approximately 147 km2 models regional groundwater flows. A small-scale model with boundaries of approximately 1 km2 is used to simulate the groundwater and lake interaction process. Results from simulations indicate Barron Lake has significant leakage to groundwater and that its water level can be maintained by injecting water from other watershed.

CE-27  A Viscoelastic Non-Linear Multilayered Model For Asphalt Pavements And Backcalculation  
Authors: Sudhir Varma; Emin Kutay

Abstract: Flexible pavements are multilayered structures, with typically top layer as viscoelastic asphalt layer followed by nonlinear (stress-dependent) unbound/bound layers. Conventionally, multilayered elastic analysis is performed to obtain response of flexible pavements for design and inverse analyses, however, assuming asphalt pavement as a linear elastic material is an oversimplification of its actual behavior. It is well known that the asphalt pavements responses are both rate and temperature dependent. In the present work, a computationally efficient model LAVAN has been developed to analyze flexible pavements considering linear viscoelastic asphalt concrete (AC) top layer; followed by stress dependent (nonlinear) base layer; and elastic subgrade. It is shown that the developed model can be used to develop a backcalculation model BACKLAVAN. The BACKLAVAN algorithm utilizes FWD load-response history at different test temperatures to backcalculate $|E^*|$ master curve of AC layers as well as linear and non-linear elastic moduli of unbound layers of in-service pavements. The BACKLAVAN algorithm was validated using two FWD test runs on a long term pavement performance (LTPP) section. Comparison between the backcalculated and measured results indicate that, it should be possible to infer linear viscoelastic properties of AC layer as well as nonlinear elastic properties of unbound layers using FWD tests.

This work was supported in part by Federal Highway Administration
A Stochastic Multi-Scale Model Of Stream-Groundwater Interaction In Strongly Heterogeneous Porous Medium And Its Application In South Branch County, Mi

Authors: Xinyu Ye; Shu-Guang Li; Huasheng Liao

Abstract: In this paper, stream depletion is assessed by the approach of multi-scale geostatistics in stressed watershed, South Branch County, Michigan. The watershed is currently under large water demand and representative of the general failure to pass the online Water Withdrawal Assessment Tool. Due to the heterogeneity of porous medium and the high variability of hydrogeological parameters and scale, there is a deviation between field observations and simulated groundwater flow in those areas. The approach of multi-scale geostatistics model based on detailed lithological data and its application in numerical groundwater simulation can be used in stream depletion assessment.

Specifically, the multi-scale transition probability geostatistics approach, supplemented with a 10m Digital Elevation Model, allows for a more realistic integration of heterogeneous medium into the development of correlated spatial variability of hydrogeological parameters at each spatial scale. This approach enables accurate simulation of complex hydrogeology, including vertical shift structural variation and aquifer thickness variations. Systematic hydrology models at the regional, local and site scale allows for simulations of reverse particle tracking and integrated water budget analysis. These simulations are necessary to evaluate the water depletions of targeted streams. The hydrology system is calibrated with the steady state water levels from 200 monitoring wells.

The stability of transition probability geostatistics model depends on the distributions, the heterogeneity of simulated area and other factors. The results show that transition probability geostatistics model provides a reasonable distribution of materials in aquifer medium, improving numerical groundwater modeling in assessing water depletion in streams.
CSE-01  Troubleshooting Quality Of Experience For Cellular Networks  
Authors: Faraz Ahmed; Alex X. Liu; He Yan; Zuhi Ge; Jeffrey Erman; Jia Wang  

Abstract: Quality of experience (QoE) of a user is one of the main factors which determine the reputation of cellular network operators. In addition to the performance of cellular network nodes, the hardware and software performance of different device types and applications also largely define a user's QoE over the cellular network. This project deals with the problem of maintaining QoE of cellular network users by proactive detection of service degradation issues. Although, cellular network providers utilize existing end-to-end service quality management systems for detecting issues inside the network, but under certain conditions issues affecting QoE of a group of customers may go undetected. These conditions may arise due to problems in different dimensions such as mobile devices, applications, websites and network nodes. We design a holistic performance monitoring system to detect and localize issues, causing service degradation for groups of customers sharing one or more of the above mentioned dimensions. Through a recursive rule mining approach we show that not only the overall training error is reduced but also there is a significant decrease in false positives.

CSE-02  Effect Of Decoder On Bit Error Rate  
Authors: Alireza Ameli Renani; Jun Huang; Guoliang Xing; Abdol-Hossein Esfahanian  

Abstract: Today wireless communications suffer from high transmission error especially in high data rates. It was believed that channel condition is responsible for most of these errors but recent research have proved that there are patterns in the bit error rate which are not caused by channel conditions. It turns out that the bit error pattern has a fluctuating nature which can potentially be used to improve the accuracy and throughput of the system, in applications such as video streaming. Our research has validated the existence of such a pattern in different environments and across different devices. Further, we have demonstrated that this behavior depends mainly on the transmission rate. It appears that the pattern is caused by the decoder in the receiver. Unfortunately the decoder codes are not available to public so we cannot find what part of the algorithm is causing this behavior. One major advantage of the bit error pattern is that it is known prior to the transmission, so no handshake or synchronization is required in order to use it. To utilize our findings, we formulated the pattern and used it in video streaming. Our preliminary results from simulations show more than 15% improvement in throughput by utilizing the pattern. We are expecting more improvement in next set of experiments.

CSE-03  3D Fingerprint Phantoms  
Authors: Sunpreet S. Arora; Kai Cao; Anil K. Jain; Nicholas G. Paulter, Jr.  

Abstract: One of the critical factors prior to deployment of any large scale biometric system is to have a realistic estimate of its matching performance. In practice, evaluations are conducted on the operational data to set an appropriate threshold on match scores before the actual deployment. These performance estimates, though, are restricted by the amount of available test data. To overcome this limitation, use of a large number of 2D synthetic fingerprints for evaluating fingerprint systems had been proposed. However, the utility of 2D synthetic fingerprints is limited in the context of testing end-to-end fingerprint systems which involve the entire matching process, from image acquisition to feature extraction and matching. For a comprehensive evaluation of fingerprint systems, we propose creating 3D fingerprint phantoms (phantoms or imaging phantoms are specially designed objects with known properties scanned or imaged to evaluate, analyze, and tune the performance of various imaging devices) with known characteristics (e.g., type, singular points and minutiae) by (i) projecting 2D synthetic fingerprints with known characteristics onto a generic 3D finger surface and (ii) printing the 3D fingerprint phantoms using a commodity 3D printer. Experimental results show that the captured images of the 3D fingerprint phantom using state-of-the-art fingerprint sensors can be successfully matched to the 2D synthetic fingerprint images (from which the phantom was generated) using a commercial fingerprint matcher. This demonstrates that our method preserves the ridges and valleys during the 3D fingerprint phantom creation process ensuring that the synthesized 3D phantoms can be utilized for comprehensive evaluations of fingerprint systems.

This work was supported in part by National Institute of Standards and Technology (NIST)
CSE-04  **Face Recognition: Identifying A Person Of Interest**  
**Authors:** Lacey Best-Rowden; Hu Han; Charles Otto; Anil K. Jain

**Abstract:** As face recognition applications progress from constrained and controlled scenarios (e.g., driver license photos) to unconstrained and uncontrolled scenarios (e.g., video surveillance), new challenges are encountered ranging from illumination, image resolution, and background clutter to facial pose, expression, and occlusion. In forensic investigations where the goal is to identify a “person of interest” based on low quality evidence, we need to utilize whatever information is available about the suspect. This could include one or more video sequences, multiple still images captured by bystanders, and descriptions of the suspect provided by witnesses. The description of the suspect could lead to drawing of facial sketch and provide some ancillary information about the suspect (age, gender, race, scars, marks, and tattoos). While traditional face matching methods take single media (a still face image, video track, or face sketch) as input, our research considers the entire media collection as a probe or query to generate a single candidate list for the person of interest. We show that our approach boosts the likelihood of forensic identification through the use of different fusion schemes, three-dimensional face models, and incorporation of quality measures for fusion and video frame selection.

*This work was supported in part by National Physical Science Consortium Graduate Fellowship*

CSE-05  **Multi-Kernel Multi-Label Ranking**  
**Authors:** Serhat S. Bucak; Anil K. Jain

**Abstract:** Recent studies have shown that multiple kernel learning is very effective for image classification, leading to the popularity of kernel learning in computer vision problems. In this work, we formulate image classification as a multi-label learning problem and develop an efficient algorithm for multi-label multiple kernel learning (ML-MKL). We assume that all the classes under consideration share the same combination of kernel functions, and the objective is to find the optimal kernel combination that benefits all the classes. In addition, we address multi-label learning with many classes via a ranking approach, termed multi-label ranking. Given a test image, the proposed scheme aims to order all the object classes such that the relevant classes are ranked higher than the irrelevant ones. We propose a wrapper approach that learns the ranking functions and optimal linear combination of base kernels simultaneously. Our experiments on ESP Game and MIRFlickr image datasets demonstrate the superior performance of the proposed multi-kernel multi-label ranking approach for image classification.

CSE-06  **Automatic Facial Makeup Detection With Application In Face Recognition**  
**Authors:** Cunjian Chen; Antitza Dantcheva; Arun Ross

**Abstract:** Facial makeup has the ability to alter the appearance of a person. Such an alteration can degrade the accuracy of automated face recognition systems, as well as that of methods estimating age and beauty from faces. In this work, we design a method to automatically detect the presence of makeup in face images. The proposed algorithm extracts a feature vector that captures the shape, texture and color characteristics of the input face, and employs a classifier to determine the presence or absence of makeup. Besides extracting features from the entire face, the algorithm also considers portions of the face pertaining to the left eye, right eye, and mouth. Experiments on two datasets consisting of 151 subjects (600 images) and 125 subjects (154 images), respectively, suggest that makeup detection rates of up to 93.5% (at a false positive rate of 1%) can be obtained using the proposed approach. Further, an adaptive pre-processing scheme that exploits knowledge of the presence or absence of facial makeup to improve the matching accuracy of a face matcher is presented.

*This work was supported in part by the NSF Center for Identification Technology Research (CITeR)*

CSE-07  **Identifying Transcription Start Sites And Transcription End Sites Of MiRNAs In C.elegans**  
**Authors:** Jiao Chen; Yanni Sun

**Abstract:** MiRNAs are crucial small non-coding RNAs that regulate gene expression in the growth period of C.elegans. Transcriptional regulation of miRNAs is critical because it directly affects miRNA-mediated gene regulatory networks. However, the transcription start sites (TSSs) and transcription termination sites (TTSs) of most miRNA genes have not been characterized because pri-miRNAs are quickly spliced in cells. Here, we performed a whole genome analysis of DNA sequence, chromatin signatures, and Polymerase II surrounding intergenic miRNAs in C.elegans genome to identify their TSSs and TTSs. Our results will improve the understanding of the regulation of miRNAs.
CSE-08 Visual Diagram Interpretation For Blind Programmers
Authors: Sarah Coburn; Charles Owen

Abstract: Computer Science education frequently demonstrate program structure through the use of visual diagrams (such as UML diagrams), which are largely inaccessible to blind programmers. These diagrams show things like relationships between objects in the program using lines to connect shapes, with types of shapes indicating the types of objects and relationships. This heavy reliance on visual cues (such as peripheral information and complicated connections between objects) is a hurdle that blind programmers must get over in order to succeed academically. Some programs exist to translate UML diagrams into a format readable by blind programmers, but frequently do not accurately and efficiently communicate all of the essential information. We developed a program that will automatically interpret UML diagrams into an auditory format. Information is related using a combination of audio tones and text to speech audio presented in stereo to help relate location. We will also discuss information that should be included by any diagram translator, and the future directions of this research.

CSE-09 A Difference Resolution Approach To Compressing Access Control Lists
Authors: James Daly; Alex X. Liu; Eric Torng

Abstract: Access Control Lists (ACLs) are the core of many networking and security devices. As new threats and vulnerabilities emerge, ACLs on routers and firewalls are getting larger. Therefore, compressing ACLs is an important problem. We present a new approach, Diplomat, to ACL compression. The key idea is to transform higher dimensional target patterns into lower dimensional patterns by dividing the original pattern into a series of hyperplanes and then resolving differences between two adjacent hyperplanes by adding rules that specify the differences. This approach is fundamentally different from prior ACL compression algorithms and is shown to be very effective. We implemented Diplomat and conducted side-by-side comparison with the prior Firewall Compressor, TCAM Razor and ACL Compressor algorithms on real life classifiers. Our experimental results show that Diplomat outperforms all of them on most of our real-life classifiers, often by a considerable margin, particularly as classifier size and complexity increases. In particular, on our largest ACLs, Diplomat has an average improvement ratio of 30.6% over Firewall Compressor on range-ACLs, of 12.1% over TCAM Razor on prefix-ACLs, and 9.4% over ACL Compressor on mixed-ACLs.

This work was supported in part by Nation Science Foundation Grant No. CNS-0916044

CSE-10 iSleep: Unobtrusive Sleep Quality Monitoring Using Smartphones
Authors: Tian Hao; Guoliang Xing; Gang Zhou

Abstract: The quality of sleep is an important factor in maintaining a healthy life style. To date, technology has not enabled personalized, in-place sleep quality monitoring and analysis. Current sleep monitoring systems are often difficult to use and hence limited to sleep clinics, or invasive to users, e.g., requiring users to wear a device during sleep. iSleep is a practical system to monitor an individual’s sleep quality using off-the-shelf smartphone. It uses the built-in microphone of the smartphone to detect the events that are closely related to sleep quality, including body movement, cough and snore, and infers quantitative measures of sleep quality. By providing a fine-grained sleep profile that depicts details of sleep-related events, iSleep allows the user to track the sleep efficiency over time and relate irregular sleep patterns to possible causes.

This work was supported in part by the NSF under grant CNS-0954039 (CAREER), CNS-1250180 and ECCS-0901437.

CSE-11 WiFi-BA: Choosing Arbitration Over Backoff In High Speed Multicarrier Wireless Networks
Authors: Pei Huang; Xi Yang; Li Xiao

Abstract: Advancements in wireless communication techniques have increased the wireless physical layer (PHY) data rates by hundreds of times in a dozen years. The high PHY data rates, however, have not been translated to commensurate throughput gains due to overheads incurred by medium access control (MAC) and PHY convergence procedure. At high PHY data rates, the time used for collision avoidance (CA) at MAC layer and the time used for PHY convergence procedure can easily exceed the time used for transmission of an actual data frame. As collision detection (CD) in wireless communication became feasible recently, some protocols migrate random backoff from the time domain to the frequency domain, but they fail to address the introduced high collision probability. We investigate the practical issues of CD in the frequency domain and introduce a binary mapping scheme to reduce the collision probability. Based on the binary mapping, a bitwise arbitration (BA) mechanism is devised to grant only one transmitter the permission to initiate data transmission in a contention. With the low collision probability achieved in a short bounded arbitration phase, the throughput is significantly improved. Because collisions are unlikely to happen, unfairness caused by capture effect of radios is also reduced. The bitwise arbitration mechanism can further be set to let high priority messages get through unimpeded, making WiFi-BA suitable for real time prioritized communication. We validate the effectiveness of WiFi-BA through implementation on FPGA of USRP E110. Performance evaluation demonstrates that WiFi-BA is more efficient than current Wi-Fi solutions.

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CSE-12 **ARC: Adaptive Reputation Based Clustering Against Spectrum Sensing Data Falsification Attacks**  
**Authors:** Chowdhury Hyder; Brendan Grebur; Li Xiao; Max Ellison  

**Abstract:** IEEE 802.22 is the first standard based on the concept of cognitive radio. It recommends collaborative spectrum sensing to avoid the unreliability of individual spectrum sensing while detecting primary user signals. However, it opens an opportunity for attackers to exploit the decision making process by sending false reports. In this paper, we address security issues regarding distributed node sensing in the 802.22 standard and discuss how attackers can modify or manipulate their sensing result independently or collaboratively. This problem is commonly known as spectrum sensing data falsification (SSDF) attack or Byzantine attack. To counter the different attacking strategies, we propose a reputation based clustering algorithm that does not require prior knowledge of attacker distribution or complete identification of malicious users. We provide an extensive probabilistic analysis of the performance of the algorithm. We compare the performance of our algorithm against existing approaches across a wide range of attacking scenarios. Our proposed algorithm displays a significantly reduced error rate in decision making in comparison to current methods. It also identifies a large portion of the attacking nodes and greatly minimizes the false detection rate of honest nodes.

CSE-13 **A Wireless Sensor Network Within An Aquatic Environment**  
**Authors:** Tam Le; Matt Mutka  

**Abstract:** Wireless sensor networks have been widely used in many environmental monitoring applications. For aquatic environments, the deployment is quite expensive since the sensors need to be anchored to prevent them from floating away and losing communications. We propose an inexpensive and flexible approach to provide environmental monitoring in aquatic environments. We propose a special mobile sensor robot that acts as a mobile base station and travels the water area to collect data from sensors as well as locations that cannot be covered by sensors. The sensors in the water have a jumping capability that enables an extended communication range in comparison to sensors that merely float upon the water. By leveraging the jumping capability, the sensors can collaborate with others to exchange data and communicate with the robot, so that the robot can compute an efficient path to travel. The problems we study are: 1) given a set of visited points, how to find the robot's optimal path with support of sensors to cover the remaining points; 2) to design an efficient jumping strategy and communication protocol between sensors.

CSE-14 **miR-PREFeR: An Accurate, Fast, And Easy-To-Use Plant miRNA Prediction Tool Using Small RNASeq Data**  
**Authors:** Jikai Lei; Yanni Sun  

**Abstract:** Plant microRNA prediction tools that utilize small RNA sequencing data are emerging with the advances of the next generation sequencing technology. These existing tools have at least one of the following problems: 1. high false positive rate; 2. the positions of the predicted miRNAs are not accurate; 3. long running time; 4. work only for genomes in their databases; 5. hard to install or use. We develop miR-PREFeR, which utilizes expression patterns of miRNA and follows the criteria for plant microRNA annotation to accurately predict plant miRNAs from one or more small RNA-Seq data samples of the same species. We tested miR-PREFeR on several plant species. The results show that miR-PREFeR is sensitivity, accurate, fast, and has low memory footprint.  

*This work was supported in part by NSF*

CSE-15 **Discrete Connection And Covariant Derivative For Vector Field Analysis And Design**  
**Authors:** Beibei Liu; Fernando de Goes; Yiying Tong; Mathieu Desbrun  

**Abstract:** In this paper, we introduce a discrete definition of connection on simplicial manifolds, with closed-form continuous expressions within simplices and finite rotations across simplices. The finite-dimensional parameters of this connection are optimally generated by minimizing a quadratic measure of the deviation to the discontinuous connection induced by the embedding of the input mesh. We also construct from this discrete connection a covariant derivative through exact differentiation, leading to analytical expressions for local integrals of first-order derivatives (such as divergence, curl and the Cauchy-Riemann operator), and for L2-based energies (such as the Dirichlet energy). We finally demonstrate the utility, flexibility, and accuracy of our discrete formulations for the design and analysis of vector, n-vector, and n-direction fields.  

*This work was supported in part by NSF*
Learning To Mediate Perceptual Differences In Situated Human Robot Dialogue

Authors: Changsong Liu; Joyce Chai

Abstract: To support natural interaction between a human and a robot, technology enabling human-robot dialogue has become increasingly important. In human-robot dialogue, although a robot and its human partner are co-present in a shared environment, they have significantly mismatched perceptual capabilities (e.g., recognizing objects in the surroundings). When a shared perceptual basis is missing, communication about the shared environment often becomes difficult, such as identifying referents in the physical world that are referred to by the human (i.e., a problem of referential grounding). To overcome this challenging problem, we have developed an optimization based approach that allows the robot to quickly adapt to the perceptual differences. Given any new situation, through a couple of dialogues, the robot can quickly learn a set of weights indicating how reliable/unreliable each dimension of its perception of the environment maps to human’s linguistic expressions. The robot then adapts to the situation by applying the learned weights for grounding linguistic expressions to physical entities. Our empirical results have shown that, when the perceptual difference is high (i.e., the robot can only correctly recognize 10-40% of objects in the environment), applying learned weights significantly improves referential grounding performance by an absolute gain of 10%.

This work was supported in part by N00014-11-1-0410 from the Office of Naval Research and IIS-1208390 from the National Science Foundation.


Authors: Pei Huang; Chin-Jung Liu; Li Xiao

Abstract: Duty cycling improves energy efficiency but limits its throughput and introduces significant end-to-end delay in wireless sensor networks. In this paper, we present a traffic-adaptive synchronous MAC protocol (TAS-MAC), which is a high throughput low delay MAC protocol tailored for low power consumption. It achieves high throughput by using Time Division Multiple Access (TDMA) with a novel traffic-adaptive allocation mechanism that assigns time slots only to nodes located on active routes. TAS-MAC reduces the end-to-end delay by notifying all nodes on active routes of incoming traffic in advance. These nodes will claim time slots for data transmission and forward a packet through multiple hops in a cycle. The desirable traffic-adaptive feature is achieved by decomposing traffic notification and data transmission scheduling into two phases, specializing their duties and improving their efficiency respectively. Simulation results and tests on TelosB motes demonstrate that the two-phase design significantly improves the throughput of current synchronous MAC protocols and achieves the similar low delay of slot stealing assisted TDMA with much lower power consumption.

Hierarchical Classification Of Mobile Applications Using Semi-Supervised Non-Negative Matrix Tri-Factorization

Authors: Xi Liu; Pang-Ning Tan; Han Hee Song; Mario Baldi

Abstract: The proliferation of smartphones in recent years has led to a phenomenal growth in the number and variety of mobile applications developed for personal use, businesses, education, and other purposes. The app markets, such as Google Play and Apple iTunes, provide a one-stop shop for users to download or purchase their apps and for software developers to market their inventions. As the number of mobile apps rapidly grows, searching or recommending relevant apps for users becomes a challenging problem. The broad, coarse-grained categories currently provided by the market place may not fit the actual description and intended use of the apps. In this poster, we present a hierarchical classification approach based on non-negative matrix tri-factorization to classify mobile apps while simultaneously constructing a category tree that reveals a deeper relationship among the categories. We demonstrate the limitations of using existing concept hierarchies (such as Google Ad Trees) and present a semi-supervised learning approach that integrates existing hierarchies with the mobile app description data to significantly improve classification accuracy.
CSE-20  **Toward Tractable Instantiation Of Conceptual Data Models**  
**Authors:** Matthew Nizol; Laura K. Dillon; R.E.K. Stirewalt

**Abstract:** Complex, data-intensive software systems play an increasingly crucial role in enterprise decision making. Developers of these systems must validate both the database design and the application programs that interact with the database. If a conceptual data model is developed during requirements analysis, instantiation of that model can facilitate both validation activities. Domain experts can inspect test instances of the model to confirm that constraints have been properly expressed, and application programmers can generate data to test their programs. Object Role Modeling (ORM) is a popular modeling language that maps to predicate logic. Due to ORM's expressive constraint language, instantiating an arbitrary ORM model is NP-hard, but a restricted subset of the language called ORM- can be solved in polynomial time. Some models that include "hard" constraints (i.e., constraints outside the ORM-subset) can nevertheless be transformed into ORM-models. Such transformations do not necessarily need to preserve the original model's semantics: the existence of some mapping from instances of the target model to instances of the original model is sufficient. This poster presents a research project to extend the set of ORM models that can be transformed to ORM-models through a class of non-semantics-preserving transformations called constraint strengthening. We illustrate an example constraint-strengthening transformation and note limitations of the approach. Future research will investigate the composition of transformations, the use of genetic algorithms to search for instances of complex models, and the use of SAT-solvers to find partial instances of the "hard" portions of a model that may be combined to form an instance of the original model.

CSE-21  **Regular Distance-Preserving Graphs**  
**Authors:** Ronald Nussbaum; Abdol-Hossein Esfahanian

**Abstract:** A graph is distance-hereditary if the distances in any connected induced subgraph are the same as those in the original graph. Relaxing the requirement that every connected induced subgraph be distance-preserving allows us to explore the idea of a distance-preserving graph. Formally, a graph of order n is distance-preserving if for each integer k in the interval [1, n] there exists at least one isometric subgraph of order k. Previously we worked to characterize and find applications for distance-preserving graphs. Here we give methods for constructing r-regular distance-preserving graphs on n vertices for various values of r and n. We also consider constructing r-regular non-distance-preserving graphs on n vertices for various values of r and n, and related conjectures.

CSE-22  **De-Identifying Biometric Images For Enhancing Privacy And Security**  
**Authors:** Asem Othman; Arun Ross

**Abstract:** The goal of this poster is to discuss methods that have been developed in our lab (i-probe) to extend privacy to biometric data in the context of an operational system. Biometric data can be viewed as personal data, since it pertains to the biological and behavioral attributes of an individual. Therefore, it is necessary to ensure that the biometric data stored in a system is used only for its intended purpose by de-identifying prior to storage. In this poster, we will briefly discuss two approaches to de-identify biometric images. The first approach is based on Visual Cryptography that de-identifies a face image prior to storing it by decomposing the original image into two images in such a way that the original image can be revealed only when both images are simultaneously available; further, the individual component images do not reveal any information about the original face image. The second approach is based on the concept of mixing to extend privacy to fingerprint images. The proposed scheme mixes a fingerprint with another fingerprint (referred to as the "key") in order to generate a new mixed fingerprint image that can be directly used by a fingerprint matcher. The mixed image obscures the identity of the original fingerprint; further, different applications can employ different "keys", thereby ensuring that the identities enrolled in one application cannot be matched against the identities in another application.

CSE-23  **Demographic Estimation From Face Images: Human Vs. Machine Performance**  
**Authors:** Charles Otto; Hu Han; Anil K. Jain

**Abstract:** We present a generic framework for automatic age, gender and race estimation from face images, including a quality assessment measure used to identify low-quality images for which it will be difficult to obtain reliable estimates. Experimental results on a diverse set of face image databases show that the proposed approach has better performance than other state of the art methods. Finally, we use crowdsourcing to study humans' ability to estimate demographics from face images, and compare the crowdsourced estimates to our automatic demographic estimates.
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**CSE-24 RAIL: Robot-Assisted Indoor Localization**  
**Authors:** Chen Qiu; Matt Mutka

**Abstract:** Location Based Services (LBS) are expanding rapidly for mobile devices. Global Positioning System (GPS) has been commonly adopted for outdoor localization. However, since the accuracy of GPS is very low (or nonexistent) indoors, it cannot support LBS in indoor environments. The indoor location information available for most current mobile devices is not accurate. We introduce an approach that improves a smartphone’s localization accuracy with help of a moving robot. By installing on a robot a tablet personal computer, the proposed application program and a known map, moving robots can improve a smartphone's localization accuracy. The robot can use Bluetooth to send its accurate location information to the customers' smartphones. Customers who carry smartphones do not need any special-purpose device to obtain location information. We need to design a path for a robot so that all the smartphones in the environment may have smaller deviations from the ground truth due to interaction with the robot. The robot collects Bluetooth RSSI values from smartphones in different rooms. We classify different rooms into different crowd density levels by the RSSI values. Higher crowd density rooms should be served more often. By using different crowd density levels, we use dynamic programming to design algorithms to generate a robot's moving route. We evaluate our approach in different environments, the location errors from a localization application on a smartphone are reduced effectively. After each serving round, a robot can choose an appropriate algorithm from proposed algorithms according to crowd density.

*This work was supported in part by the National Science Foundation grant no. CNS-1320561.*

**CSE-25 Efficient Kernel-Based Data Stream Clustering**  
**Authors:** Radha Chitta; Anil K. Jain

**Abstract:** Recent advances in sensor technologies have facilitated “continuous” data collection. Unbounded sequences of data called data streams are generated in many applications such as IP networks, stock markets, and social networks. There are two major challenges in data stream analysis: (i) Due to the unbounded nature of the data, it is not possible to store all the data in memory, so the data can be accessed at most once, and (ii) the data evolves over time, i.e. the recent data in the stream may be unrelated to the older data in the stream.

Stream clustering is the task of finding groups in the data stream, based on a pre-defined similarity measure. Most of the current stream clustering algorithms are “linear” clustering algorithms, and use Euclidean similarity. Kernel-based clustering algorithms use non-linear similarity measures, thereby achieving higher clustering accuracy than linear clustering algorithms. However, kernel-based clustering algorithms are ill-suited to streams because of their high computational complexity. In this poster, we present an approximate kernel-based stream clustering technique which identifies the most influential points in the stream, and retains only these points in memory. The final clusters are then obtained using only the stored data points. Only a small subset of the data (less than 1%) needs to be stored in memory, thereby enhancing the efficiency of kernel clustering for data streams. We demonstrate the accuracy and efficiency of our approximate stream clustering algorithm on several public domain data sets like the Network Intrusion and Tiny image data sets.

*This work was supported in part by the Office of Naval Research (ONR Grant N00014-11-1-0100).*

**CSE-26 Detecting Fake Fingerprints**  
**Authors:** Ajita Rattani; Arun Ross

**Abstract:** Recent research has highlighted the vulnerability of fingerprint recognition system to spoof attacks. A spoof attack occurs when an adversary mimics the fingerprint of another individual in order to circumvent the system. Fingerprint liveness detection algorithms have been used to disambiguate live fingerprint samples from spoof (fake) fingerprints fabricated using materials such as latex, gelatine, etc. Most liveness detection algorithms are learning based and dependent on the a) fabrication material used to generate and b) sensor used to acquire the fake fingerprints during the training stage. Consequently, the performance of a liveness detector is significantly degraded in multi-sensor environment and when novel fabrication materials are encountered during the testing stage. The aim of this work is to improve the interoperability of fingerprint liveness detectors across different sensors and fabrication materials. To this aim, the contributions of this work are i) a graphical model that accounts for the impact of the sensor on fingerprint match scores, quality and liveness measures and ii) a pre-processing scheme to reduce the impact of fabrication material on fingerprint liveness detector.
CSE-27  Local Predictions In Social Network Graphs  
Authors: Dennis Ross; Guoliang Xing; Abdol-Hossein Esfahanian

Abstract: Using the data from social networks, predictions have been made in several domains including: disease proliferation modeling, criminal activity detection, and recommender system design. With data from established social networks, like Twitter and Facebook, we try to make accurate predictions of several national trends on a local level. To do this with a social network G, an influential subgraph is created for each vertex v called Gamma of v. Each Gamma of v is chosen using a variety of graph properties like degree, modularity, and the clustering coefficient. Efficient algorithms to determine Gamma of v are discussed. By extracting the influential subgraph for each v in G, we attempt to make relevant predictions for any individual user. Some results will be presented along with potential real-world system deployments.

CSE-28  On Hair Recognition In The Wild By Machine  
Authors: Joseph Roth; Xiaoming Liu

Abstract: We present an algorithm for identity verification using only the information from the hair. Face recognition in the wild (i.e., unconstrained settings) is highly useful in a variety of applications, but performance suffers due to many factors, e.g., obscured face, lighting variation, extreme pose angle, and expression. It is well known that humans utilize hair for identification under many of these scenarios due to either the consistent hair appearance of the same subject or obvious hair discrepancy of different subjects, but little work exists to replicate this intelligence artificially. We propose a learned hair matcher using shape, color, and texture features derived from localized patches through an AdaBoost technique with abstaining weak classifiers when features are not present in the given location. The proposed hair matcher achieves 71.53% accuracy on the LFW View 2 dataset. Hair also reduces the error of a COTS face matcher through simple score-level fusion by 5.7%.

CSE-29  NSGA-III Performance In Bi-Objective Optimization  
Authors: Haitham Seada; Kalyanmoy Deb

Abstract: NSGA-III is a recently suggested evolutionary many-objective optimization algorithm that is designed to solve three or more objective problems. Although, NSGA-III was found to be superior to other state of the art algorithms in handling three or more objectives (up to 20), no formal assessment of its performance was conducted on handling only two objectives. This study aims at directing subsequent lines of research, either towards enhancing NSGA-III in terms of two objectives without sacrificing its superiority in higher number of objectives, or towards a more unified version of NSGA-III that can handle any arbitrary number of objectives with the same efficiency. In this paper, we assess the performance of NSGA-III against a number of test as well as real-life engineering problems. We also empirically investigate the effect of some critical parameters on the overall performance. Based on the obtained results, we introduce some interesting directions that researchers in the field can pursue in the future.

CSE-30  Secure Unlocking Of Mobile Touch Screen Devices By Simple Gestures: You Can See It But You Can Not Do It  
Authors: Muhammad Shahzad; Alex X. Liu; Arjmand Samuel

Abstract: With the rich functionalities and enhanced computing capabilities available on mobile computing devices with touch screens, users not only store sensitive information (such as credit card numbers) but also use privacy sensitive applications (such as online banking) on these devices, which make them hot targets for hackers and thieves. To protect private information, such devices typically lock themselves after a few minutes of inactivity and prompt a password/PIN/pattern screen when reactivated. Passwords/PINs/patterns based schemes are inherently vulnerable to shoulder surfing attacks and smudge attacks. Furthermore, passwords/PINs/patterns are inconvenient for users to enter frequently. We propose GEAT, a gesture based user authentication scheme for the secure unlocking of touch screen devices. Unlike existing authentication schemes for touch screen devices, which use what user inputs as the authentication secret, GEAT authenticates users mainly based on how they input, using distinguishing features such as finger velocity, device acceleration, and stroke time. Even if attackers see what gesture a user performs, they cannot reproduce the behavior of the user doing gestures through shoulder surfing or smudge attacks. We implemented GEAT on Samsung Focus running Windows, collected 15009 gesture samples from 50 volunteers, and conducted real-world experiments to evaluate GEAT’s performance. Experimental results show that our scheme achieves an average equal error rate of 0.5% with 3 gestures using only 25 training samples.

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Abstract: The project focuses on quantifying the computational effectiveness of mRNAseq protocols on various cloud computing platforms. The Illumina HiSeq 2500 (currently used at MSU's RTFS) can produce 600 GB of data per run. While the price of extracting a single dataset at this sensitivity level is extremely high in its own right, adding in steps to assemble and analysis it can easily cost $10K. This results in small biology labs being instantly excluded from conducting research. Through high-level analysis of patterns in during all stages of the protocol, bottlenecks in algorithms can be identified and addressed. Since each cloud-computing cluster has a different hardware implementation, the bottleneck is not universally constant. By leveraging the strengths of each platform, the GED lab aims to reduce overall cost. The Eel Pond mRNAseq Tutorial by C. Titus Brown, et al., has been the basis of initial testing. The results from this testing show Amazon's vCPU system out-performs traditional CPU structures.

CSE-33 Stain Simulation On Curved Surfaces Through Homogenization
Authors: Shiguang Liu; Xiaojun Wang; Yiying Tong

Abstract: This poster provides methods for physically-based simulation in stain formation in computer graphics. We propose to use proper averaging of the textile diffusion property to create realistic stains. The simulation is performed directly on the surface. For different type of knitting, we apply the homogenization technique in 2D to extract bulk diffusion tensor which is anisotropic in general. We then map the diffusion tensor onto curved surfaces by specifying the alignment of the textile to a direction field on the surface. The influence on the shape of the stain is determined by using the inertial force experienced in a comoving framework attached to the deforming surface. Our results demonstrate that the process is physically plausible.

This work was supported in part by NSF

CSE-34 ORION: Online Regularized Multi-Task Regression And Its Application To Ensemble Forecasting
Authors: Jianpeng Xu; Pang-Ning Tan; Lifeng Luo

Abstract: Ensemble forecasting is a well-known numerical prediction technique for modeling nonlinear dynamic systems. The ensemble member forecasts are generated from computer-simulated models, where each forecast is obtained by perturbing the initial conditions or using a different model representation of the dynamic system. The ensemble mean or median is typically chosen as a point estimate of the final forecast for decision making purposes. However, this approach is limited in that it assumes each ensemble member is equally skillful and does not consider the inherent correlations that may exist among the ensemble members. In this poster, we cast the ensemble forecasting task as an online, multi-task regression problem with partially observed data and present a novel framework called ORION to estimate the optimal weighted combination of the ensemble members. The weights are updated using an online learning with restart algorithm to deal with the partially observed data. The framework can accommodate different types of loss functions including epsilon-insensitive and quantile loss. Experimental results on seasonal soil moisture predictions from 12 major river basins in North America demonstrate the superiority of the proposed approach compared to the ensemble median and other baseline methods.

This work was supported in part by NOAA Climate Program office through grant NA12OAR4310081 and partially supported by NASA Terrestrial Hydrology Program through grant NNX13AI44G.
Abstract: The scale of the plant phenotyping data is growing exponentially, and they have become a first-class asset for understanding the mechanisms affecting energy intake and storage in plants, which are essential for improving crop productivity and biomass. However, the quality of data is compromised by systematic errors, unbiased noise as well as abnormal patterns, which are difficult to remove in data collection step. Given the value of clean data for any operation, the ability to improve their quality is a key requirement.

Data cleaning is the process of identifying incorrect or corrupt records in a dataset, integrating ad-hoc tools, manually tuned algorithms designed for specific tasks, and ideal statistical methods. However, removing impurities from long time-series plant phenotyping data requires the handling of high temporal dimension, which has not been extensively discussed in literature.

In this work, we develop a novel computational framework to effectively identify abnormalities in plant phenotyping data using Michaelis-Menten kinetics, one of the best-known models of enzyme kinetics in biochemistry. Specifically, our model employs an EM process to repeatedly classify the temporal data into two classes: abnormalities and non-abnormalities. In each iteration, it uses values of non-abnormality class to generate photosynthesis-irradiance curves at different granularities using Michaelis-Menten kinetics, and then reassigns the class membership of every value based on their fitness to the curves. The iteration stops when all the class memberships don't change. The results show our algorithm can identify most of the abnormalities in both real and synthetic datasets. Note that our algorithm is independent of actual biological constrains. With simple extension, it makes it possible to automate the cleansing process on long time-series data for a variety of domains.

This work was supported in part by NSF’s Center for Identification Technology Research (CIeR)

CSE-37 WWN: Integration With Coarse-To-Fine, Supervised And Reinforcement Learning
Authors: Zejia Zheng; Juyang Weng; Zhengyou Zhang

Abstract: Are your visual capabilities largely learned or largely innate? How does a human child learn directly from his cluttered environments? How do his actions play a central role in not only associating between sensation with the required action, but also attention and perception of objects of interest in a cluttered scene? How does the child develop concepts and invariant properties when he is not even aware of such concepts? Our research group has been addressing these scientific questions that are fundamental to not only Artificial Intelligence (AI) and its practical applications but also our understanding of human intelligence. This poster explains the work after Where-What Network 8 (WWN-8), where we intend to show how the above questions are addressed not only in a brain-inspired way, but also in terms of efficiency of autonomous learning: How learning must incorporate various modes of learning by a single general-purpose architecture --- supervised learning, coarse-to-fine learning, and reinforcement learning (i.e., learning through punishments and rewards).

This work was supported in part by Microsoft Research
ECE-01 1.0 RobustICA-Based Blind Separation Of Convulsive Mixtures  
Authors: Zaid Albataineh; Fathi Salem

Abstract: We present a frequency-domain method based on robust independent component analysis (RICA) to address the multichannel blind source separation (BSS) problem of convulsive speech mixtures in highly reverberant environments. We apply the algorithm to separate the source signals in adverse conditions i.e. highly reverberation conditions and when the short observation signals are available. Furthermore, we study the impact of several parameters on the performance of separation, e.g. overlapping ratio and window type in the frequency-domain method. We also perform the comparison between different techniques to solve the permutation ambiguity. Through Simulations and real-world experiments, we verify the superiority of the presented algorithm over other state-of-the-art BSS algorithms, e.g., recursive regularized ICA (RR-ICA), independent vector analysis (IVA) and others.

ECE-02 Constrained Blind Multiuser Detection For DS-CDMA System  
Authors: Zaid Albataineh; Fathi Salem

Abstract: A blind multiuser detector is presented to enhance the computational complexity and mitigate the multiple access interference (MAI). This detector is targeting direct-sequence code division multiple access DS-CDMA communication systems. The ill-condition of the covariance matrix of the received signals degrades the performance of the linear minimum mean-squared error LMMSE detector- especially, when the Signal to noise ratio is high and small data set is available.. In this poster, we introduce a constrained blind multiuser detection approach in order to improve performance with imposing a regularization parameter to tackle the ill-conditioning of the covariance matrix. Through simulation results, we verify that the proposed method improves the performance of the blind multiuser detection and outperforms the conventional multiuser detections.

ECE-03 Increasing Efficiency Of Monte Carlo Particle-Fluid Collision Calculations On GPU  
Authors: Charles Bardel; John Verboncoeur

Abstract: Monte Carlo particle collision calculations are computationally expensive for particle-in-cell codes. One approach is to calculate the energy of every particle to calculate the probability of a type of collision, then perform those collisions for a small number of particles. An alternative approach is utilizing the null collision method [1], which consists of taking randomly selected sample particles for collision with total collision probability, which is independent of particle energy. The approach described above is then applied to the sample. The full collision method has sparse random access of particles in the particle array which has drawbacks on the GPU threads. The threads work in sets called warps and issues one memory instruction with SIMD architecture. When memory instructions are distant, they are issued as individual instructions, however, when two memory instructions are located within 128 bytes [2] of each other they can be coalesced into one instruction. By utilizing the data structure and algorithm presented in [3], for efficient particle to grid charge accumulation on the GPU, all particles contained within a cell are memory contiguous. This paper examines the effect of selecting contiguous particles for collision through the same list. This setup does not require energy of each particle to be calculated and optimizes the memory-bandwidth in GPU without significant effect on the result of the simulation.

This work was supported in part by AFOSR Grant on the Basic Physics of Distributed Plasma Discharges.

ECE-04 Dynamic Modeling Of Robotic Fish Actuated By Pectoral Fins With Flexible Passive Joint  
Authors: Sanaz Bazaz Behbahani; Xiaobo Tan

Abstract: Pectoral fins are important actuation mechanisms in achieving maneuvering and propulsion for robotic fish. Existing designs predominantly adopt a rigid joint connecting the actuator to the pectoral fin, which requires differential actuation speeds in the power and recovery strokes in order to produce thrust and limits the overall actuation frequency. To address this problem, we propose a novel design of a flexible joint, which enables the pectoral fin to sweep back passively along the fish body in the recovery stroke, to minimize the drag, while maintaining the prescribed motion in the power stroke. The pectoral fin mechanism is modeled by two rigid segments connected with a pair of torsional spring and damper. This design results in a net thrust even with the same recovery and power stroke speed within each fin beat cycle, which simplifies the fin control. Experimental results on a robotic fish prototype validates the effectiveness of the proposed model, and demonstrates the significant advantage of the proposed fin joint over the rigid joint.

This work was supported in part by National Science Foundation (Grant DBI-0939454, CNS-1059373, IIS-0916720, IIS-1319602, and CCF-1331852).

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ECE-05  A Lyapunov Function Based Fast Transient Stability Screening And Ranking Tool  
Authors: Mohammed Ben-Idris; Joydeep Mitra

Abstract: As a result of market forces, increased renewable generation, and recent advances in power flow control technologies, power systems are increasingly being operated closer to their stability limits. On-line transient stability assessment, TSA, has become one of the important features for systems that operate in such stressed environment. Attempts to reach on-line transient stability assessment have been facing high computation burden and low calculation speed. Most of the current strategies drop off the non-severe contingencies using screening tools and perform detailed simulations on the severe contingencies. The most important factors of any screening tool are the absolute capture of the unstable events and the efficiency of capturing the stable events. This work introduces a fast transient stability screening tool to classify a designated set of contingencies into stable and unstable subsets using direct methods. The proposed method is based on the conservativeness of the transient stability direct methods. The classification processes of the contingencies are performed along the solution trajectory towards the Controlling Unstable Equilibrium Point, controlling UEP. The proposed screening tool is intended to reliably capture the unstable contingencies and efficiently reduce the number of contingencies that need further analyses. If a numerical problem is encountered during the computation, the proposed scheme applies homotopy-based approaches to find the desired solution. If the numerical problem cannot be solved using homotopy-based methods, the contingency is sent to a time-domain simulator for further analysis. The method is applied to the Western System Coordinating Council (WSCC) test system and results are presented.

ECE-06  Application Of Single Crystal Diamond For Swift-Heavy Ion Beam Detector  
Authors: Ayan Bhattacharya; Andreas Stolz; Timothy A. Grotjohn

Abstract: Diamond has some extreme material properties which makes it a very attractive candidate for thermal, optical and nuclear fusion applications. In the last couple of decades, application of diamond for high energy radiation detector has become an emerging field of interest. The nature of interaction of ions with materials depend on the ion’s mass, energy. Diamond has good radiation tolerance for detecting swift heavy ion beam as compared to many other semiconductor materials. In this study, single crystal diamond is investigated as a detector for swift heavy ion beams. Here detection performance of plasma-assisted CVD diamond is studied with the long-term objective of better understanding the detector degradation process and the detector lifetime in swift, heavy ion beam applications.

Detectors are fabricated using lab grown single crystal diamond at MSU that are first mechanically polished followed by chemical-mechanical polishing and/or plasma-assisted etching to reduce surface roughness. Some properties of the diamond material are characterized using birefringence, UV-VIS and FTIR (Fourier Transform Infrared spectroscopy) measurements. The detectors are characterized using capacitance and dark current (leakage current) measurement. The charge collection efficiency (CCE), the charge collection distance (CCD) and transient current characteristics are also studied for better realization of detectors performance. The detectors are tested with an alpha-particle source and by irradiation with a 150 MeV/u 78Kr beam. The detailed experimental characterization measurements are conducted both prior to and after the samples are irradiated with swift heavy ion beam to understand the effect of radiation damage.

This work was supported in part by SPG - MSU/MSU Foundation

ECE-07  A Novel Microfluidic Sensor Using Metamaterial Periodic Structure  
Authors: Jennifer Byford; Kyoung Youl Park; Prem Chahal

Abstract: There is a growing demand for inexpensive sensors that can effectively detect changes in minute samples of liquids. Applications range from biomedical devices, lab on chip devices, environmental monitoring and forensic investigations. The proposed microstrip based microwave structure of this poster does not require calibration, does not require tagging, is simple and inexpensive to fabricate and can easily be miniaturized. Our structure, based on an open split ring resonator (OSRR) design, works by detecting dielectric changes in liquids as the liquids load the circuit. This dielectric loading interacts with the electric field around the structure and causes its resonant frequency to change. Given the shift in resonant frequency and change in amplitude, changes in the liquids loading the circuit can be determined. Multiple unit cells can be integrated on a single microstrip line to detect several samples in parallel and thus leading to high throughput. The structure and microfluidic channels were designed and simulated in the finite element analysis tool Ansoft HFSS. The structure was made using wet-etching techniques and the channel using a PDMS (Polydimethylsiloxane) mold. The sensor was tested as a single unit cell, in a three cell aperiodic array and as an array of three different sensors. Different concentrations of water-isopropanol (IPA) and water-methanol were used to characterize the sensor. Measurements are carried out using a network analyzer and resonance frequencies are determined. A biosensor application was demonstrated in detecting glucose-d concentration in deionized water.
ECE-08  Infrared Light Field Imaging Using Single Carbon Nanotube Detector
Authors: Liangliang Chen; Ning Xi; Ruiguo Yang; Bo Song; Zhiyong Sun; Zhanxin Zhou

Abstract: The conventional photographs only record the sum total of light rays of each point on image plane so that they tell little about the amount of light traveling along individual rays. The focus and lens aberration problems have challenged photographers since the very beginning and light field photography was proposed to solve these problems. Lens array and multiple camera systems were used to capture angular information, by reordering which the different views of scene were captured. The coded aperture is another method to encode the angular information in frequency domain. However, lens aberration still is an inescapable problem when acquiring angular image. In the paper, we propose micro plane mirror optics, together with compressive sensing algorithm to record angular information to avoid aberration problem, which was named digital computational light field photography. The micro mirror reflects objects and forms a virtual image behind the plane in which the mirror lies. It consists of millions microscales mirror which works as CCD array in camera and it was controlled separately so as to project linear combination of object image on lens array. The carbon nanotube based infrared detector, which has ultra high signal to noise ratio, and fast responsibility, will sum up all image information on it, without image shape effect. Based on a number of measurements, compressive sensing algorithm was used to recovery angular image, and computed different views of scene to reconstruct infrared light field scence.

ECE-09  Modeling Of Natural Language Controlled Robotic Systems
Authors: Yu Cheng; Yunyi Jia; Rui Fang; Lanbo She; Ning Xi; Joyce Chai

Abstract: Instructing robots through natural language commands is an intuitive and flexible way to interact with robots by humans. It has tremendous advantages of reducing users’ recognition load, decreasing personnel cost and providing great convenience to untrained users, especially for the old and the disabled. Since robotic systems and humans have totally different structures, it is difficult for robots to understand natural language commands directly. Currently, extensive research has been focused on the action scheduling extracted from the natural language instructions, i.e., the translation from natural language input to a representation that the robots can understand. However, a more practical problem arises when implementing the generated action plans which is whether the performances of a robotic system can satisfy the given task specifications or not. Since current action scheduling processes are designed open-loop, the robotic system’s performances may not meet the desired requirements in face of modeling errors, system variations, and uncertainties. We propose a closed-loop action scheduling framework to handle unexpected events that may occur in both the robot side and the environment side. A minimum-cost action scheduling method is used to search for the shortest action sequence. Experimental results on a natural language controlled mobile manipulator demonstrate the effectiveness, advantages and robustness of the proposed method.

This work was supported in part by NSF: RC101957

ECE-10  GMM-MLFMA: A Fast Solver For Electromagnetic Scattering Problems
Authors: D. Dault; B. Shanker

Abstract: The ongoing explosion in radiative electromagnetic devices, from smartphones to wireless Internet to satellite communication, demands flexible and fast electromagnetic simulation capabilities. However, the efficient modeling of electromagnetic scattering and radiation from large and multiscale structures is a continuing open problem in the field of Computational Electromagnetics. This work provides a step forward in resolving this problem through the introduction of an acceleration methodology that hybridizes the recently developed Generalized Method of Moments (GMM), an electromagnetic integral equation method, with the Multilevel Fast Multipole Algorithm (MLFMA), the most widely used acceleration technique for electromagnetic integral equations. The resulting scheme combines the advantages of both methods. First, it harnesses the ability of GMM to provide quasi-optimal representations of electromagnetic fields via blending of local geometry and field representations over the surface of the target object. Second, it introduces spatial blending into the MLFMA acceleration algorithm, and therefore permits optimal acceleration of any mixture of lower and higher order field descriptions on discretizations of the scattering body using subdomains of arbitrary size. Traditional MLFMA approaches do not maintain optimal acceleration as subdomain size is varied, and applying MLFMA to discretizations with subdomains that are large with respect to a wavelength is an unsolved issue. The approach developed in this work is the first to maintain optimal MLFMA acceleration regardless of subdomain sizes, and furthermore retains its optimality for any arbitrary mixture of representations. The resulting method provides solutions to electromagnetic scattering and radiation problems that are both accurate and efficient relative to the current state of the art.

This work was supported in part by NSF Graduate Research Fellowship Program; NSF CCF-1018516; NSF CMMI-1250261
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**ECE-11 Improving The Boron Doping Efficiency Of Single Crystal Diamond**

**Authors:** Shannon N. Demlow; Robert Rechenberg; Timothy A. Grotjohn

**Abstract:** As an electronic material, diamond would be particularly well suited to high-temperature and high-power devices, such as vertical Schottky Barrier diodes, due to its high breakdown voltage and carrier mobilities and exceptional thermal conductivity. Fabrication of high quality vertical diode structures necessitates freestanding, single crystal p-type diamond substrates, with low resistivity obtained through heavy doping (> 1020 cm⁻³). To achieve freestanding substrates, the diamond must be mechanically handleable after laser cutting from the growth substrate, and therefore thick (> 300 μm). A problem of current interest in boron doped single crystal diamond (SCD) is the observation of decreasing doping efficiency at higher pressures (higher plasma discharge power) [1].

This work expands upon our previous effort to grow and characterize high-quality diamond for electrical applications [2], and examines the factors which contribute to increasing the gas chemistry to solid-phase doping efficiency. Homoeptaxial diamond is grown on type Ib high-pressure high-temperature (HPHT) SCD substrates in a microwave plasma-assisted chemical vapor deposition (MPACVD) bell-jar reactor with feedgas mixtures including hydrogen, methane, and diborane. We summarize strategies for increasing the boron doping efficiency of SCD, including the effects of deposition temperature, growth rate and total flow rate of the plasma feedgas.

References


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**ECE-12 Strongly Coupled Plasmas**

**Authors:** Gautham Dharuman; John Verboncoeur; Andrew Christlieb

**Abstract:** Strongly Coupled Coulomb Plasmas are non-ideal plasmas with strong inter-particle interactions that dominate thermal motion. The strong correlations result in interesting properties that are absent in conventional plasmas. However, to understand these properties expensive computational studies are required due to the large number of particles and the associated interactions. Adding to the complexity are some quantum effects that are crucial in the dynamics of such plasmas. A complete quantum mechanical simulation is computationally prohibitive. This study focuses on semi-classical methods that can capture the essential quantum aspects within reasonable computational expense.

*This work was supported in part by Air Force Office of Scientific Research (AFOSR)*

**ECE-13 Quantitative Assessment Of Customer Perception From Vehicle Service Data**

**Authors:** Kalyanmoy Deb; Sunith Bandaru; Abhinav Gaur; Vineet Khare; Rahul Chougule

**Abstract:** We have developed a method for the quantitative modeling of a Customer Satisfaction Index (CSI) function for consumer vehicles. The mathematical model is evolved using an evolutionary computation technique such that the satisfied and dissatisfied customers are equally distributed on either side of the mean satisfaction level. Instead of relying on a conventional survey based assessment, we extract various important features from the service (field failure) data of five different vehicle models and build optimized CSI functions for each. The approach is extended so that a single CSI function can predict the satisfaction for all customers of all five models, thus providing a measure of the market's perceived quality of one vehicle model relative to another. Different combinations of vehicle models are used and the corresponding CSI functions are validated against the ratings published by Consumer Reports. A sensitivity analysis reveals interesting information about the features extracted from the service data. Thereafter, the CSI function which best differentiates between all five vehicle models is chosen for further use. Finally, we present how such a model can be useful in gaining important insight into factors affecting the customer perception of vehicle quality and extract actionable knowledge, crucial from Customer Relationship Management (CRM) point of view, from the service data such as; (i) identifying high-priority problems for different vehicle models and (ii) identifying high priority customers customer-perception per se.

*Abstracts of the 2014 Engineering Graduate Research Symposium, Michigan State University*
Abstract: Nedelec edge elements remain a popular choice when choosing a basis for the numerical solution of electromagnetic fields and have been extensively used in commercial applications; however, while this basis set naturally satisfies tangential continuity of fields across element interfaces, no such condition is imposed on normal components as is necessary to correctly represent electromagnetic fields. Additionally, electromagnetic problems involving both the vector and scalar potentials, prominent in the interaction of quantum mechanical states and electromagnetic fields, cannot be solved with a strictly vector basis set.

Hermite interpolatory polynomials were proposed as a basis set for scalar FEM modeling of electromagnetic fields in a waveguide as early as 1987 (Israel and Miniowitz, IEEE Trans. Microwave Theory Tech. MTT-35, 1019-1025, 1987). Recently, a method was introduced for deriving sets of minimal-order C^n interelement continuous Hermite interpolatory polynomials on triangles (Kassebaum, et al., J. Comput. Phys. 231, pp. 5747–5760, 2012). This interpolation method can specify continuity of not only tangential and normal fields at interelement surfaces, but their derivatives as well. Another recent work hybridizes Hermite interpolation methods with discontinuous Galerkin geometric discretizations in both 1-D and 2-D (Chen, et al., J. Comput. Phys. 257, pp. 501-520, 2014).

In this work, we will present the 3-D Hermite interpolatory basis set on tetrahedra. Several results will be presented to study the following: (i) h- and p-convergence of eigenvalues, (ii) convergence of field representation in piecewise inhomogeneous domains, (iii) comparison against higher order vector finite elements for field representation in complex topologies.

This work was supported in part by AFOSR

ECE-15 Modeling And Simulation Of Strongly Coupled Plasmas
Authors: Mayur Jain; John Verboncoeur; Andrew Christlieb

Abstract: This work focuses on the development of new modeling and simulation tools for studying SCP which differ from traditional plasmas in that their potential energy is larger than kinetic energy. The standard quasi neutral plasma model does not account for two major effects in SCP: 1) Change in the permittivity for modeling electromagnetic waves. 2) Impact on relaxation of charged particles undergoing Coulomb collisions with weakly shielded long range interactions. These objectives will be met through the development of: (i) Electrostatic particle based models based on PIC and Boundary integral Treecode (BIT) methods (ii) Electromagnetic particle based models based on PIC and new implicit particle methods based on treecodes (iii) Continuum models with long range correlations incorporated through fractional derivatives in time.

BIT is a mesh free method offering advantages in simulating resolved SCP with boundary conditions, whereas resolved PIC necessitates a prohibitively fine mesh when including boundary conditions. A treecode algorithm reduces operation count from O(N^2) to O(N log N). The particles are divided into a hierarchy of clusters and particle-particle interactions are replaced by particle-cluster interactions evaluated using multipole expansions. Treecodes use monopole approximations and a divide-and-conquer evaluation strategy and have been very successful in particle simulations with ongoing interest in optimizing their performance. BIT is an ideal method for studying strongly coupled electrostatic plasmas consisting 10^8 atoms. In this context BIT can be used to simulate a one to one representation of the ultra cold SCP, each particle representing a physical particle, naturally resolving long range interactions.

This work was supported in part by U.S. Army Research Office Contract No. W911NF-11-D-0001, and U.S. Army Research Office Grant No. W911NF-09-1-0321 and W911NF-10-1-0358, and National Science Foundation Award No. CNS-1320561 and IIS-1208390.

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ECE-17  
**Defect Characterization In A 2D Steel Plate Using Non-Destructive Evaluation (NDE) Methods**  
**Authors:** Victor U. Karthik; Sivamayam Sivashathan; S. Ratnajevan H. Hoole  

**Abstract:** When a steel plate in an army ground vehicle is found to be defective, usually it is taken out of service for repairing without determining if the defect warrants withdrawal or not, whereas the defect might be minor and withdrawal wasteful. On the other hand the defect might be invisible, yet warranting replacement. In our work we investigate and establish a procedure for defect characterization – thin crack, defect size and shape, spall, etc. – so that a decision to withdraw may be thought-out, justifiable and ensure the safety of the vehicle and its passengers. The methodology at present examines the response of the hull under test to an excitatory signal from an eddy current probe. Knowing the response when there is no defect, if the response is different because of the defect, the test object is presently flagged as defective and the vehicle sent for repairs without assessing if the defect is serious enough for removal from service. In this paper, we extend that methodology to defect characterization. A defect shape is characterized by parametric dimensions and properties (h), and we then solve the associated finite element problem with the defect, optimizing h until the computations match the measurements. The methodology is demonstrated by reconstructing a crack in a vehicle hull plate using eddy current probes. The problem is shown to be amenable to rapid analysis using the new GPU capabilities. This defect characterization would allow unseen serious defects to be flagged, and not allow minor defects leading to a vehicle being pulled out of service.

*This work was supported in part by US Army TARDEC*

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ECE-18  
**Study Of Reduced Graphene Oxide Based Microwave Circuits On Flex Substrates**  
**Authors:** Amanpreet Kaur; Xianbo Yang; Premjeet Chahal  

**Abstract:** Flex Radio frequency (RF) and microwave circuits enable various applications in wireless communication, security, bio-sensing and smart IDs. Although significant progress has been made in the area of flex circuits, fabrication of RF circuits still poses a significant challenge, esp. realization of active components. The material system used in the design of active circuits should have high carrier mobility at room temperature, good mechanical properties and ease of integration. Along with conventional semiconductors, various nanomaterials such as carbon nanotubes and graphene have been explored for RF applications. Carbon nanotubes (CNTs) and graphene have unique electrical properties such as high carrier mobility at room temperature; ballistic transport and micron-scale mean free paths. CNT based devices have high impedance and pose challenge in impedance matching which can be overcome with the use of graphene based devices.

This paper demonstrates fabrication and characterization of reduced graphene oxide (RGO) based RF devices on a flexible substrate. The current-voltage measurements show strong non-linearity. Diodes are tested for high frequency applications such as detection, frequency multiplication and mixing over a frequency range of 1 – 18 GHz. The devices show third order frequency multiplication for measured fundamental frequencies of 1, 2, 3, and 4 GHz and shows low-loss frequency mixing. Details of DC characteristics, RF rectification, mixing and multiplication using RGO Schottky diodes are presented.

*This work was supported in part by the DARPA YFA program.*

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ECE-19  
**Characterization And Modeling Of Humidity-Dependence Of IPMC Sensing Dynamics**  
**Authors:** Hong Lei; Chaiyong Lim; Xiaobo Tan  

**Abstract:** Ionic polymer-metal composites (IPMCs) have intrinsic actuation and sensing capabilities. For an IPMC sensor operating in air, the water content in the polymer varies with the humidity level of the ambient environment, which leads to its strong humidity-dependent sensing behavior. In this study, the influence of environmental humidity on IPMC sensors is characterized and modeled from a physical perspective. Specifically, a cantilevered IPMC beam is excited mechanically at its base inside a custom-built humidity chamber. We first obtain the empirical frequency responses of the sensor under different humidity levels, with the IPMC base displacement as input and the tip displacement and short-circuit current as outputs. Based on physics-based model for a given humidity level, we then curve-fit the measured frequency responses to identify the humidity-dependent physical parameters, including Young’s modulus, strain-rate damping coefficient, and viscous air damping coefficient for the mechanical properties, and ionic diffusivity for the mechanoelectrical dynamics. Static charging experiments of the IPMC are also conducted simultaneously, which are used to identify the effective dielectric constant. These parameters show a clear trend of change with the humidity. By fitting the identified parameters at a set of test humidity levels, the humidity-dependence of the physical parameters is captured with polynomial functions, which are then plugged into the physics-based model for IPMC sensors to predict the sensing output under other humidity conditions. The latter humidity-dependent model is further validated with experiments.

*This work was supported in part by National Science Foundation (ECCS 0547131); the Office of Naval Research (N000140810640, N000141210149).*
Abstract: Portable low-cost microplasma sources received interest in the past decade due to their various applications including materials processing, biomedical and chemical analysis, and optical radiation sources.[1-5] In particular, for atmospheric pressure microwave microplasmas that do not require vacuum systems, it is possible to realize 3D motion operation and portable lower-cost operation. Further, by using higher frequency energy (radio frequency and microwave) to power the microplasma discharge, non-LTE (non-local thermo-dynamic equilibrium) plasmas have the advantage of reducing the erosion of electrodes and also producing high power density plasmas with reasonably low power consumption.

In this investigation two microwave-powered microplasma systems are characterized using optical emission diagnostics. The first system is developed based on a double-strip-line structure. Top and bottom copper strip-lines are separated by a dielectric material. The structure is powered at one end and the plasma is formed at the other end where the two copper strip-lines are brought together to a gap with 250 microns separation. The feedgas is flowed through a channel in the dielectric such that it exits with the feedgas flowing into the gap created by the two strip-lines. The second system is constructed using a small foreshortened cylindrical cavity that has a hollow inner conductor and a small capacitive gap at the end of the cavity. The feedgas is flowed through a 2 mm inner diameter quartz tube which is located inside the hollow inner conductor of the cavity. Pure Argon, Argon-Oxygen mixtures (up to 10% Oxygen) and Argon-Hydrogen (with 2% hydrogen) are used as feedgas. The microwave power used for the discharges varies from 5 to 60 Watts. The flow rate of the feed-gases varies from 900 sccm - 2100 sccm. The optical emission spectroscopy technique was used to diagnose the discharges. Plasma properties such as rotational temperatures and electron densities under different conditions (power, flow rate and gas combinations) are measured and analyzed.

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ECE-22 Two-Dimensional Svd For Event Detection In Dynamic Functional Brain Networks
Authors: Arash Golibagh Mahyari; Selin Aviyente

Abstract: In recent years, there has been a growing interest in analyzing functional connectivity networks estimated from neuroimaging technologies using graph theory. Previous studies of the functional brain networks have focused on extracting static or time-independent networks to describe the long-term behavior of brain activity. In this paper, we propose a dynamic functional brain network tracking and summarization approach to describe the time-varying evolution of connectivity patterns in functional brain activity. The proposed approach is based on two-dimensional SVD of the three-mode tensor representation of dynamic graphs. First, the event intervals are identified based on the change in the reconstruction error in the lower dimensional space and then the activity in the event intervals are summarized. The proposed method is evaluated for characterizing time-varying network dynamics from event-related potential (ERP) data indexing the well-known error-related negativity (ERN) component related to cognitive control.

This work was supported in part by the National Science Foundation under Grant No. CCF-1218377.

ECE-23 A Periodic Discontinuous Galerkin Time Domain Framework With A Floquet Mode Absorbing Boundary Condition
Authors: Nicholas Miller; Andrew Baczewski; John Albrecht; Balasubramaniam Shanker

Abstract: In electromagnetics and optics, periodic structures are important for effecting engineered frequency responses. Applications include conventional microwave frequency selective surfaces (FSS), metamaterials, or synthetic periodic systems that effect extraordinary properties. Numerical simulations offer an economical means for designing these periodic structures. Modeling becomes difficult when engineering designs require increasingly complex structures and broadband spectral content. For doubly infinite structures, the grid-based computational framework requires periodic and radiation boundary conditions to analyze broadband, higher order Floquet mode content. This framework should also be amenable to inhomogeneous, dispersive, and non-linear materials.

A computational framework which meets all this criteria is the nodal Discontinuous Galerkin Time Domain (DGTD) method. Recently, a periodic DGTD framework was developed to analyze homogeneous and lossless doubly periodic structures under oblique broadband excitation (Miller et al., pre-print, arXiv:1311.0790). This framework employed field transformations to render causal periodic boundary conditions and a planewave absorbing boundary condition (P-ABC) to truncate fundamental Floquet modes. The P-ABC, however, is shown to be insufficient for absorbing higher order Floquet content. In this contribution, we will develop a formulation which relates the transformed electric field Floquet modes to magnetic field Floquet modes to properly absorb outward propagating scattered waves. The outward propagating solutions will be used as a Dirichlet boundary condition in the periodic numerical flux to truncate the computational domain. Results presented will validate our formulation and demonstrate utility for studying structures in which Floquet modes beyond zeroth order are excited.

This work was supported in part by the National Science Foundation through grant CCF:1018576.

ECE-24 Investigating The Dependencies And Limitations Of High Pressure Microwave Plasma Assisted Chemical Vapor Deposition Of Single Crystalline Diamond
Authors: Matthias Muehle; M. F. Becker; T. Schuelke; J. Asmussen

Abstract: Our research activities have focused on improving single crystalline diamond (SCD) growth rates and quality and also have been directed toward the development of microwave plasma reactors for high pressure diamond synthesis. Two new reactors, Reactor B and Reactor C have been developed. These reactors allow the safe and fast deposition of SCD material for pressures up to 300 Torr. However, the commercialization of an “electronic grade” SCD synthesis process requires the production of very high quality, large area SCD substrates at even higher growth rates. Increasing the SCD synthesis process pressure increases the growth rate and also seems to enhance crystalline quality. Here a new reactor, Reactor B’, is introduced, where a continuous wave (CW) microwave power supply is used. At high pressures exciting Reactor B with a 120 Hz pulse rate causes a flickering plasma ball and the plasma becomes unstable, thus it limits the safe and low maintenance operation of the reactor to an upper pressure limit of 280 Torr.

The results of a number of exploratory experiments using reactor B’ are presented. SCD deposition experiments were performed with process pressures up to 380 Torr (0.5 atm). A linear increase in growth rate versus pressure is observed. Additionally the dependency of the growth rate as a function of methane concentration is analyzed. For low concentrations a linear behavior has been identified, at higher methane concentrations (> 6-7%) the growth rate flattens out and appears to saturate versus additional increases of methane.
ECE-25  A Multi-Layered Metamaterial Inspired Dynamically Tunable Antenna
Authors: Joshua C. Myers; Premjeet Chahal; Edward Rothwell

Abstract: A multi-layered metamaterial inspired antenna with a pixel grid loading structure is introduced. The antenna consists of two layers separated by a thin dielectric substrate. The first layer contains a folded monopole antenna surrounded by a metal pixel based loading structure, while the second layer is envisioned to consist of a photoconductive pixel grid utilized to tune the antenna. The state of each pixel is controlled by a binary genetic algorithm, which is implemented with a Matlab-HFSS interface. HFSS simulations show that the second layer has a wide tuning ability with the appropriate state formed through optimization. As a proof of concept, the pixel grid on the second layer is initially made of a metal conductor. Multiple states corresponding to different resonant frequencies are selected and the antennas are constructed using conventional photolithography. The measured reflection coefficients are shown to be in good agreement with HFSS simulations, successfully demonstrating the ability to dramatically tune the antenna with a second pixel grid.

This work was supported in part by AFRL Research Grant

ECE-26 Performance And Efficiency Of Microwave Cavity Plasma Reactors Utilized In The Synthesis Of High Quality CVD Single Crystal Diamonds (SCDs)
Authors: Shreya Nad; Jes Asmussen

Abstract: High power and high pressure (100-300T) MPACVD reactors employ microwave discharges that provide an appropriate environment for synthesis of SCD. Microwave plasma reactors that operate in this high pressure regime must be able to sustain an efficient and stable high power density discharge hovering over the substrate. Recent reactor design advancements have led to an internally tunable microwave reactor [1]. This reactor has four independent geometry variables - short length (Ls), probe length (Lp), and reactor lengths (L1, L2). Here we investigate the nonlinear relationships between these mechanical variables and the usual input variables like pressure, power, substrate temperature, flow rate etc. Microwave coupling efficiency and substrate temperature are measured over the wide pressure, high input power regime as a stable plasma is formed and in contact with the substrate surface but placed away from the reactor walls. The reactor operating field map is experimentally defined and the diamond synthesis temperature window (700 – 1200°C) is determined. It is shown that as the substrate position varies the substrate temperature and the plasma shape can be varied with a modified discharge boundary layer. Regions where the reactor behaves in a safe and efficient manner are identified. Microwave coupling efficiencies of > 95% are demonstrated throughout the operating region and the mechanical variability of the reactor enables the optimization of the high quality SCD synthesis and yields a stable, controllable discharge over the entire pressure regime. This variability enables process control and process optimization over time.


This work was supported in part by Block gift from II-VI Foundation

ECE-27 General-Purpose Kinetic Global Modeling Framework For Multi-Phase Chemistry
Authors: Guy Parsey; Yaman Güçlü; John Verboncoeur; Andrew Christlieb

Abstract: Spatially averaged (global) models are ubiquitous in plasma science, and the required data and equations are conceptually very similar for most applications. Unfortunately, it is common practice to implement a custom-developed software for each new global model; this unnecessary duplication of efforts negatively affects quality control and code maintenance. We present a general purpose kinetic global modeling framework (KGMf) designed to support plasma scientists in all modeling phases: collection and analysis of the reaction data, automatic construction of a system of ordinary differential equations (ODEs), time evolution of the system, and dynamical optimization of some target function. Originally motivated by the study of plasma assisted combustion (PAC) systems, the KGMf incorporates both gas-phase and plasma driven reactions. Accordingly, densities of each species, gas temperature, and electron effective temperature are evolved in time. The model generator can be used interactively, or with user defined control files, to manipulate the EEDF, boundary fluxes, and external forcing terms (e.g. MW/RF power). The ODE system is created first symbolically, for interactive manipulation, and then compiled to a standalone C function; this allowing for fast evaluation independent from the KGMf. Batch (parameter scanning) and result-search evaluation methods are included as Python modules for exploring the extensive parameter space of the physical model. In order to demonstrate the capabilities and ease of use of the KGMf, we apply it to a plasma assisted system: CO2 dissociation with hydrocarbon catalyst.

This work was supported in part by MSU Strategic Partnership Grant

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ECE-28  **Full Wave Graphical Processing Unit (GPU) Analysis Of Circular Guiding Structures Using The Finite Difference Frequency Domain (FDFD) Method**  
**Authors**: Mohammad R. Rawashdeh; Nihad I. Dib; S. Ratnajeevan H. Hoole

**Abstract**: Modeling and determining propagation characteristics of waveguides and transmission lines is very important for quick analysis in designing microwave circuits. In this research, full wave finite difference frequency domain (FDFD) will be presented to analyze different magnetically isotropic and non-isotropic circular cylindrical guiding structures. The FDFD equations are presented for both one and two dimensional structures according to the nature of the problem. The first step was finding the results which are obtained through solving these FDFD equations via the eigen-value problem using CPU computing languages like C/C++ or MATLAB. The computed eigen-values and eigen-vectors are used to produce the propagation constants and the distribution of the fields. For ferrite loaded circular structures, full derivation and analysis is presented for completely filled azimuthally magnetized ferrite loaded coaxial lines and circular waveguides by using 2D-6FDFD and 1D-3FDFD equations. Most applications for azimuthally magnetized ferrite loaded coaxial lines and circular waveguides, such as isolators and phase shifters, operate using the TE0m modes. These TE0m modes are analyzed in detail in this research. The next step now is to use the benefits of the hardware accelerated scientific computing capability provided by graphics processing units (GPUs) to accelerate computations especially for complicated structures. CUDA-C will be used to build the needed algorithms in order to solve the eigen value problem of the FDFD.

ECE-29  **Genre Categorization Of Amateur Sports Videos In The Wild**  
**Authors**: Seyed Morteza Safdarnejad; Xiaoming Liu; Lalita Udpa

**Abstract**: Various sports video genre categorization methods are proposed recently, mainly focusing on professional sports videos captured for TV broadcasting. This paper aims to categorize sports videos in the wild, captured using mobile phones by people watching a game or practicing a sport. Thus, no assumption is made about video production practices and existence of field lining and equipment. Motivated by distinctiveness of motions for many sports activities, we propose a novel motion trajectory descriptor to effectively and efficiently represent a video. Furthermore, we propose a temporal analysis algorithm of local descriptors that integrates the categorization decision over time. Extensive experiments on a newly collected dataset of amateur sports videos in the wild demonstrate that our trajectory descriptor is superior for sports videos categorization and temporal analysis of descriptors improves the categorization accuracy further.

ECE-30  **Spherical Harmonic Expansion Method For Coupled Electron-Phonon Boltzmann Transport**  
**Authors**: Marco Santia; John Albrecht

**Abstract**: The thermal and electrical properties of semiconductors have traditionally been modeled by independent treatments for the phonon and charge carrier Boltzmann transport equations (BTE). These approaches, to varying degrees of approximation, work well near equilibrium and steady-state thus providing the baseline for many device simulations. Particle-based treatments, such as Monte Carlo methods, can in general allow for arbitrarily complex physical interactions but their stochastic nature has practical limitations for representing distribution functions in systems wide disparities in population. This work develops a coupled electron-phonon BTE based on a momentum-space spherical harmonic expansion (SHE) of the electron and phonon distribution functions and of the crystal eigenstates of electrons and phonons. We present a deterministic method which allows for detailed treatment of scattering processes comparable to particle solvers, yet alleviates the issues that arise in a system with populations ranging orders of magnitude from region to region in phase space. In this work we present the method formalism and examine the accuracy of the SHE for phonon band structures in GaN, scattering rates determined within that representation, and compare our preliminary results for distribution statistics in control examples such as thermal conductivity and drift velocity.

*This work was supported in part by Office of Naval Research.*
ECE-31 Extended Kalman Filtering For Remaining Useful Life (RUL) Estimation Of Bearings
Authors: Rodney Singleton II; Elias Strangas; Selin Aviyente

Abstract: Condition based maintenance, which includes both diagnosis and prognosis of faults, is a topic of growing interest in manufacturing, structural health monitoring and electrical drive operation. Although many signal processing and machine learning techniques have been successfully applied for fault identification and classification, prognosis of faults and especially predicting the remaining useful life (RUL) of the components is a remaining challenge. One reason for this challenge is lack of accurate physical models as well as the dependency of the existing algorithms to labeled training data. Bearings are one of the most widely used mechanical parts in rotational machinery and constitute a large portion of the failures. In this work, an extended Kalman filtering based framework is introduced to predict the RUL of bearing faults under different operating conditions and to provide a confidence interval to the RUL estimates. Various time domain features as well as joint time-frequency domain features are extracted from vibration signals and are used to define state space vectors to monitor the health of bearings and predict the remaining useful life. Performance of the prognosis method is evaluated on datasets from a test bed that generates bearing run-to-failure vibration data.

This work was supported in part by National Science Foundation under Grant No. EECS-1102316 and by the National Science Foundation Graduate Research Fellowship under Grant No. DGE-0802267.

ECE-32 A General Purpose Parameter Based Two Dimensional Mesh Generator For Seamless Optimization Problems
Authors: Sivamayam Sivasuthan; Victor. U. Karthik; S. Ratnajeevan H. Hoole

Abstract: In inverse electromagnetic problem solutions, parameter based mesh generation plays an essential role. As the geometry defined by parameters is optimized it changes shape, and a new finite element mesh must be created without stopping the optimization iterations to create a new mesh. Available mesh generators do not support such parameter based mesh generation without some manual input. This means that as optimization changes the shape we need to stop the program and make manual entry for a new mesh. The required mesh generator must therefore support parameter based mesh generation and be completely automatic once the optimization process begins – that means we must be able to change the physical shape of the problem during run time and generate the mesh. Such a mesh generator would help us implement a seamless optimization process in finite element analysis. This paper presents such an efficient, automatic, parameter-based mesh generator for optimization problems in finite element analysis. We present new software that can handle any general 2D geometrical shape and uses object oriented data structures to achieve superior performance. Examples of optimization carried out with this mesh generator are presented. Object oriented data structures are used to represent the problem. The software is developed in C/C++ and has been checked for many problems successfully.

This work was supported in part by TARDEC Grant No: RC103378

ECE-33 Ultra Accurate Positioning And Motion Control In SPM Based Nanomanipulation: Non-Vector Space Control With Hysteresis-Creep Hybrid Compensator
Authors: Bo Song; Ning Xi; Zhiyong Sun; Ruiguo Yang; Liangliang Chen

Abstract: Scanning probe microscopy (SPM) based nanomanipulations have been successfully applied in various fields such as physics, material science and biological studies. In general, the further development of SPM based nanomanipulation has been tackled due to the precision problem of tip positioning which is brought mainly by hysteresis and creep. In this research, a new approach for improving the positioning accuracy in multi-scale is proposed. In this approach, there are two steps to increase the positioning accuracy. First, a scan-range associated adaptive hysteresis-creep hybrid (SAH) compensator is design to compensate the non-linear hysteresis and linear rate-dependent creep effect of the open-loop SPM scanner to control the position error within 10 nanometers. Next an additional non-vector space controller is applied to further increase the accuracy using compressed image as the feedback. Because this controller is designed in a non-vector space, it does not require prior information on features or landmarks which are widely used in traditional visual servoing. In order to illustrate the contributions and potential applications of this control strategy, an application of carbon nanotube local electrical property characterization is shown to clearly verify the concept. Compared with other research in the local electrical property characterization, the non-vector space controller can ensure that the measurement accuracy (position error) is controlled within a few nanometers, which also ensures the reliability of measurement results. Additionally, this non-vector space control method can be implemented into any kind of SPM to realize a real-time control for nanomanipulation such as nanofabrication and nanoassembly.

This work was supported in part by NSF Grants IIS-0713346 and DMI-0500372; ONR Grants N00014-04-1-0799 and N00014-07-1-0835; NIH Grant: R43 GM084520

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ECE-34  An Analytical Method For Constructing A Probabilistic Model Of A Wind Farm
Authors: Samer Sulamean; Sirisha Tanneeru; Mohammed Benidris; Joydeep Mitra

Abstract: Wind energy penetration levels have increased in recent years all over the world. Despite the advantages of wind power, wind power introduces complexity to the planning and operation of power system due to output fluctuations. In addition, maintaining the efficiency, reliability and operation of the main power grid in present of intermittent resources has become avital challenge. For power systems, the intermittent nature and uncertainty of wind turbine generators (WTG) output power introduce complexity of applying traditional reliability methods to evaluate system reliability for planning and operation. In contrast to conventional generators, the operational characteristics of WTG add complexity to the reliability assessment methods applied on conventional generators. Since the output power of WTG depends mainly on wind speed regime in a particular wind farm geographical location, and mechanical availability of WTG, wind power output will exhibit variation due to the intermittent nature of wind speed which adds complexity of applying traditional techniques used for adequacy assessment of power system. Therefore, it is important to investigate the expected output power of wind turbines due to wind speed and mechanical availability. In addition, a model represents wind power should consider the intermittent nature of power output, and should also be applicable to meet with adequacy assessment techniques used for conventional generation with inclusion of variability and intermittency nature of wind power. This poster introduces a new method to model the output power of wind farms in reliability evaluation. The proposed model is presented in terms of capacity outage probability table (COPT) considering the mechanical failure of WTG and the correlation between the outputs of turbines on the same farm. Normal convolution methods are not applicable because the correlation between the turbines. Based on the proposed model, the COPT of wind farm has been constructed and applied on the IEEE RTS-79 to calculate the well known reliability indices. Furthermore, a comparison of the reliability indices with and without considering the mechanical failures of WTG is shown. The results indicate the importance of inclusion WTG mechanical availability in estimating reliability of wind power. The results were validated using Monte Carlo simulation.

ECE-35  Two-Dimensional Device Simulation Of Diamond Diodes
Authors: Nutthamon Suwanmonkha; Timothy Grotjohn

Abstract: Diamond semiconductor devices are of interest due to the exceptional properties of diamond including wide bandgap, high thermal conductivity, high breakdown electric field, and high electron and hole mobilities. While diamond has these exceptional properties, it also has a set of challenges associated with the substitutional donors and acceptors being deep. In particular the primary p-type dopant is boron and a promising n-type donor is phosphorus. Because of the deep level of the dopants, the behavior of the diamond electrical properties are temperature dependent in the 300-700K temperature range due to only partial dopant ionization. This work uses the two-dimensional device simulation software (MEDICI) to model potential diamond diode designs. This work focuses at incorporating appropriate material parameters into the software for diamond to handle important effects including incomplete donor and acceptor ionization, avalanche breakdown, and temperature and impurity dependent mobility. These material parameters are based primarily on experimental data found in the research literature. The semiconductor device simulation software is then used to computationally model diamond diode structures including Schottky diodes, p-n junction diodes and merged diodes. Important device structures considered are the electrical contacts to the device including Ohmic contacts and Schottky contacts made of various metals. The diode simulations are compared to experimentally measured characteristics of various diamond diodes across a temperature range from 300-700K.

ECE-36  A Microwave Tomography System Using A Metamaterial-Inspired Tunable Reflectarray For Beam Steering
Authors: Amin Tayebi; Junyan Tang; Pavel Roy Paladhi; Lalita Udpa; Satish Udpa

Abstract: Microwave imaging using tomographic reconstruction has shown considerable promise in the fields of medical applications and NDE, particularly for the detection of anomalies in dielectric and composite laminate materials. Traditional microwave tomography systems use an array of transceivers placed around the area of interest to collect projection data 360° around the test object. However, the construction of such tomography systems using an array of transceivers is rather complex. This paper presents an alternate system that employs an electrically tunable beam-steering mirror coupled to a single microwave source which generates multi-angle projection data for tomographic reconstruction. The tunable mirror can be built using reflectarray antennas. Reflectarrays are low-profile antennas inheriting the features of both reflector antennas and antenna arrays. The desired radiation pattern is shaped by changing the surface impedance of the array. In case of microstrip reflectarrays one way to do this is to manipulate individual elements (unit cell) of the array, such as physical size. However, to build a tunable reflectarray with beam steering capabilities, the unit cell characteristics should dynamically alter. In this work, beam steering is achieved by changing the capacitance of individual elements of the array using varactor diodes. Simulation and experimental measurements of a single unit cell of the reflectarray, the measured radiation pattern of the array and initial experimental results of the tomography system will be presented.
Abstract: The study of resting state connectivity within the brain has been found to be of great utility in the study of neurological disorders. The resting-state networks are commonly studied through the blood-oxygen level-dependent (BOLD) response acquired from functional magnetic resonance imaging (fMRI). Current analysis techniques of resting-state fMRI networks rely mostly on linear measures, such as Pearson’s correlation. However, these methods cannot take into account the nonlinearities exhibited by the BOLD response and are susceptible to noise in the signals. Therefore alternative methods such as phase synchrony have been proposed to quantify the connectivity. The most common approaches to computing phase synchrony include the Hilbert transform and the Wavelet transform. This work introduces a measure of phase locking from the Rihaczek time-frequency distribution, which overcomes the drawbacks of other time-frequency phase locking methods such as time-frequency resolution tradeoff. In addition, as a time-frequency technique, this method has the advantage of avoiding the need of band-pass filtering the signal in a narrowband of frequencies for estimating the correlation in a particular frequency band, and provides information regarding to the spectro-temporal dynamics of synchrony. This work presents the assessment of whole brain synchrony with the isthmus of the cingulate cortex, and pairwise synchrony among areas included in the default-mode network (DMN). Results from the proposed method for estimating the phase synchrony are consistent with the definition of the DMN.

This work was supported in part by National Science Foundation

ECE-38 Design, Modeling And Control Of Autonomous Robotic Fish
Authors: Jianxun Wang; Xiaobo Tan

Abstract: With five hundred years of evolution, fish and other aquatic animal are endowed with a variety of morphological and structural features that enable them to move through water with speed, efficiency and maneuverability. These remarkable feats have stimulated extensive theoretical, practical research by mathematicians and engineers, in an effort to understand and mimic locomotion, maneuvering, and sensing mechanism adopted by aquatic animals. Over the past two decades, there has been significant interest in developing underwater robots that propel and maneuver themselves as real fish do. Often terms robotic fish, these robots provide an experimental platform for studying fish swimming, and hold strong promise for a number of underwater applications such as environmental monitoring. In this poster, we present several bio-inspired robotic fish prototypes we have developed that make use of periodic tail motion for robust operations for a variety of applications e.g. studying live fish behavior, serving as educational tools. Mathematic models of these robots are presented to capture the interactions between them and the surrounding aquatic environment to predict their global motion. We also present a target tracking controller design approach, based upon the control-oriented average model that we recently developed.

This work was supported in part by National Science Foundation

ECE-39 In Vivo Tumor Interstitial Fluid Pressure Measurement Using Static Micro Force Sensor And Mechanical Tumor Model
Authors: Zhiyong Sun; Ruiguo Yang; Pavlo Kovalenko; Bo Song; Liangliang Chen; Mary F. Walsh; Marc D. Basson; Ning Xi

Abstract: Tumor interstitial fluid pressure (IFP) plays a major role in the microcirculatory process of the formation and growth of malignant tumors. The tumor growth phase is accompanied by remodeling of the vasculature and tumor-induced angiogenesis. Typically, the leakage from the newly formed blood vessels abnormal lymphatics often leads to the rise of IFP. The increase of IFP has been deemed as one of the main barriers to the transcapillary transport of therapeutic agents as well as the uptake of these large molecules, which depends upon fluid perfusion to penetrate into the tumor. Moreover, elevated IFP may also lead to the poor prognosis of some cancer patients. Therefore, the IFP can be an important indication of tumor growth and biology. The most common methodology of IFP measurement is the so-called “wick-in-needle” approach which employs a sharp needle to penetrate into the tumor. This method is invasive, and it cannot make continuous monitoring of the same tumor which is meaningful for drug testing. To solve this problem, a potential non-invasive measurement technique was proposed to estimate the IFP using the applied force and the consequent deformation of the tumor surface. We used a sensitive Polyvinylidene Fluoride (PVDF) force sensor with drift-compensated numerical inverse approach to provide the force and developed a load-deformation mechanical tumor model to deduce the IFP. Convincing results were obtained to confirm the potential of the technique on measuring tumor inner pressure in vivo and non-invasively.

This work was supported in part by NSF Grants IIS-0713346 and DMI-0500372; ONR Grants N00014-04-1-0799 and N00014-07-1-0935; NIH Grant: R43 GM084520; and this work is approved by MSU IACUC.

Abstracts of the 2014 Engineering Graduate Research Symposium, Michigan State University
Abstract: The terahertz (THz) frequency spectrum (0.1-10THz) has drawn great research interest in the past few years, with a large amount of applications in communications, spectroscopy, imaging, sensing, and non-destructive evaluation. Existing THz systems are quasi-optical and bulky (table top systems). However, there is a growing demand to advance these setups from quasi-optical THz setup to integrated form in order to achieve similar benefits such as multi-functionality and low-cost provided by integrated circuits in the digital and RF area. An approach to embed active devices for the fabrication of THz integrated circuits is presented in this paper. GaAs Schottky barrier diodes (SBDs) are integrated with broadband log-periodic antennas to demonstrate a THz imaging sensor. Calculated optical noise equivalent power (NEP) based on a measured I-V characteristic and diode small-signal equivalent model shows that a minimum value of 3.6 pW/Hz^(0.5) can be reached at 100GHz. Calculated and measured voltage sensitivity of the detector is shown to be closely matched to existing THz detectors. The detected image of a concealed object is also presented, which illustrates the reliability of the fabrication process and its ability to reduce parasitic elements associated with high frequency operation. The proposed fabrication approach is also large-area, low-cost, and low-temperature process compatible, which can also be implemented in heterogeneous integration of THz integrated circuits on a host of flexible substrates for variety of applications.

This work was supported in part by NSF.

Abstract: Exposure to air pollution consistently ranks among the leading causes of illness and mortality globally, and the growing potential impact of airborne pollutants and explosive gases on human health and occupational safety has escalated the demand for sensors to monitor hazardous gases. Unfortunately, current preventative measures and treatments for air toxins are ineffective due in large part of our inability to properly characterize and quantify acute exposure to air pollutants. To overcome these challenges, a wearable autonomous multi-gas sensor system capable of real-time environmental monitoring could provide immediate feedback to warn the wearer of imminent environmental threats as well as a record of individual exposure that would aid the development of new treatment approaches. We present an Intelligent Electrochemical Gas Analysis System (iEGAS) that seeks to achieve this goal by synergistically integrating sensors, electronics, and data analysis algorithms into an autonomous wearable system. Electrochemical sensors featuring room temperature ionic liquid are utilized for low-power operation, high sensitivity and selectivity, and long life with low maintenance. A stacked platinum mesh electrode sensor structure enables miniaturization and rapid response. A custom multi-mode electrochemical instrumentation circuit combines all needed signal condition while minimizing system cost, size and power consumption. Embedded sensor array signal processing algorithms are being developed to enable gas classification and concentration estimation of a real-world mixture of gas analytes within the iEGAS system.

This work was supported in part by the National Institute for Occupational Safety and Health (NIOSH) under Grant R01OH009644

Abstract: Aquatic ecosystems and processes exhibit a high degree of spatial and temporal heterogeneity, which presents significant challenges for their monitoring. In this poster, we report a novel underwater robot, called gliding robotic fish, as an emerging platform for mobile sensing in aquatic environments that can potentially provide high spatiotemporal coverage. The robot represents a hybrid of an underwater glider and a robotic fish, and is capable of exploiting gliding to achieve energy-efficient locomotion while using a fish-like active tail to achieve high maneuverability. The mechanical-electrical design of the robot is presented for the buoyancy control system, mass distribution system, and the tail control system. Two energy-efficient locomotion profiles are proposed, namely the sagittal-plane gliding motion and the three-dimensional spiraling motion, both of which consume almost zero energy for propulsion. We then show the dynamic modeling for such two motions and present the experimental validation results with the lab-developed prototype. The field-test results are also demonstrated, where the robot was used to sample the Kalamazoo River and the Wintergreen Lake in Michigan for concentrations of crude oil and harmful algae, respectively. Finally, we discuss some preliminary results of the extension of the current work to realize commercialization, including modular design for easier maintenance, solar panel for sustained battery recharging, and underwater optical communication for multi-agent networked sensing.

Abstracts of the 2014 Engineering Graduate Research Symposium, Michigan State University
ECE-43  **Optimal Compression Of A Generalized Prandtl-Ishlinskii Operator In Hysteresis Modeling**

**Authors:** Jun Zhang; Emmanuelle Merced; Nelson Sepulveda; Xiaobo Tan

**Abstract:** Hysteresis is a nonlinear phenomenon that has been found in a wide range of areas, such as biology, economy, ferromagnetics, and various classes of smart materials-based systems. Being one of the most popular hysteresis models, the Prandtl-Ishlinskii model has been verified to be effective to capture such nonlinear behavior. The model is expressed as a weighted summation of elementary play operators. Each play operator is characterized by its play radius and weight. Existing work has typically adopted some predefined play radii for the play operators, and then identify the weights based on experimental data, the performance of which could be far from optimal. While it is true that the model will be more accurate when it consists of a larger number of play operators, computational complexity and data storage cost would also increase. In order to get an accurate model while maintaining relatively low calculation and storage cost, better schemes should be explored. This work proposes a novel scheme to optimally approximate a high-fidelity Prandtl-Ishlinskii model with a large number of play operators, with a compressed Prandtl-Ishlinskii model with a lower number of play operators. The overall compression cost function is designed based on entropy theory and the optimal compression scheme is obtained by minimizing the cost function. The proposed compression scheme is applied to the modeling of the asymmetric hysteresis between resistance and temperature of a vanadium dioxide (VO2) film, and the effectiveness is further demonstrated in a model verification experiment. In particular, under the same complexity constraint, an entropy-based compression scheme results in modeling errors around only 37 % of that under a uniform compression scheme.

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ECE-44  **A Fast Rolling And High Jumping Robot**

**Authors:** Jianguo Zhao; Weihan Yan; Ning Xi; Matt W. Mutka; Li Xiao

**Abstract:** In nature, many small insects or animals are able to move in difficult environments with obstacles with multiple locomotion methods. In this poster, we present our design of a miniature robot that can use legged wheels to fast roll on flat ground. Once encountering an obstacle, the robot can jump over it. Moreover, it has on-board energy, control, and communication abilities, which enables tetherless or autonomous operation. With the multi-modal locomotion abilities, the robot is expected to have many applications ranging from environmental monitoring, search and rescue, to military surveillance.

*This work was supported in part by U.S. Army Research Office Contract No. W911NF-11-D-0001, and U.S. Army Research Office Grant No. W911NF-08-1-0321 and W911NF-10-1-0358, and National Science Foundation Award No. CNS-1320561 and IIS-1208390.*

ECE-45  **Transport Characterization Of Boron Doped Single Crystal Diamond Films**

**Authors:** I. Berkun; S. Zajac; S.N. Demlow; T. Hogan; T.A. Grotjohn

**Abstract:** The need for electronic devices with higher power throughput, higher operating voltages and higher operational temperatures is driving the desire of fabricating new semiconductors with wider band gap such as diamond. Diamond for electronic applications requires doping to create semiconductor properties. This work is a continuation of our previous work, in which boron doped single crystal diamond (SCD) films were deposited on high pressure high temperature SCD substrates in a microwave plasma-assisted chemical vapor deposition (MPACVD) bell-jar reactor with dopant concentrations from below 1017 cm<sup>-3</sup> to over 1020 cm<sup>-3</sup> [1]. An important need in the research of boron doped diamond semiconductors is the reliable determination of the critical electronic transport properties, such as the temperature dependent conductivity, carrier concentration, and carrier mobility of the deposited film. This has previously been reported with the influence of defects and theoretical model comparisons with experimental results [2]. High temperature Hall effect measurements are essential in order to understand the properties of the SCD samples and provide feedback on the fabrication process. We have previously presented the high temperature Hall effect system which operates in the temperature range of 300K to 700K and was designed such that carrier concentrations and mobilities could be measured, as well as influences such as temperature stability and non-Ohmic contacts on the resulting measured values [3]. Temperature dependent Hall effect measurements have shown carrier concentrations from below 1017cm<sup>-3</sup> to approximately 1021cm<sup>-3</sup> with mobilities ranging from 763 (cm²/V•s) to 0.15 (cm²/V•s) respectively. This work mainly focuses on the contact resistance studies for single crystal boron doped diamond using the transmission line method, effects of the contacts on the Hall effect measurements, and analysis of the resulting measurements including mixed carrier conduction modeling. References: [1] S. N. Demlow, I. Berkun, M. Becker, T. Hogan, and T. A. Grotjohn, “Dopant Uniformity and Concentration in Boron Doped Single Crystal Diamond Films,” MRS Proceedings, 1395, (2012)

*This work was supported in part by National Science Foundation (IIS 0916720, ECCS 1050236).*

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ENE-01 Evaluation Of First Flush Phenomena For Chemical And Microbiological Pollutants In Red Cedar River
Authors: Amira Oun; Ao Chen; Fangli Xing; Thomas Voice; David Long; Irene Xagoraraki

Abstract: Michigan climate is characterized by hot humid summer, cold and snow winter, and wet spring. The state receives a good amount of perception throughout the year, averaging from 30-40 inches annually. Typically, from November through March is slightly drier, while April through August is wetter than the rest of the year. This climate creates a long period for pollutant build-up, which is deposited on surfaces during dry weather then washed away in spring when the snow starts to melt into rivers, storms, drains, and lakes. The initial storms of the spring season usually have higher pollutant concentrations, which can create a first flush phenomenon. These pollutants can be from different sources such as de-icing salt, animal waste, manure, and biosolid; pesticides and fertilizers. In this study, water samples were collected from Red Cedar River, a stream flowing through farmland and receiving effluent from several municipalities in central Michigan, in order to (1) monitor water quality of the first flush which can give an indication of pollution sources and pollution loads going into the lake Michigan (2) study the fate and transport of these contaminants (chemical and microbiological) and (3) study the effect of the DOC in nutrients and contaminants release and transport. We analyzed extensive data sets, collected over spring and summer 2013, and will continue sampling in spring and summer 2014. The samples were analyzed for fecal indicators (E. coli), human and bovine associated Bacteroides markers, DOC, sodium, potassium, chloride, and nitrate.

ENE-02 Abundance Of Segmented Filamentous Bacteria In Mice With And Without 2,3,7,8-tetrachlorodibenzop-dioxin Treatment
Authors: Prianca Bhaduri; Timothy R. Zacharewski; Norbert E. Kaminski; James M. Tiedje; Syed A. Hashsham

Abstract: Gut microbiota influence several key processes in the host including development and maturation of cellular and humoral immune responses, inflammation and pathogen clearance. Segmented filamentous bacteria (SFB) play a unique role in this dynamic system by regulating several immune cells. 2,3,7,8-tetrachlorodibenzop-dioxin (TCDD) also acts on the immune system through the aryl hydrocarbon receptor to increase the ratio of Treg cells to Th17 cells. In this study, we hypothesized that the abundance of SFBs would increase in response to TCDD dosage in mice. Loop-mediated isothermal amplification (LAMP) primers were designed for 16S rRNA SFB gene and flagellin gene and used to measure SFBs from fecal pellets. Sanger sequencing and comparison to published qPCR primers confirmed the authenticity of the LAMP primers. The presence of SFBs was also confirmed by microscopy. We have also been able to quantify SFBs directly from fecal cell suspensions without the need for DNA extraction. Our results indicate that high amounts of SFBs are present in mice fecal samples even though 454 sequencing using 16S rRNA primers for the V6 region did not detect SFBs in most samples. The abundance of SFBs showed slight increase in the treated animals. These results further our understanding of the intestinal microbiota response to TCDD levels in our system. This work increases our knowledge of the role played by the intestinal microbiota in regulating the immune system balance and has implications in several diseases including inflammatory bowel disease, Crohn's disease and others.

This work was supported in part by National Institute of Environmental Health Sciences Superfund Research Program (NIEHS-SRP)

ENE-03 Groundwater Sustainability In Michigan Lowlands – A Multiscale Modeling Study
Authors: Zachary Curtis; Huasheng Liao; Shu-Guang Li

Abstract: Analysis of a statewide groundwater quality database (1,000,000+ samples) reveals that salinity in Michigan’s lowland areas is statistically significantly higher than in the inland areas at higher elevations. Mounting evidence suggests that brine upwelling is from deep geological formations and that dynamic processes on multiple spatial scales control the extent of pollution in lowland areas. This research investigates how the complex interplay of human activity (increased water withdrawals), climate change (systematic decrease in Great Lakes water levels in the past 30 years) and natural upwelling interact to control the sustainability of freshwater resources in Michigan. A calibrated multiscale groundwater model will be used to simulate the brine upwelling dynamics and its impact on water resources sustainability in lowland areas of Michigan. This research will utilize a “hierarchical” approach to simulate the flow system at basin scale, regional scale, local scale and site scale. The hierarchical modeling system will be dynamically coupled through iterative “downscaling” and “upsampling” and will be complemented by extensive statewide data and site-specific sampling. Current work includes the development of a regional and local scale model in the Ottawa Lowlands. Model conceptualization and “first-cut” calibration using integrated well data will direct the data sampling effort through an iterative approach. A monitoring protocol for static water levels and chloride concentrations is also under development and will be carried out in the following semesters. Insights from the Ottawa Lowlands study will help direct the modeling effort of the basin-scale upwelling dynamics likely causing the lowland’s groundwater contamination.

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ENE-04 Detection And Removal Methods Of Cyanuric Acid In Swimming Pool Water
Authors: Xu Fan; Susan J. Masten

Abstract: As a common ingredient of bleaches, disinfectants and herbicides, cyanuric acid (2,4,6-trihydroxy-1,3,5-triazine, CA) is widely used in recreational swimming pool water. Specifically, chlorinated salts of CA are functionally important in water purification by releasing disinfectant chlorine, and stabilizing free chlorine. However, as CA acts as a chlorine reservoir, and prevents residual chlorine destruction by sunlight, it also can accumulate in swimming pools. If a swimming pool has an excessively high concentration of CA, water will become cloudy. It will not only pose potential threat to human health, but also increase difficulty for subsequent water treatment. In addition, CA is a very stable compound, and resistant toward chemical hydrolysis or oxidation. CA is also the final product formed during TiO2-catalyzed photocatalysis of s-triazine herbicides. Therefore, it is essential to develop cost-effective removal methods. The high-performance liquid chromatography (HPLC) can be used to detect CA. Preliminary studies have been conducted to determine CA concentrations in several public swimming pools in Lansing area. CA levels ranged from 34.03mg/L to 73.61mg/L, all within in recommended level (10-100 mg/L). Ozonation-membrane filtration and adsorption have been tested for their efficacy for CA removal. The results show both ozonation-membrane filtration and adsorption on natural zeolite were ineffective. Fortunately, activated carbon shows immense potential for CA adsorption, only 0.4 g granular active carbon could achieve 69.4% removal rate from a solution containing 500 mg/L CA. Further study will focus on determining adsorption capacities and adsorption rates of various activated carbon sources (GAC, PAC, commercial fish tank carbon).

ENE-05 Genetic Characterization Of Microorganisms On Highly Touched And Untouched Fomites
Authors: Amanda Herzog; Tiffany Stedtfeld; Charles P. Gerba; Joan B. Rose; Syed A. Hashsham

Abstract: In the indoor environment, an important route of transmission of bacterial and viral disease is through the interaction with fomites. Touched fomites are mostly influenced by the interactions with individuals while untouched fomites are influenced by air movement. Understanding the bacterial communities on the fomites in an indoor environment may affect disease transmission models and quantitative microbial risk assessments. Therefore, the work proposed is to analyze the bacterial communities on highly touched and untouched fomites in a university setting. Samples from touched and untouched fomites were collected from the common lounge, computer room, and cafeteria of six dormitories at the University of Michigan. Non-porous fomites of plastic, metal, and wood (e.g. computer mouse, door knob, and window sill, respectively) with surface areas ranging approximately 10 to 100cm2 were sampled using pre-moistened wipes. DNA was exacted from the samples and analyzed using 454 GSFLX Roche sequencing of the 16S rRNA genes. Results from 69 samples shows that the majority of the sequences found on both touched and untouched fomites were from three core phyla, Proteobacteria, Actinobacteria and Firmicutes, which represented an average of 81.4% and 83.8% of the bacteria community on touched and untouched fomites, respectively. The bacterial communities on touched and untouched fomites were statistically different. The bacterial communities on touched fomites were more diverse and had more fecal related bacteria present compared to untouched fomites. There were no correlations observed between sample date/time, locations, dormitory rooms, fomite materials or fomite types. The knowledge of the bacterial communities on touched and untouched fomites can further assist in the role fomites have on the transmission of infectious disease in the indoor environment.

This work was supported in part by This study was supported by the Center for Advancing Microbial Risk Assessment funded by the U.S. Environmental Protection Agency and Department of Homeland Security grant number R83236201.

ENE-06 A Comparison Of RDX Assimilating Microorganisms Across Soil Communities
Authors: Indumathy Jayamani; Alison Cupples

Abstract: The explosive RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) has contaminated many military sites. This chemical is particularly problematic because it is highly soluble and toxic and has the potential to move off-site. Here we combined stable isotope probing (SIP) and high throughput sequencing to identify the microorganisms able to degrade RDX across a number of soils. The final aim is to create a database of microorganisms linked to in-situ RDX degradation, so that removal through natural attenuation can be better predicted. The work consisted of an initial screening of soils for RDX degradation followed by SIP combined with high throughput sequencing. SIP experiments involved the exposure of microcosms to labeled (13C3, 99%; 15N3) or unlabeled RDX (present as the only nitrogen source). Two amendments of RDX were used (20 mg/L each). Following complete RDX degradation, DNA was extracted, ultracentrifuged and then fractionated. The fractions generated were amplified using a set of multiplex indexed primers targeting the V4 region. After amplification, individual reactions were quantitated and a pool of equimolar amounts was made. The pool was run on the Illumina MiSeq platform using a standard MiSeq paired end (2x250 bp) flow cell. The high throughput data were analyzed using Mothur. This involved the construction of contigs, error and chimera removal and sequence alignment for OTU assignment. The high throughput sequencing data generated is currently being analyzed and the sequence abundance for each phylotypes is being calculated. The relative abundance of each phylotype in each fraction is currently being examined to identify the organisms responsible for label uptake, hence RDX assimilation, for each soil. The data generated will be compared between soils and the current literature on known RDX degrading species. To
our knowledge, this work represents the first attempt to combine both SIP and high throughput sequencing to simultaneously access RDX degraders.

This work was supported in part by SERDP

ENE-07 Common Difficulties In Learning Material Balances And How Certain Teaching Methods Promote Negative Transfer (As Assessed In An Undergraduate Environmental Engineering Classroom)

Authors: Indumathy Jayamani; Susan J. Masten

Abstract: Material balance, a fundamental ‘big idea’ in the field of environmental engineering, is generally introduced in lower level environmental engineering classes. A working knowledge of this concept is required to understand several other higher level topics in the field. Previous experience has shown that students entering higher level courses in environmental engineering often carry naïve conceptions about material balance and follow pattern recognition without fully understanding the underlying assumptions. In our research, we have assessed student performance on mass balance related questions in an upper level environmental engineering course (senior year) to identify common misconceptions and the possible reasons that promote the creation of these misconceptions and negative transfer. A preliminary analysis of the data identified that students have difficulties in solving for the decay rate constant when the system is at steady state and also in writing material balance equations when given a plug flow reactor system. We also found a common tendency to solve problems by searching for a pattern that the students recall rather than using the information provided to evaluate and solve the problem using first principles. This approach underscores the problem of negative transfer. By identifying these misconceptions and difficulties we hope to develop better learning material to enhance student learning of material balance concepts.

ENE-08 DNA-Extraction Free Loop Mediated Isothermal Amplification (LAMP) Of Dehalococcoides spp. And Dehalobacter spp.

Authors: Yogendra Kanitkar; Robert Stedtfeld; Tiffany Stedtfeld; Rob Steffan; Alison Cupples

Abstract: Typically, real time PCR (qPCR) based on TaqMan probe or DNA binding dyes is used to quantify and monitor the in situ activity of Dehalococcoides and Dehalobacter spp. To date, a wide range of qPCR protocols to quantify 16S rRNA genes as well as reductive dehalogenase genes such as vcrA, tceA and bvcA are available. Although qPCR methods have been successful for monitoring reductive dechlorination, DNA extraction and amplification in an expensive real time thermal cycler require significant resources and reasonable expertise. In this study, we provide proof of concept for a novel protocol involving direct amplification (without DNA extraction) to detect and quantify Dehalococcoides and Dehalobacter spp. in commercial reductive dechlorination cultures as well as groundwater samples. Loop mediated isothermal amplification (LAMP) primers were designed for Dehalococcoides spp. and Dehalobacter spp. 16S rRNA genes and key functional reductive dehalogenase genes using Primer Explorer V4. The method was applied to commercial reductive dechlorinating cultures (SDC-9 and TCA20) and groundwater samples from contaminated sites. For each primer set, threshold times and sensitivities were determined and compared using the DNA-extraction free LAMP assays on a real time PCR thermal cycler. Candidate primer sets for several key dechlorinating genes associated with Dehalococcoides spp. were identified. The selection was based on the performance of these primers at low detection levels. Furthermore, preliminary data indicates that DNA-extraction free LAMP was able to detect Dehalococcoides spp. below 10-7 cells/L, the accepted threshold for natural attenuation. Future research will focus on the genes associated with Dehalobacter spp.

This work was supported in part by the Strategic Environmental Research and Development Program (SERDP) of the Department of Defense (Project ID# ER-2309)

ENE-09 Antibiotic Resistance Gene Abundance And Diversity In The Great Lakes Region Using Targeted Functional Gene Sequencing And Gene-Z

Authors: Maggie R. Kronlein; Robert D. Stedtfeld; Yen-Chen Liu; James Tiedje; Syed A. Hashsham

Abstract: Heavy use of antibiotics has resulted in the widespread prevalence of antibiotic resistance (AR) genes in bacteria, which is of great concern to human health. Characterizing the abundance and allelic diversity of these AR genes in aquatic environments is the first step for better understanding of the problem. In this study, AR genes were or are in the process of being analyzed in lake and river samples using two approaches: 1) Functional gene targeted next generation sequencing for 200 AR genes using Wafergen platform, and 2) Isothermal amplification based quantification of selected AR genes in a 64-well microfluidic chips using Gene-Z platform. One liter of water samples were collected from 30 lakes and rivers throughout Michigan. Direct amplification of the AR gene containing samples without DNA extraction was also demonstrated for selected samples. Wafergen analysis revealed significantly higher abundance of multiple AR genes (including: tetA, tetM, sul1, aphA3, mphA, aadA, mefA and vanA) throughout Michigan, particularly in areas of high population density, high density of septic tanks, and near treated wastewater discharge points. Future experiments include the analysis of 20 selected AR genes on the Gene-Z platform (patent pending). This study demonstrates the potential of functional gene-based high throughput sequencing and direct amplification in assessing the problems related to antibiotic resistance.

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Evaluating The Effect Of Brown Bridge Dam Removal In Grand Traverse County, MI: An Integrated Hydrological Analysis
Authors: Zhi Li; Shu-Guang Li

Abstract: Many dams are targeted for removal to restore ecosystems, but without having a clear understanding of the effects it will have on the watershed’s ability to avoid flooding. This is due the complex and varied response of different watersheds to dam removal. As such, a deep analysis of the surrounding watershed is required for sound water resource management when considering dam removal. This research explores the effect of Brown Bridge Dam removal. The Brown Bridge Dam was the first of three dams to be removed (circa January 2013) and is located on the Boardman River approximately 14 miles upstream of Traverse City, MI. A “before-and-after” systematic approach will be used, including watershed and groundwater modeling and hydraulic routing. We use: watershed modeling to determine an overall watershed response to both extreme climate events and changing climates; groundwater modeling to monitor the groundwater distribution caused by dam removal and hydraulic routing to look for peak flow attenuation due to the dam. Preliminary results suggest that this dam removal can potentially have adverse impacts downstream for this groundwater-dominated watershed. A hydraulic routing analysis shows that the reservoir had the sufficient capacity to decrease flood peaks and manage risks. The analysis of a typical scale flood reveals that a considerable area would be affected by floods. This indicates that the dam removal affected the water level of the Boardman River and the groundwater level within the Boardman River Watershed, matching observations and suggesting the need for a more detailed investigation.

Metagenomics To Study Phage Diversity And Antibiotic Resistance Genes In Activated Sludge From A Wastewater Treatment Plant
Authors: Mariya Munir; Terence Marsh; Irene Xagoraraki

Abstract: Bacteriophages are the most abundant entities in most environments and are being considered a suitable vehicle for the dissemination of antibiotic resistant genes (ARGs). Sludge samples were collected from East Lansing WWTP in Michigan. A method for phage DNA isolation was optimized using PEG (polyethylene glycol) precipitation and DNase (deoxyribonuclease) treatment. Phage diversity was studied by next generation sequencing (before and after DNase treatment) with Illumina (MiSeq). Metagenome data analysis reveals that after DNase treatment activated return sludge sample (RAS) contained 21,985 sequences totaling 17,227,533 basepairs with an average length of 783 bps and primary sludge (PS) sample contained 2,870 contigs sequences totaling 2,292,422 basepairs with an average length of 798 bps. On a genus level, Burkholderia phage, Coliphage, Enterobacteria phage, and Pseudomonas phage are present in all the samples. Burkholderia cepacia phage, Edwardsiella phage, Mycobacterium phage, Salmonella phage, Vibrio phage and Xanthomonas citri phage were phages detected only in RAS samples. Bacillus phage, Brochothrix phage, Lactobacillus phage, Listeria phage, Phormidium phage, Staphylococcus phage and Sugarcane mosaic virus were found only in PS samples. Phage DNA was isolated and monitored for ARGs (tetracycline resistant genes (Tet-W and Tet-O) and sulfonamide resistant gene (Sul-I)) using real-time Q-PCR. We have detected ARGs in phage DNA with concentrations ranging from 3.84×102-8.14×103 copies/100mL for Tet-W gene and 5.89×104-7.9×104 copies/100mL for Sul-I gene. In addition, phage metagenome was searched for functional signatures of resistance genes and we observed a high resistance to antibiotics and toxins compound in PS samples compared to RAS sample. Further analysis revealed that most of the antibiotic resistance belongs to methicillin, fluoroquinolones and beta-lactamase group of antibiotics. This work presents the abundance of phages in sludge samples and indicates that there is a substantial shift in the phage community over the course of the activated sludge process, thus suggesting that within the activated sludge the phage populations are dynamic. It also indicates that phage DNA is associated with antibiotic resistant genes in wastewater.

Vinyl Chloride Assimilating Microbes From A Contaminated Site-Derived Culture Identified By Stable Isotope Probing And Illumina Sequencing
Authors: Fernanda Paes; Xikun Liu; Timothy Mattes; Alison Cupples

Abstract: Vinyl chloride (VC) is classified as a known human carcinogen and is a common soil and groundwater contaminant. In this study, time series DNA based stable isotope probing (SIP) and high throughput sequencing were combined to identify the microorganisms assimilating carbon from labeled VC (13C2) in a culture derived from contaminated site groundwater. In addition, the composition of the microbial community was investigated. Microcosms were amended with labeled (13C2) or unlabeled (12C) VC and removal was monitored over 45 days. During this time, DNA was extracted at several times (days 15, 32 and 45). Both the total DNA extract samples and the heavy fractions generated during SIP were subject to Illumina sequencing (V4 region of 16S RNA gene). The data generated indicated the microbial community was dominated by six phyla (Proteobacteria, Actinobacteria, Acidobacteria, Bacteroidetes, Firmicutes, and Verrucomicrobia). The most abundant families in these phyla included the Comamonadaceae, Burkholderiales incertae sedis, Nocardioidaeaceae, Chitinophagaceae, Flavobacteriaceae, Clostridiales incertae sedis XI and Gp4. The analysis of the heavy fractions indicated five phylotypes were more dominant in the labeled fractions compared to the controls, including Nocardioides (Actinobacteria), Brevundimonas.
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EN13 Produced Water Treatment Using Hybrid Hydrocyclone-Membrane Technology
Authors: Brian Starr; Andrii Gorobets; Volodymyr Tarabara; Merlin Bruening; André Bénard

Abstract: This research aims to develop crossflow filtration hydrocyclone (CFF-HC) as a hybrid hydrocyclone-membrane technology that separates oil-water mixtures into a water stream that meets standards for discharge into the environment and an oil stream sufficiently dewatered for energy use. The hypothesis of this work is that rotational flow in a CFF-HC will force oil droplets away from a membrane surface and reduce fouling. Initial fouling studies using a CFF-HC test apparatus to separate oil-water emulsions have demonstrated that centripetal forces in the membrane reduced fouling compared with conventional crossflow filtration. Commercialization will require the synergistic benefits to outweigh additional complications associated with a hybrid unit. Ongoing work is focused on maximizing the clean water permeate stream while maintaining the reduction in fouling.

This work was supported in part by EPA, NSF

EN14 Influence Of Soil Characteristic, Ph And Calcium Ion On Adsorption Behavior Of Aristolochic Acids
Authors: Chaiyanun Tangtong; Lulu Qiao; David T.Long; Thomas C.Voice

Abstract: Aristolochic acids (AAs) were believed as environment agents induced Balkan Endemic Nephropathy (BEN). The fate and transport of AAs in soil is important property in determination of exposure pathway. This study investigated the soil sorption behavior of AAs through batch sorption experiment. The results showed that adsorption isotherm are fitted well to linear type with correlation coefficient (r2)>0.93. Both organic matter and clay were significant components that control the adsorption. In natural soil pH, AAs were in anion form and showed high sorption capacity (Koc are more than 3) even they were very hydrophilic. This finding indicated that specific mechanism had been involved other than hydrophobic partitioning. pH had high effect to sorption of AAs. The sorption coefficient (Kd) of neutral species in acid condition were much higher than anion species in basic condition. This was due to the higher hydrophobic partitioning of neutral molecules and electrostatic repulsion of anion molecules to the soil. Increasing of calcium ion in solution found to promote the adsorption of AAs to soils that had high cation exchange capacity (CEC) which support the idea of cation bridging mechanism. The model of different adsorption capacity among different soil types may describe the available of AAs in BEN and non-BEN area.

This work was supported in part by MSU Center of Water Sciences (CWS), Royal Thai Government, NIH.

EN15 Effect Of Ozone Dosage And Hydrodynamic Conditions On Permeate Flux In Titanium Oxide And Manganese Oxide Coated Catalytic Membrane Filtration System
Authors: Xiaoyu Wang; Susan Masten; Simon Davies

Abstract: This project focuses on the effects of ozone dosage and hydrodynamic conditions on the performance of virgin titanium oxide and manganese oxide coated catalytic membrane systems. The coated catalytic membranes are produced by coating commercial ceramic ultrafiltration titanium oxide membranes with manganese oxide nanoparticles using a layer-by-layer self-assembly technique. Membrane fouling (a parameter that significantly affects the design and operation of membrane filtration facilities) was evaluated under different ozone dosages with two operation modes (dead-end and cross-flow). An economic analysis of each membrane system was performed to optimize the design. A comparison of the performance of the two catalytic membrane systems in terms of the recovery of the permeate flux and removal of natural organic matter was also assessed. The results of the proposed projects can be applied to membrane based water treatment plants to achieve economic operational costs and high treatment efficiency.

EN16 Constraining Mechanistic Models Of Indicator Bacteria At Recreational Beaches In Lake Michigan Using Easily Measurable Environmental Variables
Authors: Aaron Wendzel; Phanikumar Mantha

Abstract: Beach closures have significant economic and human health implications and the ability to create and use near-realtime hydrodynamic and transport models that accurately simulate fecal indicator bacteria (FIB) levels at our nation's recreational beaches is important to effectively managing coastal resources. Here we describe the development and application of an unsteady, three-dimensional hydrodynamic fate and transport model constrained using easily measurable environmental variables such as electrical conductivity (EC) and turbidity. The model was able to accurately simulate observed Escherichia coli

This work was supported in part by a collaborative NSF Grant (number 1233154) awarded to T. Mattes and A. Cupples.

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concentrations at three beaches in close proximity to the Burns Waterway along the Indiana Dunes National Lakeshore. This model utilized an unstructured grid that has the ability to accurately represent local features in the area, including the complex shoreline and breakwaters that influence hydrodynamics and mixing. This allows for the better prediction of FIB at local beaches reducing human health risks and decreasing the number of unnecessary beach closures.

ENE-17 Human Adenovirus Removal By Hollow Fiber Membranes In A Bench-Scale MBR: The Effect Of Silica Particles And Humic Acid As Model Fouants
Authors: Ziqiang Yin; Volodymyr V. Tarabara; Irene Xagoraraki

Abstract: Membrane bioreactors (MBRs) are rapidly developing as a preferred advanced wastewater treatment technology. Virus removal by MBRs is of concern, since membrane pore sizes can be larger than the size of certain viruses. In this bench-scale study, virus removal experiments were carried out using PVDF hollow fiber (0.22 and 0.45 micron nominal pore sizes) membranes operated under constant flux regime and in the presence of aeration. The permeate flow was recirculated in the feed tank. Silica particles (1-3.5um in diameter) and humic acid were selected as model foulants. Human adenovirus (HAdV) 40 was used as a model virus and quantitative polymerase chain reaction (qPCR) was employed to determine virus concentration. The individual and combined impacts of model foulants on membrane fouling and virus removal were determined and compared. The results indicate that the mixture of silica particles (800ppm) and humic acid (40ppm) can cause severe and fast fouling on both membranes (0.22 and 0.45um), while the fouling is not significant when only each one of the foulants was used alone. The effect of SiO2 alone on virus removal was very small. Presence of humic acid enhanced virus removal, especially with the 0.22um membrane. When membrane filtration is carried out in the mixture of silica particles and humic acid, virus concentrations in the permeate samples were consistently higher than in the feed samples. One potential explanation is that humic acid facilitates virus adsorption on silica particles and subsequently, during filtration, silica particles accumulate on the membrane surface and form a porous layer. Then, viruses are desorbed from the silica particles due to the flux through the porous layer and are detected in the permeate. All data suggest that adsorption plays an essential role in membrane systems regarding to membrane fouling and virus removal.

This work was supported in part by a Strategic Partnership Grant from the Michigan State University Foundation and in part by the National Science Foundation award CBET 1236393.

ENE-18 The Groundwater Recharge Model Base On Grids’ Distributed Parameters
Authors: Jing Zhang; Shu-Guang Li

Abstract: The estimation of net infiltration of water below the root zone plays an important role for quantifying the potential recharge to an underlying water-table aquifer. The net infiltration below the bottom of the root zone is assumed to equal net recharge to an underlying water-table aquifer in many applications of research. Thus, it is necessary to accurately estimate the infiltration flux when quantifying recharge as input to groundwater models. A grid-based model using distributed parameters, deterministic precipitation-runoff and net-infiltration water balance is proposed to calculate the daily net infiltration water to be used as recharge to water-table aquifer modeling. Precipitation, infiltration, evapotranspiration, drainage and water-content redistribution characterize the root-zone components of the water balance. These parameters are combined with surface-water flow to simulate the daily water balance. Specific input data includes daily climate records (i.e., precipitation and air temperature), the spatially distributed characteristics of drainage-basin and the geology, soil, and vegetation distribution. A set of spatially distributed input variables uniquely assigned to each grid can represented the drainage-basin characteristics. The State of Michigan is chosen as case study. The expected outcome will be mapping of net infiltration at different temporal and spatial scales. In addition, the relationship between the dynamic net infiltration in Michigan and the global climatic warming would be obtained by sensitivity analysis. Moreover, the major controls of net infiltration would be extracted from the model parameters by the methods of factor analysis and clustering analysis. Then, the empirical results will be compared to the grid-based modeling technique.
MSE-01 The Effect Of Extrusion Temperature On The Microstructure, Mechanical Properties And Deformation Behavior Of Mg-1Mn-1Nd (wt%)

Authors: Ajith Chakkedath; Jan Bohlen; Sangbong Yi; Dietmar Letzig; Zhe Chen; Carl Boehlert; María Teresa Pérez-Prado; Javier Llorca

Abstract: An in-situ characterization technique combining mechanical testing inside a scanning electron microscope (SEM) with electron backscatter diffraction (EBSD) analysis was employed to study the tensile deformation behavior of Mg-1Mn-1Nd (wt%) extruded at two different temperatures (300°C and 275°C) over the temperature range of 50-250°C. Rare-earth additions to Mg alloys tend to reduce the strong basal texture exhibited by conventional wrought Mg alloys and this work was intended to study the effect of extrusion temperature on the deformation behavior and microstructure. EBSD was performed both before and after the deformation. A slip/twin trace analysis technique was used to identify the distribution of the deformation systems as a function of strain. Both materials showed superior high temperature strength retention compared to conventional alloys. Basal slip, prismatic slip, pyramidal <c+a> slip, and extension twinning were active at all temperatures, except for the material extruded at 300°C, in which case extension twinning was not observed at 250°C. The extent of twinning decreased with increasing temperature and basal slip was the major deformation mode at 150°C and 250°C. Basal slip was associated with high Schmid factors in all cases. Extension twinning was distributed over the entire Schmid factor range suggesting that extension twinning does not follow Schmid law. Based on the distribution of identified deformation modes and the texture, the estimated critical resolved shear stress (CRSS) ratio of extension twinning with respect to basal slip was less than 1, suggesting that the addition of Nd results in an increase in the CRSS of basal slip.

MSE-02 Fiber Diameter And Porosity Studies On Carbon Nanofiber Mats For Bioelectrodes

Authors: Duyen Do; Scott Calabrese Barton

Abstract: Carbon nanofiber mats (CNFM) having fiber diameters ranging from 2 nm to 8 μm have been investigated as electrode materials for enzymatic bioelectrodes. The morphology and porosity of CNFM were characterized by SEM and porosimetry, respectively. CNFM of desired fiber diameter were also produced by electrospinning from Polyacrylonitrile (PAN) precursor followed by thermal treatments (stabilization at 250°C and carbonization at 1000°C). Subsequently, glucose oxidase (GOx) and redox polymer mediator are immobilized on CNFM electrode by cross-linker to measure the electrochemical properties. By relating current density to CNFM thickness, fiber diameter and porosity, the optimum CNFM properties will be identified that boost the performance of bioelectrodes.

MSE-03 Simulation Of Bi-Crystal Grain Boundary Deformation In Commercially Pure Tantalum

Authors: Bret Dunlap; Philip Eisenlohr; Claudio Zambaldi; David Mercier; Yang Su; Thomas Bieler; Martin Crimp

Abstract: Nanoindentation was carried out near grain boundaries to investigate how strain transfer at the boundaries influences heterogeneous deformation in commercially pure polycrystalline tantalum. Misorientation of several grain boundaries was determined by electron backscattered diffraction. Inclinations were determined using backscattered electron contrast on focused ion beam milled cross-sections. Pile-up topographies that formed during indentation at or away from boundaries were measured by atomic force microscopy or confocal microscopy. The influence of boundaries on slip transfer was characterized through differences between topographies inside grains and close to boundaries. The parameters of a phenomenological constitutive description were determined in an iterative approach that improves the match of crystal plasticity finite element simulation of single crystal indents against corresponding experimentally measured topographies for different grain orientations. A graphical user interface that was developed allows automating the simulation of indentation at grain boundaries based on experimental parameters such as grain orientations, indent position, or boundary inclination. The ability of the simulations to accurately reproduce the effect of the grain boundaries has been assessed by carrying out a subtraction procedure with the simulated and experimentally measured pile-ups and comparing with correlated subtraction using experimental measurements. This work is supported by a grant from Sandia National Lab and by a Materials World Network grant (NSF DMR-0710570 and DFG EI681/2-1). This work was supported in part by a grant from Sandia National Lab and by a Materials World Network grant (NSF DMR-0710570 and DFG EI681/2-1).

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Abstract: Mg2(Si,Sn) solid solution are promising thermoelectric materials due to the excellent thermoelectric properties. The constituent elements of the materials are abundant in earth and they are non-toxic. It is also of very low density which is favored in device fabrication. High ZT of ~1.5 has been found in Mg2.08Si0.364Sn0.6Sb0.036 compounds in our previous study. But composition analysis on the specimen showed that Mg was deficient on most samples, which indicating the formation of the Mg-vacancy. Compared with other reported high ZT results, more Sb dopant was needed in our work. It has been reported that the Mg-vacancy and Sb-compensation could lead to band structure engineering of the Mg2Si1-xSbx materials. Thus, it is worthwhile investigating the Mg-vacancy and Sb-compensation effects in the Mg2.08-xSi0.364Sn0.6Sb0.036+x materials, to better understand the origin of the high ZT in this material system.

This work was supported in part by DOE-EFRC

Abstract: The deformation behavior of titanium can be complex due the relatively low crystal symmetry of the HCP phase (compared with cubic metals). Here the deformation behavior of a Ti-8Al-1Mo-1V (wt.%) alloy was investigated during in-situ deformation inside a SEM. Tensile experiments were performed at room temperature (RT), 260oC and 455oC, while tensile-creep experiments were performed at 370oC and 455oC. EBSD was performed both before and after the deformation and slip trace analysis was used to identify the activation of the different slip modes as a function of temperature and the associated global stress state Schmid factors. The material exhibited a very weak fiber texture with the c-axis 30o off from the normal sheet direction. During the tensile tests extensive slip occurred. Prismatic slip made up the majority of the observed slip systems during the RT tensile test, while basal and prismatic slip were nearly equally active during the 455oC tensile test. Grain boundary sliding (GBS) and dislocation slip appeared to be the dominant deformation mechanisms during the creep deformation. Cracking occurred both during the tensile tests as well as during the tensile-creep tests, the source of cracking being the triple point junctions and the grain boundaries. The effect of alloy elements on tensile and tensile-creep deformation mechanisms will be discussed with respect to related experiments on other alloys.

This work was supported in part by US DOE/BES grant No. DE-FG02-09ER46637

Abstract: Nb has been the material used for building accelerator cavities over the past couple decades, as it has the highest superconducting transition temperature in elemental metals. Crystal orientation dependent slip system activities affect the shape change of ingot slices during deep drawing, and form a dislocation substructure that affects subsequent recrystallization and ultimately, cavity performance. Two groups of single crystal tensile specimens with different orientations were extracted from a large grain ingot slice. The first group was deformed monotonically to 40% engineering strain. Analyses suggest that slip on (112) planes controlled the work hardening behavior. The second group was heat treated at 800 °C for two hours, and then deformed incrementally to 40% engineering strain. The results indicate that the heat treated group had lower yield strengths, and in most cases, the rotations of crystals differed from corresponding specimens in the first group. Trace analyses reveal that (110) slip was favored for the heat treated group over (112) slip, which could be a result of the lower initial dislocation content. Slip traces were not observed at early deformation stages for some specimens, which could be due to homogeneous slip on (110) planes. Despite the small differences in the initial orientations and the potentially different operating slip systems, the stress-strain curves for corresponding specimens are quite similar. This variation in initial specimen states poses a challenge to interpreting and predicting the deformation behavior of Nb, in that initial dislocation density needs to be installed in a useful material model.

This work was supported in part by U.S. Department of Energy, Office of High Energy Physics, Grant No. DE-FG02-09ER41638
Abstract: Recent developments in the field of solid state secondary lithium ion batteries has yielded new compounds that show high room temperature ionic conductivity and good stability to lithium metal. One class of compounds of particular interest is the garnet series Li7-xLa3Zr2-xTaxO12. The preliminary results presented here are of molecular dynamic simulations for the X=2 (LLT) compound using the DL_POLY software. Employing randomized initial structures from energy minimization studies previously performed by the group, NPT and NVE simulations were carried out, mapping the lithium diffusion pathways in the crystal represented by isosurfaces. This work explores the understanding how the local environment of lithium plays a role in the diffusion of the ion. The results presented are to demonstrate the feasibility of our model with the expectation to apply it to other compounds, to better understand the effects of composition on the local environment of lithium. These simulations are to help supplement the impedance spectroscopy, X-ray diffraction, and neutron diffraction experiments that have been carried out in the literature to give an atomistic perspective on solid electrolyte conduction. The mechanism of a single lithium diffusion step has not yet been rigorously studied in the literature, and this study looks to investigate the jumping of a single lithium between neighboring 24d and 48g lattice positions.

This work was supported in part by the Ceramics Program of National Science Foundation

Abstract: The United States Air Force uses infrared sensors on satellites to detect and track unique infrared signatures that occur around the globe originating from missile or rocket launches. Infrared signals are detected by sensors and in order to increase the signal to noise ratio, these sensors must be cooled to an optimal temperature, typically in the cryogenic range (< 123K, or -150 degrees C). Currently the Air Force utilizes mechanical devices to achieve the necessary cooling; however, these mechanical cryocoolers have several drawbacks including: limited lifetime due to moving parts, difficulty of production and integration, poor scalability, large size and mass, narrow range of temperatures, and finally the introduction of vibrations into the system. Many if not all of these disadvantages could be overcome by using a solid state cooling device such as a thermoelectric cooler. However, the current thermoelectric cooling technology is limited by the poor efficiency of the basic materials, and in particular, there are no know good thermoelectrics for cooling below 150 K. This work investigates the cooling potential of unique ytterbium-based materials and methods for increasing their efficiency for the Air Force’s space-based cooling applications.

This work was supported in part by the Air Force Office of Scientific Research under Multi-University Research Initiative (MURI) “Cryogenic Peltier Cooling” under contract number FA9550-10-10533.

Abstract: The intermetallic compound Ni3Al is the main strengthening phase in Ni-based superalloys, which has attracted great interest in view of the increased yield stress that occurs with increased temperatures. However, the Ni3Al alloy is brittle. It has been found that the addition of ternary alloying elements can greatly improve the mechanical properties of Ni3Al. These properties can be affected by the presence of the precipitated phase. Therefore, it is important to investigate precipitation in the alloy. It is difficult to obtain this information with experimental methods, but computer simulations provide valuable information. In this research, a microscopic phase-field model is used to investigate the early precipitation events in a Ni3(Al1-xFe) alloy by simulating the atomic morphology, calculating long-range order parameters and concentration, and characterizing the site occupation of Ni, Al, Fe atoms in the gamma-prime ordered phase. The temporal evolution of the atomic site occupation and the atomic anti-sites behavior was revealed in detail with Fe content change. It was shown that such research could predict volume fraction of phase, precipitation mechanism, the size of phase, coarsening and atomic site preference. The above research results could provide information valuable for controlling and optimizing the heat treatment process, thereby improving the alloy making it more suitable for industrial production.
MSE-10  A Dynamic Hardening Rule For Crystal Plasticity With A Generalization To The Classical Hardening Rule For Single Crystal Nb
Authors: Aboozar Mapar; Thomas R. Bieler; Farhang Pourboghrat; Christopher C. Compton

Abstract: The classical empirical crystal plasticity hardening rule assumes that the increase in critical resolved shear stress on a slip system during deformation is directly proportional to the increase in shear strain on each of the other slip systems. Although this assumption works well for polycrystals, it cannot accurately predict the deformation of a single crystal, due to the ability of dislocations to escape from a free surface. To address this issue, a dynamic hardening model is proposed which can increase the accuracy and numerical stability of crystal plasticity models. The classical hardening model is a special case of this model. A crystal plasticity model based on this dynamic hardening rule was calibrated for single crystal Niobium (Nb) and used to simulate the deformation of many tensile samples with different crystal orientations. Comparison to the experiments showed that the dynamic hardening rule considerably increases the accuracy of the crystal plasticity model.

This work was supported in part by the U.S. Department of Energy, Office of High Energy Physics, through Grant No. DE-SC0004222.

MSE-11 Creep And Fatigue Analysis Of Friction Stir Welded Al 2139-T8 Alloy
Authors: Ucheki Okeke; Tomoko Sano; Jian Yu; Chian-Fong Yen; Carl Boehlert

Abstract: Aluminum alloys are commonly used for structural applications due to their high strength and low weight. Welding techniques are often applied to join two or more aluminum alloy plates together. The welding process introduces heat, plastic deformation, and chemical variation into the weld joints and modifies the microstructure, strength, and elongation-to-failure of the welded region. The Al 2xxx alloy series is difficult to weld using conventional methods, therefore friction stir welding is being studied. Samples studied were extracted from two plates of Al 2139-T8 alloys friction stir welded together. Fatigue and creep tests were performed on samples from the unwelded, or base metal (BM), region and the friction stir welded region (FSW). The results of the room temperature fatigue tests at 100, 150, 200, and 250 MPa indicated no significant differences in performance between the BM and the FSW regions. The creep test results at 250C and 300C at 25MPa and 50MPa reveal that the FSW region has significantly poorer creepresistance than the BM samples. Backscattered electron (BSE) images were taken of the microstructures of failed samples of both tests to try to understand the different fracture behaviors of the materials.

This work was supported in part by NSF, Army Research Laboratory

MSE-12 In-Situ Characterization Of Deformation Twinning In Pure Titanium
Authors: H. Phukan; L. Wang; C. Zhang; T.R. Bieler; A.J. Beaudoin; J.S. Park

Abstract: Deformation behavior in polycrystalline materials is heterogeneous in nature due to inherent anisotropy and interaction among the constituent grains. In hexagonal metals like titanium the local stress-strain response is strongly dependent upon the texture and c to a ratio. For ‘soft’ orientations, where the c-axis is almost normal to the direction of the applied load, first order prismatic slip is favored. On the other hand, for ‘hard’ orientations, where the c-axis is almost parallel to the loading direction, deformation twinning is often observed. The conditions that lead to the nucleation and evolution of such twins are not clearly understood. In the present work, a strongly textured specimen of commercial purity titanium is subjected to a few percent strain in a tensile test. 3D X-ray diffraction is used for in-situ characterization of type 1 (T1) extension twinning events. A total of eleven layers along the gage length of the specimen were evaluated. The local stress and center of mass positions of the grains are evaluated for each layer at every stress state. The slip transfer parameter is used to ascertain whether the T1 twins observed were nucleated as a result of slip transfer across a grain boundary (S+T twins) or twin induced shear transfer (T+T). This study is expected to facilitate the development of reliable predictive models for meso scale deformation behavior that include mechanical twinning.

This work was supported in part by Material World Network NSF-DMR-1108211 DFG ZA 523/3-1, use of APS supported by DOE/BES

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MSE-13 Multifunctional Nancomposite Foams For Space Applications
Authors: Diandra Rollins; Lawrence T. Drzal

Abstract: Materials combined with a small amount of nanofillers offer new possibilities in the synthesizing of multifunctional materials. One novel nanomaterial is graphene, which due to its hexagonal atomic structure has excellent mechanical, thermal, barrier, flammability reducing and electrical properties. A procedure developed at Michigan State University creates graphene nanoplatelets 1-5 layers thick which are a more robust form of graphene and can be produced at cost competitive prices compared to other additives and fillers. The addition of these nanoplatelets to a polymer foam offer improved mechanical, thermal and electrical properties, at an overall lower cost that allows the foam to maintain its unique cellular structure and low density. A foam material with such combination of properties has potential applications in space technology as the nanocomposite foam would have ranges of stiffness and resilience that are outside the limits of pure polymer foams, be flame resistant, demonstrate electrical and thermal conductivity and yet be both weight and cost effective space stable materials. This research is directed at understanding the physical and chemical challenges associated with embedding graphene nanoplatelets in the struts and cell walls of a polymer foam in order to achieve percolation. This relies on the creation of a good dispersion using both mechanical and chemical methods while varying concentration and the physical properties of the platelets. Investigating each of these effects will help to determine the best GnP selection and dispersion methods to create the optimal multifunctional nanocomposite foam for space applications.

This work was supported in part by NASA Space Technology Research Fellowship

MSE-14 Preparation Of Poly (Lactic Acid)/Polystyrene Bioblend Hollow Microparticles Embedded With Nanoparticles Via A One-Step Emulsion-Diffusion Method
Authors: Anna Song; Ilsoon Lee

Abstract: Poly (lactic acid) (PLA) is a highly potential drug delivery carrier because of its biodegradation and biocompatibility. However, the brittleness and high cost of PLA limit its application. PLA combined with polystyrene (PS) has been considered as a potential bioblend for biomedical applications. In this work, PLA and PS have been dissolved in ethyl acetate under heating, which is a good solvent for PLA but a non-good solvent for PS. This PLA/PS blending solution has then been mixed with a 1:1(v/v) water/glycerol system to form an oil-in-water emulsion, which is followed by the diffusion process to obtain the spherical particles. From the SEM result, hollow microparticles embedded with nanoparticles can be clearly observed. Electron energy loss spectroscopy (EELS) will be employed to define the composition of the dispersive nanoparticles and the continuous phase of the microparticles, respectively. This type of microparticles can be used to design a “two-stage” release system for drug delivery due to the two separated polymer phases and will be tested in the future work.

This work was supported in part by DOD SERDP, SPG

MSE-15 Quantifying Nanoindentation Deformation Processes Near Grain Boundaries In Alpha-Titanium Using Microscopic Characterization And Crystal Plasticity Modeling
Authors: Y. Su; C. Zambaldi; D. Mercier; P. Eisenlohr; T. R. Bieler; M.A. Crimp

Abstract: To understand the roles different grain boundaries play in plastic deformation of commercially pure Titanium, instrumented spher-conical nanoindentations were placed at preselected grain boundaries where corresponding grain orientations were mapped by electron backscatter diffraction. The topographies of the nanoindentations were measured using atomic force microscopy. The effects of grain boundary misorientation and boundary inclination (determined from focused ion beam sections) on indentation pile-ups were categorized by slip transmission parameters. These bi-crystal indentations were simulated using crystal plasticity finite element (CPFE) models to better understand the details of the mechanical response of the different slip systems. Indents in grain interiors were used to identify adjustable parameters in the material model using a single crystal optimization process to match simulated and experimental indentation topographies [Zambaldi et al. J. Mater. Res.

This work was supported in part by the NSF Materials World Network Grant DMR-1108211 and corresponding DFG grant ZA523/3-1.
MSE-16 Optimization Of The Seebeck Coefficient For Low Temperature Thermoelectric Use Of PtSb2 By Tellurium Doping
Authors: Spencer Waldrop; Donald Morelli

Abstract: As part of the ever changing energy demand landscape, thermoelectric materials have shown promise with their capacity to transform thermal energy into electrical energy. The properties of import to a thermoelectric material are its Seebeck coefficient, electrical conductivity, and thermal conductivity. As a generalization, the bulk of research on thermoelectric materials has been concerned with optimization at high temperatures. However, little work has been performed on low temperature thermoelectric materials where there are many venues of application such as in earth orbiting satellites. An investigation of the material PtSb2 was performed to examine the effects of tellurium doping on the Seebeck coefficient. Stoichiometric amounts of platinum and antimony were reacted at 800 C for 4 days and subsequently sintered using Spark Plasma Sintering at 900 C and 60 MPa for 30 minutes. X-ray diffraction was performed before and after sintering to ensure a single phased sample was produced. It was seen that nominal PtSb2 has a positive Seebeck coefficient which peaks with a magnitude of 230 microV/K. The compositions PtSb2-\(x\)Tex ; \(x = 0.0005, 0.001, 0.002, 0.005, 0.02,\) and 0.04 were examined. At all tellurium dopant concentrations the Seebeck coefficient was seen to be negative and readily dependent in magnitude on the concentration. The highest magnitude of Seebeck coefficient seen in these concentrations was found in PtSb2-\(x\)Tex where \(x = 0.0005\). These results inspire further investigation of this material to find at what concentration of tellurium the Seebeck coefficient will be fully maximized.

This work was supported in part by Air Force Office of Scientific Research under the Multi-University Research Initiative (MURI)

MSE-17 Impression Creep Behavior Of Cast Mg-10Gd-3Y-0.5Zr (wt.%) Alloy At Elevated Temperatures
Authors: Huan Wang; Qudong Wang; Carl J. Boehlert; Jie Yuan

Abstract: The impression creep behavior of a cast Mg-10Gd-3Y-0.5Zr (GW103) alloy was investigated by flat cylindrical indenter at temperatures ranging from 250 to 325 oC and stresses ranging from 80 to 505 MPa. The impression creep stress exponents varied from 1.36 to 5.10, which were lower at lower temperatures and stresses. The impression creep activation energies increased from 106.11 kJ/mol to 190.65 kJ/mol with increasing stress. Dislocation-controlled creep was suggested in high temperature and stress regime, while grain boundary sliding could contribute more at lower temperatures and stresses. The zone just beneath the indenter almost maintained the same during impression creep, while the zone inside cycle segments under the indenter deformed severely. The zone at the edge of the indenter underwent largest stress and strain, resulting in broken of grain boundaries and bending of most intragranular precipitates. Intergranular crack was also observed in this zone due to severe deformation. The impression creep data could be converted to be consistent with conventional tensile creep data of the same alloy in certain regions by conversion factors, indicating that impression creep testing is a valuable method to characterize creep behavior and localized deformation in Mg-RE alloy.

MSE-18 Reducing The Thermal Conductivity In Ge-Sb-Te Alloys Through The Incorporation Of Amorphous Ge2Sb2Se5 Particles
Authors: Jared Williams; Donald Morelli

Abstract: We currently live in a world where energy demands continue to escalate, and the way we currently meet those energy needs, via fossil fuels and nonrenewable resources, will very soon no longer be available. Much of today’s research in materials science, chemical engineering, and physics is focused on finding, and improving, alternative forms of energy generation. Cars, power plants, trains, boats, and even solar cells, emit heat as a waste product from their processes. Thermoelectric materials possess the unique ability to convert wasted heat from various thermodynamic processes into useful electrical current. If even a fraction of that heat could be captured and converted back into electrical current, a significant improvement in the efficiency would be achieved. The mechanisms which govern waste heat recovery are exhibited in all materials, but are especially high in a handful of semiconductors. My current research involves developing new thermoelectric materials, and engineering these materials for power generation. Ge4SbTe5 and its relatives, with equal numbers of atoms on the cation and anion sites, form stably in the cubic rocksalt structure. For thermoelectric applications a cubic compound is advantageous because there is no issue regarding anisotropy of the thermoelectric properties. This study investigated the feasibility of incorporating amorphous Ge2Sb2Se5 particles into the Ge4SbTe5 crystal matrix and their effects on the thermoelectric properties.

This work was supported in part by Department of Energy
MSE-19 Angle-Dependent Performance Of Thin-Film, Transparent Photovoltaics
Authors: Margaret Young; Yunhua Ding; Richard Lunt

Abstract: Understanding the angle dependent performance is an important consideration for building integrated photovoltaics (PVs), such as transparent PV windows, where illumination angles are rarely at normal incidence. While the transfer matrix model (TMM) has been widely utilized to model optical interference and quantum efficiency in thin-film PVs at normal incidence, self-consistent simulations for PVs under oblique illumination have not yet been demonstrated. We derive an updated model that is self-consistent for all angles, light polarizations, and electrical / optical configurations, and experimentally verify the predicted angular quantum efficiency response of planar heterojunction (PHJ) transparent PVs. We subsequently use this model to optimize PHJ transparent PVs for maximum short circuit photocurrent density (Jsc) and transparency as a function of the multivariable landscape under a variety of optical and electrical configurations, showing that it is possible to greatly reduce the angle-dependent roll-off in efficiency by moving in this multi-parameter space. We will provide insights into the lesson learned for designing devices that can reduce this roll-off and increase overall yearly power output.

This work was supported in part by National Science Foundation (Career Grant #: 1254662)

MSE-20 Study Of The Subsurface Slip Activity Of Polycrystalline Ti-5Al-2.5Sn Alloy With Crystal Plasticity Finite Element Method Using 3D Microstructure
Authors: Chen Zhang; Hongmei Li; Philip Eisenlohr; Thomas R. Bieler; Martin A. Crimp; Carl J. Boehlert

Abstract: The study of slip activity of polycrystalline material generally focuses on the sample surface since the subsurface slip activity is difficult to characterize using conventional experimental methods. However, the heterogeneous deformation process of polycrystalline material is three dimensional by nature, indicating that understanding the subsurface slip activity is crucial for the study of heterogeneous deformation of polycrystalline material. Computational models with a microstructure that is representative of the sample are generally used to provide insight about the slip activation and propagation during plastic deformation. In this study, a new method is used to simulate the deformation process of a Ti-5Al-2.5Sn sample deformed under uniaxial tension at room temperature using a Crystal Plasticity Finite Element (CPFEM) model with realistic 3D microstructure based on Electron Backscatter Diffraction (EBSD) and Differential Aperture X-Ray Microscopy (DAXM) data. Schmid analysis and generalized m' factor analysis were used to analyze the subsurface slip activity, using the local stress tensor and local accumulative shear from simulation. Correlation between experiment observation of the sample surface and simulation results was attempted to gain better understanding of the effect of subsurface slip activity on the deformation history visible on the surface of polycrystalline Titanium alloys. The DAXM characterization was conducted at beamline 34-ID-E, Advanced Photon Source at Argonne National Lab. Supported by DOE/BES grant DE-FG02-09ER46637.

This work was supported in part by DOE/BES grant DE-FG02-09ER46637

MSE-21 In-Situ HE-XRD Characterization Of Microstructure Evolution In SAC Solder Joints With Different Cooling And Thermal Cycling Conditions
Authors: Quan Zhou; Huili Xu; Choong-Un Kim; Thomas R. Bieler; Tae-Kyu Lee

Abstract: Lead freed solders have replaced the conventional leaded solder in the electronic packaging industry for several years, but there still exist unpredictable failures arising from the highly anisotropic properties of Sn-based solder joints. In our previous study, the effects of cooling rates on the microstructure and grain orientation evolution in lead-free solder joints in ball grid array packages was characterized using polarized light microscopy and electron backscattered diffraction (EBSD). This study shows that either higher or lower cooling rates than in common use will refine grains by promoting new grain generation or triggering mechanical twinning. The amount of microstructural refinement varied depending on the cooling rate, joint location, and the original crystal orientation(s). The observations of microstructure change depend on the general anisotropy of the joint arising from its initial crystal orientations. New grains and twins with different orientations weaken the joint anisotropy and new interfaces and orientations slow the damaging effects on electromigration. With the possibility to improve the mechanical properties by modifying the microstructures, cooling rate experiments were designed for in-situ measurements of a joint using high-energy X-Ray diffraction (HE XRD) at beamline 6-ID-D to investigate the microstructure evolution and its effect on mechanical properties. Microstructure evolution during the cool down following solidification was captured, and the related mechanical response during thermal cycling was further characterized. Structure-property relationships are discussed as well as fundamental analysis of grain refinement and mechanical twin formation. The findings will provide guidance for package design and process control in the electronic packaging industry.

This work was supported in part by NSF-GOALI Contract 1006656 and Cisco Systems Inc., San Jose, CA. Use of the Advanced Photon Source was supported by the US Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.

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Abstract: Development of efficient and low-emission colorless distributed combustion (CDC) systems for gas turbine applications require careful examination of the role of various flow and combustion parameters. Numerical simulations of CDC in a laboratory-scale combustor have been conducted to carefully examine the effects of these parameters on the CDC. The computational model is based on a hybrid modeling approach combining large eddy simulation (LES) and filtered mass density function (FMDF) and high order numerical methods with complex chemical kinetics. The simulated combustor operates based on the principle of high temperature air combustion (HTAC) and has shown to significantly reduce the NOx, and CO emissions while improving the reaction pattern factor and stability without using any flame stabilizer and with low pressure drop and noise. The focus of the current work is to investigate the mixing of air and hydrocarbon fuels, the non-premixed and premixed reactions and emission levels within the combustor by the LES/FMDF with the reduced chemical kinetic mechanisms for the same flow conditions and configurations investigated experimentally. The main goal is to develop better CDC with higher mixing and efficiency, ultra-low emission levels and optimum residence time. The computational results establish the consistency and reliability of the LES/FMDF model and its Lagrangian-Eulerian numerical methodology.

Abstract: As an important flow-sensing organ, the lateral line system is involved in various behaviors of fish such as schooling, station holding and object detection. Theoretical work is also conducted on flow modeling to help explain hydrodynamic imaging by fish and extract information in artificial lateral lines. Much of the aforementioned research on information processing for biological and artificial lateral lines has been focused on the localization of a dipole source, which emulates the rhythmic movement of fish body and fins, and has been commonly used as a biological stimulus such as conspecific, predator or prey. Dipole source localization has also played an important role in the development of artificial lateral lines, detection and estimation of nearby fish-like robots, and coordination and control of underwater robot. Despite much research on dipole source localization, there are few studies on optimal design of artificial lateral line system in order to maximize reliability of localization. Presence of diverse sources of uncertainty challenges reliability of localization and practicability of the underlying idea. In this study, different sources of uncertainties are identified and modeled in the problem formulation. A bi-level robust optimization method is proposed to handle inherent uncertainties in the problem. The best design obtained by the proposed optimization method is compared with the initially proposed design on a large number of data set which demonstrates significant advantages of robust optimization over sole engineering intuition. The proposed method clearly illustrates the use of evolutionary algorithms in handling uncertainties and is extendable to similar other problems.

This work was supported in part by BEACON.

Abstract: 3D printing (3DP) is a manufacturing process that is well-suited for topology optimization because of the design freedom made possible by 3DP. Most of the work in topology optimization has focused on maximum stiffness design of structures subjected to externally applied mechanical loads. However, because of thermal gradients, in 3DP the pattern of layout of material may contribute to thermal stresses that affect performance. Traditional topology optimization does not account for this. In 3DP process-induced stresses may be high enough to affect the structural integrity of the part, and the part will warp. The aim of this study is to determine the residual stresses during the manufacturing process; identify process conditions that result in reduced residual deformation; and then take thermal stresses into account within a topology optimization formulation. To simulate the forming mechanism in 3DP, a time-dependent finite element multiphysics model is used. The model simulates a high intensity laser energy source moving along a pre-defined time dependent path, used to solidify the powder being laid down along the path. The model includes the effect of parameters such as convection coefficient, laser velocity, part dimensions, and path direction. It is found that by adjusting the speed of the laser along its path, path direction, and layer thickness, the resulting residual deformation can be reduced or eliminated.
ME-04  Real-Time Control Of The Boundary Layer Disturbance Induced By A Dynamic Isolated Roughness Element Using Plasma Actuators
Authors: Kyle Bade; Ahmed Naguib

Abstract: Fluid flows found in most engineering applications are generally turbulent (i.e. chaotic, three-dimensional, and time-dependent). In many of these applications, it is desirable to maintain the flow in a laminar (i.e. orderly) state in order to reduce the friction drag between the fluid and solid surfaces. Motivated by the delay/prevention of transition from the laminar to turbulent state, this study examines the ability to sense unsteady disturbances in a Blasius laminar boundary layer and to attenuate their transient growth using plasma actuators. It is well established that a certain ubiquitous type of boundary layer transition (known as "bypass") is initiated by the formation and growth of unsteady disturbances, known as streaks. Thus, by actively controlling these disturbances in engineering applications, it could be possible to delay transition to turbulence, increasing system efficacy and energy efficiency. In this work, the unsteady streaks are introduced into the boundary layer using an isolated roughness element that is dynamically actuated from flush with the wall to a specified height; resulting in a time varying disturbance. A real-time, closed-loop, feedforward-feedback control system is designed to apply an appropriate voltage to a plasma actuator in order to reduce the roughness induced disturbance. The control system inputs come from two in-wall hot-wire shear stress sensors located within a high-speed streak disturbance, one upstream and one downstream of the plasma actuator. The controller is shown to effectively drive the shear stress at the feedback sensor toward the Blasius level, and effectively reduce the disturbance strength.

This work was supported in part by National Science Foundation (NSF Grant: CMMI 0932546)

ME-05  Controlled Diffusion Blade: Fluid Mechanical Mechanistic Effects On Fan Performance
Authors: David Barrent; John Foss

Abstract: Experimental work to identify the mechanistic effects on fan performance will be carried out in the Axial Fan Research and Development Facility at the Turbulent Shear Flows Laboratory. Fan performance curves have been generated for both the three and nine blade conditions for the Rotating Controlled Diffusion Blade (RCDB) fan. Calibration of the mass flow sensing device (Morris) inside the AFRD was required to obtain these data. The annular opening for the fan was selected as the inlet for the calibration. The discharge coefficient of this opening was unknown and required for the mass flow calibration. Hotwire surveys along four equally spaced radial lines were used to find the Reynolds number dependent discharge coefficient. Once the calibration for mass flow measurements was complete, performance data for the three and nine blade fan were obtained. Each fan configuration was tested at varying rotational velocities to see if the behavior of the fan would scale in a non-dimensional fashion. The RCDB has instrumented blades with eighteen pressure taps at five radial locations. These will be utilized to find the pressure coefficients along the suction and pressure side of the blade at varying radial locations. Near wake stationary hotwire measurements will be made to characterize the wake of the RCDB.

This work was supported in part by the Consortium for Ultra High Efficiency Quiet Fans

ME-06  Design Of A Sliding Mechanism In The Application Of Vibration Suppression Of A Nonlinear Beam
Authors: Tingli Cai; Ranjan Mukherjee; Alejandro R. Diaz

Abstract: This work presents the experimental realization of a slider to be applied in a vibration suppression system for a nonlinear beam. The slider constrains the transverse displacement of the beam locally but not the beam's rotation. Friction is designed to be minimum while the slider moves on the surface of the beam. The device measures the reaction force from the beam and prescribes sliding motion through a belt-drive actuator to do negative work on the beam. Filters are used to meet the bandwidth requirement of the actuator. The goal of this design is to stabilize the vibrating beam which is subject to various disturbance.
Multiscale Free Edge Investigation Of Composite Laminates
Authors: Christopher Cater; Xinran Xiao

Abstract: Stress gradients are present at the free edges of laminated composites as a result of property mismatch between lamina of varying orientations. This phenomenon, known as the free edge effect, has been studied extensively at the meso-scale. Typically, each lamina is assumed to be transversely isotropic and homogenous. This approach, however, neglects the heterogeneous nature of the composite at the microscopic scale and its influence on damage initiation. In this work, a multiscale approach is presented to explore the microscopic stresses, at the scale of fiber and matrix, present near the free edge. To accomplish this task, a semi-concurrent multiscale approach is implemented into ABAQUS. Two length scales are utilized: 1) the meso-scale, utilizing a composite laminate Representative Volume Element (RVE), to capture the heterogeneity of the individual lamina; and 2) the micro-scale, containing a 3D RVE of the fiber and matrix constituents. The standard kinematic relations of a computational homogenization approach are modified to allow for the use of free-edge boundary conditions at both the meso-scale and micro-scale, allowing for the investigation of free-edge effects. To simplify the problem, constituent materials are assumed linear elastic, allowing for a one-way coupling between the two length scales, similar to a global-local approach. The research addresses the validity of the solutions to the free edge boundary value problem (BVP), determining appropriate RVE sizes to achieve accurate free-edge stresses near the regions of interest. It will also present the microscopic stresses, which are potential sources of fiber/matrix debonding or matrix cracking.

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Aeroacoustic Measurements Of The Self-Noise Of A Rotating Controlled Diffusion Blade
Authors: Behdad Davoudi; John Foss

Abstract: The self-noise of a 9 blade fan has been examined using an array of microphones. The array allows the principle of beam forming to be used such that extraneous noise effects are minimized. The blades are shaped as controlled diffusion airfoils with a chord length of 133.9 mm and a span of 126 mm. The nominal tip clearance is 4 mm. The pressure rise and flow rate measurements are based upon the techniques described in Morris and Foss (2001) and their representation of the Axial Fan R & D facility at MSU. Acoustic measurements were obtained with arrays of Panasonic microphones placed above the fan plane (in the upstream flow). Microphones were located in two different circular patterns (r = 303 mm) at two different height levels, which are both directly above the blades’ mid-span. Each Panasonic microphone is calibrated with a Larson Davis microphone which is the reference microphone for the acoustic measurements. The beam forming method was employed to process the data obtained from two distinct circular arrays. Since the microphones in each array were at different distances with respect to the fan (sound source), combining the microphone voltage signals while accounting for the "source-to-microphone" distances enhances the extraction of the self-noise characteristics from the microphone measurements. By manipulating specific operating conditions, selected based on the performance curves for each blade configuration, the relative incidence angle seen by the blades is altered, and its effect on the propagated broad band noise has been recorded.

This work was supported in part by UHEQ Consortium

Analytical Solution For Fluttering Motion Of A Free Falling Rigid Flat Plate In A Stationary Viscous Fluid
Authors: Behdad Davoudi; Indrek Wichman

Abstract: The problem of freely falling thin flat plates in a stationary viscous fluid has been previously examined. This phenomenon, for falling cards or flying leaves, is often called fluttering motion. Fluttering motion depends on specific conditions, i.e. plate/fluid relative dimensions and densities, and it can undergo a transition to tumbling motion (not discussed here). Previous studies have dealt with this problem using computational, analytical and experimental approaches. In most of the computational approaches, researchers have tried to either directly solve the Navier-Stokes equations or to utilize the circulation around the plate (for example) in various semi-empirical models. The analytical works employ a variety of force coefficients or a relation for the circulation. We follow a similar approach. Only a few studies involve experiment. In this work, a simple analytical approach for fluttering motion is presented assuming 2-D motion (i.e., planar descent). The aerodynamic force balance is written, and a variable angle of attack based on the plate transitional velocity and direction is defined. The force balance utilizes relations for lift and drag coefficients suggested by flat plat theory. The moment coefficient around the center of the plate is obtained using an experimental correlation formula for the moment coefficient about the quarter chord. A rotational drag term is developed to take into account the drag force exerted to the plate by its rotation. Since the Reynolds number based on the plate chord is of the order of 1000 the Blasius solution is used in order to approximate the frictional drag over the plate. The remaining forces considered here are exerted by the actions of buoyancy and gravity. The advantage of this model is that equations of motion are universal, and therefore valid throughout the fluttering motion. The numerical solutions are in reasonable agreement with the previous experiments with respect to both order of magnitude of various derived quantities and also the plate trajectory (motion) through the fluid.

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Abstract: The maximum diameter and their growth rates are usually regarded as key factors for making a decision on therapeutic operation time for an abdominal aortic aneurysm (AAA) patient. There is, however, debate on what the better standard method is to measure the diameter and there are still remaining shortcomings among different methods. Currently, two dominant methods for measuring the maximum diameter are one on the planes perpendicular to the centerline (orthogonal diameter) and the other on the axial planes (axial diameter). Alternatively, a new robust method, named ‘inscribed sphere diameter’, proposes to measure the diameter and, additionally, addresses the similarities and discrepancies of these three methods. We investigate if the spherical diameter is a better representative of AAA volume and if it serves as a better measurement for aneurysm size in analogy with other measurements. A set of longitudinal CT scan images from nine Korean patients are investigated and compared with a previous study conducted with patients from Europe. Growth rate parameters are calculated in different diameters and the total volume and the correlations between them are studied. Furthermore, an exponential growth pattern is sought for the maximum diameters over time to examine a nonlinear growth pattern in AAA expansion, globally and locally. The results indicate that the inscribed-spherical diameter shows the most reliable and robust measurement of the diameter compared to transverse, in-plane diameters. Based on growth parameters calculated in the results, we suggest that growth parameters in the Korean and European patients are not significantly different.

Keywords: Korean patients, exponential growth, transverse diameter

This work was supported in part by National Institute of Health (NIH)

Abstract: The recent heightened interest in the aerodynamics of flapping-wing flight is motivated by the potential for engineering unmanned micro aerial vehicles (UMAV) with unique capabilities similar to natural fliers, e.g. effective generation of lift at low Reynolds number, high maneuverability, and tolerance to wind gusts. Such UMAVs could have a wide range of applications in search and rescue operations, monitoring hazardous emissions, and reconnaissance. In this work, computations are performed for studying the flow field and accompanying forces induced by asymmetrically pitching a NACA 0012 airfoil at low Reynolds number. The majority of past research addresses sinusoidal motions, with almost none considering the influence of motion asymmetry: a parameter that is likely important for designing UMAVs. The current implementation of the flow solver utilizes a multi-grid approach to adequately resolve the flow details in the wake of the airfoil. Results are presented for two motion trajectories: equal pitch-up and pitch-down (i.e. symmetric motion) and a pitch-up that is faster than pitch-down. The computed lift and drag forces on the sinusoidally pitching airfoil show convergence for freestream Mach number below 0.025. In addition, the vortex street in the wake of the asymmetrically pitching airfoil shows two modes for vortex shedding during the slow phase of the motion depending on the Mach number: 1) two vortices that eventually merge together; 2) two vortices whose separation increases as they convect downstream. The impact of the asymmetry on the flow field and the forces is illustrated for the low Mach number of 0.025.

This work was supported in part by AFSOR Grant No. FA9550-10-1-0342.

Abstract: An experimental and numerical investigation is performed of premixed flame propagation in a constant volume rectangular channel with an aspect ratio of six (6) that serves as a combustion chamber. The ignition event is followed by an accelerating convex shaped flame-front. A deceleration of the flame is followed by the formation of a concave “tulip” shaped flame-front. Eventually, the flame is extinguished because of collision with the cold wall on the opposite end of the confined channel. Numerical calculations of the combustion event are performed to understand the influence of pressure waves, instabilities, and flow field effects causing changes to flame structure and morphology. The transient 2-D numerical simulation results are compared with transient 3-D experimental results.

This work was supported in part by Advance Research Projects Agency - Energy (ARPA-E)
ME-13 The Effects Of Chlorinated Compounds On Instantaneous Water Heaters
Authors: Andrew Koch; Alex Schuen; Elisa Toulson

Abstract: Bradford White Corporation requested the investigation of the impact of water with a high concentration of chlorine compounds in an instantaneous water heater. Research was done to identify chlorinated compounds found in water supplies in the United States. An analysis of the chlorinated compounds was completed to determine which chemicals are known to corrode metals, primarily stainless steel. An apparatus was built to test the instantaneous water heater with water containing the chlorinated compounds. This apparatus was designed to simulate realistic conditions for water heaters. A GCMS analysis was developed to test the degradation rate of the chlorinated compounds. Test samples with distilled water and the correct concentration of each chemical were made and heated to simulate the conditions in the water heater. The GCMS analysis results indicate minimal degradation of the chemicals in water.

This work was supported in part by Bradford White Corporation

ME-14 Unit Cell Modeling To Predict Permeability For Composite Manufacturing
Authors: Timothy Luchini; Stephen Sommerlot; Alfred Loos

Abstract: Detailed geometric models can be used to accurately design molds, to predict imperfections, and correct potential design issues before more expensive resources are spent in fabrication of composites by liquid molding processes. Fiber preforms are frequently modeled by using a unit cell of repeating geometry, which allows the model to be developed in a computationally efficient manner. Using models to numerically predict permeability can reduce the need for experimentation and allow for fast characterization of large numbers of fiber preforms. The research described here validates this by using the unit cell approach to model in-plane saturated permeability and comparing the predictions with experimental results obtained using a custom test fixture to measure permeability of a plain weave S glass fabric. The fabrics are characterized using a scanning electron microscope (SEM) and the finished composites are studied at the desired volume fraction for material characteristics. The actual fabric geometry is important in the geometrical prediction of permeability, and the model is generated based on a set of python scripts defined in an open source textile software package called TexGen. A unit cell computational fluid dynamics (CFD) model for permeability prediction is presented, which considers a dual scale preform that uses Stokes flow in the inter-tow voids and Gebart’s permeability prediction in the fiber preform. The CFD results produced with the commercial package Fluent are shown to correlate well with experimental results, and this research further validates the results of the open source software with data produced by commercial fluids solvers.

This work was supported in part by GE Aviation

ME-15 Crystal Plasticity Modeling Of Deformation Of Ferrite And Martensite Micropillars In A Dual Phase Advanced High Strength Steel
Authors: Aboozar Mapar; Taejoon Park; Farhang Pourboghrat

Abstract: Advanced high strength steels (AHSS) have been widely used in auto industry over the past few decades. These steels, without compromising their mechanical properties, have made a considerable weight reduction in cars. The weight reduction, increases the fuel efficiency of the automobiles and makes them more appealing to customers. Many of AHSS contain multiple phases. One needs to know the behavior of each phase in order to understand the deformation behavior of the multiphase steel. Ferrite and Martensite phases respectively have BCC and BCT crystal structures. The classical crystal plasticity model, however, was initially developed for FCC material, which has close packed planes and 12 distinct slip systems. The active slip systems in a FCC crystal can be found from the Schmid law, which states that dislocation slip occurs when the shear stress on a slip system parallel to the slip direction reaches a critical value. This law is not valid in BCC and BCT materials, which do not have close packed planes. In these materials, stress on non-planar or non-parallel to the slip direction can affect the initiation of dislocation slip. This is known as non-Schmid behavior.

In this study, a non-Schmid crystal plasticity model was developed and implemented into a commercial FEM software (Abaqus) as a user defined subroutine. This model was then used to simulate the compression behavior of Ferrite and Martensite micropillars. The results of the experiments and simulations will be discussed in the poster.
ME-16  Control Of Hybrid Dynamics With Application To A Hopping Robot  
Authors: Frank Mathis; Ranjan Mukherjee

Abstract: Control of dynamic motion is a crucial area of study in robotics as on frequently wants the robot to behave in a desired motion pattern rather than moving to a set point. Furthermore, the motion of the robot commonly involves changing dynamic behaviours commonly due to environmental effects such as surface contacts, which leads to hybrid dynamic systems. A common area of such hybrid dynamic control is in legged robots which have hybrid dynamic behaviour such as switched dynamics due to changing legs and impulsive dynamics due to ground contacts, but also require control to a dynamic trajectory defining the walking or running motion. For this, the spring loaded inverted pendulum (SLIP) model is commonly used as a simplified model to describe the dynamic motion. Based on this model, the control of hopping robots has been widely investigated. A fundamental limitation of the model is that it fails to account for impact with the ground, and this is due to its single degree-of-freedom in the vertical direction. Here we investigate the dynamic control of a four-link hopping robot. The advantage of our method is that the entire dynamics of each robot is considered for the control design allowing the controller to compensate for the impulsive dynamics as well as higher order behaviour which are unaccounted for in simplified models such as the SLIP model.

ME-17  Pore Formation And Deformation In Membrane Bilayers  
Authors: Vahid Mirjalili; Nikolai Priezjev; Michael Feig

Abstract: In this study, we have developed a new method called Density Biasing method, that under molecular dynamics (MD) framework can be used to effectively form pore and one-sided deformation in membrane bilayers. The density biasing method tries to increase the density of water molecules in a cylinder aligned to bilayer normal axis. Using this method, we evaluated the free energy cost of forming a pore in the bilayer, and how the presence of hydrophilic compounds in bilayer center affect this process. It is found that under the presence of acetamide in bilayer center, two equi-stable states (flat bilayer and deformed state) exist, which are separated by a free energy barrier. The flat bilayer state is stabilized by penetration of a single water molecule.

ME-18  Analyses Of Hydrodynamic Features And Separation Performance Of A Hydrocyclone Used For Oil-Water Separation  
Authors: Abdul Motin; Volodymyr V. Tarabara; Charles A. Petty; André Bénard

Abstract: This research addresses critical aspects of the hydrodynamics and separation performance of a de-oiling hydrocyclone used in produced water treatment, oil spills cleanup, as well as refining of petroleum products. Fundamental hydrodynamic features that influence separation performance of a de-oiling hydrocyclone are examined. Velocity and pressure inside the hydrocyclone are calculated by numerically solving Reynolds Average Navier-Stokes equations closed with Reynolds Stress Model. Separation efficiency of the hydrocyclone is estimated by analyzing trajectories of dispersed oil droplets in the flow where the trajectory is calculated by solving the equation of motion and the force balance on a dispersed droplet. Effects of hydrocyclone geometry and the inlet conditions on the internal flow structure, short circuit flows, vortex core pattern, and trajectories of droplets are investigated based on computational fluid dynamics. Results indicate that the conventional de-oiling hydrocyclones have a finite turndown ratio i.e. it exhibits acceptable separation efficiency only for a certain range of the Reynolds number. Internal flow structures provide a fundamental understanding for possible approaches to redesign a hydrocyclone.

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ME-19  Surface Pressure Measurements From Multiline Single-Component Molecular Tagging Velocimetry  
Authors: David Olson; Ahmed Naguib; Manoochehr Koochesfahani

Abstract: Knowledge of the aerodynamic forces acting on an object in relative motion to a fluid is of paramount importance for the structural design of the object, for determining the payload, if the object is of the lifting type, and for minimizing the energy consumption in moving the object relative to the fluid. Traditional experimental methods of obtaining these forces require either considerable embedded instrumentation or intrusive hardware in the flow. An ideal measurement technique would provide a non-intrusive pressure and shear stress distribution around the body without the expense and limitations of fixed embedded instrumentation. This study considers the feasibility of estimating the surface pressure distribution and shear stress based on high-resolution single-component molecular tagging velocimetry. The method relies on the connection between the surface pressure gradient and the second order wall-normal derivative of the velocity component tangent to the wall. We show the application of this approach to measuring the surface pressure and shear stress distribution on a circular cylinder in cross flow at Re = 6,000. Results compare favorably with data in the literature.

This work was supported in part by AFOSR grant number FA9550-10-1-0342.

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ME-20  **Blood Flow Responses To Loading: Interpretations For Skin Ulcers**  
**Authors:** Wu Pan; Josh P.Drost; Marc D.Basson; Tamara Reid Bush

**Abstract:** Skin ulcers are a significant health concern affecting the elderly, diabetics, individuals with vascular disease and amputees resulting in deep penetrating wounds. One of the factors under investigation for increased risk of skin ulcers is post occlusive reactive hyperemia injury. Such aggressive increase of blood flow in the vessel has been shown in animal studies to be related to tissue damage. The goal of this research was to determine differences in reactive hyperemia responses across a population of healthy individuals, and individuals with chronic leg wounds. A custom designed force applicator was adopted for different loading applications and was accommodated with Laser Doppler probe allowing loading to occur around the perfusion probe. Twenty-one patients with wounds and twenty healthy individuals participated in the tests. The Absolute Reactive Hyperemia Value (ARHV), i.e. the maximum value of perfusion after load release, and the Relative Reactive Hyperemia Magnitude (RRHM), i.e. the difference between ARHV and the perfusion value during the loading, were compared across all three categories. Results showed that wounded legs have the highest ARHV and RRHM values followed by non-wounded legs of patients with wounds, and healthy legs had the lowest values. Statistically significant differences occurred between all groups for both normal and combined loading Understanding changes in blood flow responses across healthy patients and patients with skin ulcers is critical to improving our understanding of skin wound formation, developing better preventive measures, and providing inputs for tissue injury models.

ME-21  **Equilibria Analysis And Wave Propagation In Nonlinear Chains**  
**Authors:** Smruti Panigrahi; Brian Feeny; Alejandro Diaz

**Abstract:** We present the dynamics of nonlinear structures with both quadratic and cubic nonlinearities. We first studied the bifurcations of equilibria of a two-degree-of-freedom twinkling oscillator in order to investigate the capacity to harvest energy. Twinkling occurs when the nonlinear structure is loaded slowly and the masses snap through, converting the low frequency input to high frequency oscillations. The kinetic energy born in these oscillations can then be harvested. We also studied the propagation of waves in an infinite nonlinear chain to highlight the effects of quadratic nonlinearity. When multiple waves pass through the chain we observe their interactions and exchange of energy in the sub and super-harmonic resonance conditions. Studying the dynamic behaviors of these structures is an important step toward understanding the capacity for energy harvesting, energy dissipation and crashworthiness, vibration isolation, vibration absorption, event detection, and nonlinear waveguides.

*This work was supported in part by National Science Foundation*

ME-22  **Development Of Soft Nanoimprint Lithography And Its Application In Nanowire Fabrication**  
**Authors:** Snehan Peshin; Junghoon Yeom

**Abstract:** As an unconventional lithographic technique with high throughput patterning at great precision and low cost, soft nanoimprint lithography has a great scope for fabricating nanowires and other nanostructures in combination with metal assisted chemical etching. Traditional lithographic approaches use photons or electrons thus incorporating the limitation of wavelength and beam scattering. But in soft nanoimprint lithography, there is a direct mechanical deformation of a polymeric film on the substrate by impressing with soft elastomer replica typically made of PDMS. We are developing a process to replicate micro- and nanostructures from a soft master mold by imprinting on a UV-curable polymer-coated substrate. This process is facile, reliable, and scalable hence inexpensively creating an array of patterns of various geometries. For example, an array of dot patterns has been fabricated by soft nanoimprint lithography, and metallization followed by the lift-off process produces a metal film with ordered holes. Now a noble metal film such as Au or Ag can catalyze the etching reaction with the silicon substrate in the presence of oxidant (e.g. H2O2) and HF. This combined technique creates a new opportunity to cheaply fabricate nanowires. These nanowires will find applications in gas sensors and various optoelectronic applications. The focus of the presentation will be placed on challenges related to producing good quality imprints and various parameters for optimized quality as well as time factor.
ME-23 Generative Variable Length Genetic Algorithms
Authors: Matthew Ryerkerk; Ron Averill; Erik Goodman; Kalyanmoy Deb

Abstract: Optimization algorithms typically operate with a fixed-sized genome. However, there exists a class of problems where the number of design variables may not be fixed. Such problems include sensor placement, laminate composite design, packing, or neural network problems where each solution can be defined with a range of possible component numbers. Gradient based algorithms are ill-suited for such problems. Genetic algorithms are viable candidates, however the traditional operators are of little use with a variable-size genome. Our previous work has resulted in the development of a variable-length genetic algorithm (VLGA), capable of determining solutions of the optimal size without a priori knowledge. VLGA was shown to be very effective for several testbed problems, however it requires a high number of evaluations, which limits its usefulness for real world engineering problems. The variable-size problems that we have studied are all highly multimodal, many solutions have similar fitness but dissimilar topologies. The current algorithm, and associated operators, relies on a direct encoding of the solution into the genome. This makes it near impossible to effectively explore different topologies in the design space, to move from to another would require coordinated changes to many components at once. Instead a generative, indirect encoding, and appropriate operators, for variable-size problems is proposed. Small changes to this encoding could produce a coordinated change to all components in a solution, facilitating a fast and effective search over many topologies.

This work was supported in part by BEACON - Center for the Study of Evolution in Action

ME-24 Prior Distributions Of Material Parameters For A G&R Computational Model Of Abdominal Aortic Aneurysm
Authors: Sajjad Seyedsalehi; Liangliang Zhang; Jongeun Choi; Seungik Baek

Abstract: Advances in computational modeling of the aorta in line with the use of subject-specific data have promised a growing potential in clinical diagnosis and treatments of vascular diseases. In enhancing an accurate prediction of the vascular disease progression, there is, however, an important need for a systematic tool towards the patient specific modeling. Particularly, considering the intra-patient variation of model parameters, the prior distribution has strong influence on computational results for arterial mechanics and one crucial step towards patient specific modeling is the use of patient specific model parameters instead of used population averaged values. To this goal, we present exploiting a new statistic tool of an arterial model, as a better systematic tool, and then estimate the prior distribution for the model parameters, using experimental results for 17 healthy abdominal aortas. We investigate the correlation between estimated parameters with noninvasively assessable parameters, age and gender. Using the correlation results with the application of Box-Cox transformation, we construct the conditional joint distribution and confidence intervals for model parameters. This information improves the prior distribution of subject-specific model through specifying parameters using age and gender. A Bayesian based statistic tool decreases the uncertainty and error in the prediction of subject-specific model as presenting aortic material behavior. The results from this study will be used as the prior information necessary for the statistic tool of G&R.

This work was supported in part by National Science Foundation (NSF)

ME-25 An Interfacial Debonding-Induced Damage Model For Graphite Nanoplatelet Polymer Nanocomposite
Authors: Azadeh Sheidaei; Farhang Pourboghat

Abstract: In situ tensile tests show damage initiates in nanocomposite mainly by interfacial debonding. In this paper a hierarchical multiscale model is developed to study the damage initiation in polymer /graphite nanoplatelet (GNP) composites. The cohesive zone model has been adopted to capture the nanofiller deboning. The results of atomic simulations of GNP pullout and debonding tests have been used to obtain the traction-displacement relation for cohesive zone model (CZM). The effects of volume fraction and aspect ratio of the GNP and strength of the interfacial adhesion on overall stress-strain response of the nanocomposite have been investigated. Results show debonding have a significant effect on overall stress-strain response when volume fraction and aspect ratio increase. The results also indicate that GNP/polymer interfacial strength plays a key role in damage mechanism of nanocomposite.
ME-26  A New Continuum Damage Mechanics Model For Crash Simulation Of Fiber Reinforced Composites
Authors: Danghe Shi; Xinran Xiao

Abstract: Fiber reinforced composites are widely used in aerospace, automotive industry due to their high stiffness, strength-to-weight ratio, corrosion resistant and energy absorption ability. However, their complex failure mechanisms make it very difficult to analytically and numerically model their behavior under crash and thus limited their application for massive productions. Many works have been attempted to simulate the crashworthiness of composite structures, particularly to evaluate the deformation behavior and to determine the energy absorbing efficiency of various composite structures. However, the existing simulation models generally need to introduce many non-measurable parameters which limited their practical applications. In order to solve this problem, this work focused on the implementation and development of a thermodynamically consistent continuum damage mechanics (CDM) model. All the parameters needed in this model can be determined by experiment. It was proved that this model is able to capture the behavior of several different fabric forms of fiber reinforced composites during crash including some special event like hysteresis phenomenon.

ME-27  Modeling Advancing Flow Fronts In Composite Manufacturing
Authors: Stephen Sommerlot; Timothy Luchini; Alfred Loos

Abstract: Flow front propagation in liquid composite molding (LCM) is subject to the fiber architecture, resin properties, and the preform geometry being infused. Defining accurate resin flow fronts for complex fabrics is challenging as the permeating fluid often progresses in an uneven "fingerling" manner due to variable porosity and flow channels the textile geometry creates. Modeling the advancing flow fronts in LCM accurately is important as air entrapment and void formation can arise due to the resin and air phase interaction at the flow front. These are important considerations for mold design, prediction of voids, and finished part evaluation. The research described here presents simulations of the advancing resin flow front through textile preforms. A tetrahedral and voxel based mesh is generated from TexGen scripts modeled from a unit cell of textile geometry and comparisons are made showing mesh independence for a sufficiently refined mesh. A computationally efficient, unit cell based, solution is shown to account for the intricacies of the air to resin phase transition seen in actual mold fills. A multiphase, transient finite volume solution is found in Fluent using the generated mesh, and post-processed to produce an advancing flow front simulation. For model validation, a plain weave S-glass fabric is first characterized geometrically for TexGen input parameters. Then, experimental advancing flow front infusions are conducted with an instrumented line-source to line-sink visualization fixture. Model and experimental flow fronts are overlaid yielding favorable qualitative results.

This work was supported in part by GE Aviation

ME-28  An Energetically Enhanced Plasma Ignition System For Use In Internal Combustion Engines
Authors: Bryce Thelen; Elisa Toulson

Abstract: The effects of a plasma enhanced ignition system on the performance of a small single cylinder four-stroke gasoline engine are examined. Dynamometer testing of a 34 cc gasoline engine is performed comparing a stock ignition coil with a radio frequency plasma ignition system. The radio frequency system is designed to provide a quasi non-equilibrium plasma discharge that features a high voltage pulsar capable of providing voltages of up to 30 kV and 400 mJ of energy per discharge. Tests show improvement of the engine's performance in regards to combustion stability and tolerance of lean air fuel mixtures with the radio frequency system. Additionally, high speed images of the radio frequency system taken in a different 0.4 liter optical engine are presented.

This work was supported in part by the Air Force of Scientific Research under Reward FA9550-10-1-0556.

ME-29  Numerical Simulations Of Turbulent Jet Ignition And Combustion
Authors: Abdoul Ahad Validi; Abolfazl Irannejad; Farhad Jaberi

Abstract: The ignition and combustion of a homogeneous lean hydrogen-air mixture by a turbulent jet flow of hot combustion products injected into a colder gas mixture are studied by a high fidelity numerical model. Turbulent jet ignition can be considered as an efficient method for starting and controlling the reaction in homogeneous combustion systems used in advanced internal combustion and gas turbine engines. In this work, we study in details the physics of turbulent jet ignition in a fundamental flow configuration. The flow and combustion are modeled with the hybrid large eddy simulation/filtered mass density function (LES/FMDF) approach, in which the filtered form the compressible Navier-Stokes equations are solved with a high-order finite difference scheme for the turbulent velocity and the FMDF transport equations are solved with a Lagrangian stochastic method to obtain the scalar (temperature and species mass fractions) field. The hydrogen oxidation is described by a detailed reaction mechanism with 37 elementary reactions.

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ME-30  Rotary Induced Impact Testing And Analysis Of Composite Fan Cases
Authors: Andy VanderKlok; Jim Dorer; Xinran Xiao

Abstract: High speed fans play a vital role in the automotive, aeronautical, and medical fields. In the aeronautical field alone these fans are commonly used to produce thrust for commercial and private airlines. It is well understood for these airliners to sustain ground velocities near Mach 1 speeds, the engines themselves must turn a fan at very high rpm to gain the thrust needed to propel the aircraft to such velocities. Because of the high energies involved with such fast rotating machinery, failure known as a fan blade out event (FBO) can occur often caused from bird strike or fatigue. When this happens debris is released at ballistic rates of speed and can cause catastrophic damage to nearby aircraft components. In addition, the release of a blade creates a severe imbalance of the shaft leading to eccentric motion. This motion causes the remaining blades to rub the fan housing causing further damage. Post FBO shaft imbalances can negatively affect other engine components such as the shaft, bearings, and rotors. Properly characterizing the dynamics and failure modes is crucial in understanding what happens during this event. Although this is difficult to replicate experimentally at reasonable cost; it can be with a spin pit. Utilization of a spin pit will more closely be representative of the loading conditions present during an actual FBO. The pit allows for experimental high speed video and strain data acquisition for analysis of a controlled FBO for composite blades or fan casing combinations.

This work was supported in part by NASA

ME-31  A Microstructure-Resolved Model For Li-Ion Battery With Silicon Anode
Authors: Miao Wang; Xinran Xiao

Abstract: High capacity anode materials such as silicon experience large volumetric changes during charge/discharge cycling in battery cells. Large cyclic deformation often leads to particle fracture, mechanical failure and delamination at particle-binder, particle-current collector interfaces, which results in pulverization and capacity fading. An electrode microstructure resolved full-cell model has been developed using COMSOL Multiphysics to investigate the kinetics of Li transport and electrochemical reactions, stress accumulation and structural deformation. This model is further adopted for high capacity anode material silicon by considering elastic moduli, yielding strength, partial molar volume and Poisson’s ratio variations along with lithiation/delithiation. The model validation is ongoing by comparing the computed cell voltage, stress and volume expansion with cycles with real-time experimental results. This model allows the observations of morphologies and stress distributions in silicon anode and the influence of volume variation on the electrochemical reaction of the cell. It will serve as a design tool for structured silicon lithium-ion batteries.

This work was supported in part by National Science Foundation

ME-32  The Softening Behavior Of A Polymeric Battery Separator In Solutions
Authors: Shutian Yan; Yue Qi; Xinran Xiao; Xiaosong Huang

Abstract: The mechanical integrity of the separator is crucial to the performance, abuse tolerance, and durability of Li-ion batteries. It has been observed that, when tested in electrolyte solvents, the elastic modulus of a polypropylene (PP) separator Celgard 2400 reduced to about a half of the value obtained in air or water. The separator regained its modulus in air after being dried. This recoverable softening response suggests that the behavior is induced by the solvent. The models considering the change of surface tension, however, cannot explain the magnitude of the softening. This work investigated the problem using atomistic modeling. The PP separator has a porous microstructure formed by patches of crystalline phases connected by nanofibers. To capture the mechanical responses of these phases in different environments, atomistic models for crystalline and amorphous PP nanofibres were built separately, and the molecular dynamics (MD) simulations were performed in vacuum, water and a typical electrolyte solvent dimethyl carbonate (DMC). The results showed little interaction in all cases except for the case of amorphous PP in DMC, DMC molecules penetrated into the amorphous PP nanofiber, reduced the local density and the elastic modulus. The results suggest that the softening phenomenon may be attributed to the strong attraction of the electrolyte solvent molecules with the amorphous fibrous PP regions of the separator.

This work was supported in part by NSF and GM
Abstract: Hybrid Electric Vehicles (HEV) is capable of improving fuel economy with reduced emissions over traditional vehicles powered by internal combustion engine alone. However the HEV vehicle durability is significantly limited by the useful battery life, and the battery life could be significantly reduced if it was operated at its allowed charge or discharge limits, which could occur especially at extremely low battery temperature, leading to permanent battery damage and reduced battery life. In order to extend the battery life, this paper proposed a battery boundary management control strategy based upon the predicted desired torque to proactively make the engine power available to reduce future battery over-discharging. The proposed control strategy was validated in simulations and its performance was compared with the baseline control strategy under Federal Test Procedure (FTP) and other four typical city and highway driving cycles. The simulation results show that the proposed control strategy is very effective when the battery temperature is under zero degree, and the over-discharged power are reduced around 65% under aggressive US06 and ARB02 driving cycles, 45% under highway and city FTP and NYCC city driving cycles, and 30% under highway IM240 driving cycle, respectively.

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Effect Of The Intraluminal Thrombus Layer On The Diameter – Expansion Relationship In Abdominal Aortic Aneurysm (AAA): A Longitudinal Patient Study

Abstract: Abdominal aortic aneurysm (AAA) is the permanent focal distention of the aorta and its end stage is related to death with its rupture. The rupture occurs when the wall stresses on the wall overcome by the wall strength. These stresses, according to the law of Laplace, are positive correlated to the diameter. Additionally, the diameter is positively correlated to AAA expansion rate. In other words, the larger the diameter, the larger the expansion, and the higher the stresses on the AAA wall, potentially leading to rupture. Unfortunately, these two parameters are not always reliable. This lack of reliability might be due to the presence of other factors that may contribute to AAA prognosis, like the intraluminal thrombus layer (ILT), that are not considered in the prediction. ILT buildup is found covering partially or fully the lumen wall of 75% of AAAs, increasing in prevalence as aneurysms enlarge. Hence, this study uses longitudinal CT images of 9 different patients to study the effect of the ILT in the diameter-AAA expansion relationship. Our results showed that when ILT is present, the strength of the expansion-diameter relation is not only weakened, but the nature of this relation is also altered since expansion is accelerated compared to patients without ILT. This suggests that a distinction between patients with and without ILT should be made before predicting rupture or programing the follow up time interval.

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