FIU Engineering & Computing

Mechanical and Materials Engineering

2023 MME GRADUATE RESEARCH SYMPOSIUM

A day of showcasing your research, networking, fostering community, and identifying collaboration opportunities

Feb 24, 2023
EC2300 & Panther Pit

Invited Speakers: Academia
Industry
Government

MME graduate students	Oral or poster presentation	Contest for awards	Highlight research & collaborate

Submit abstract to zhcheng@fiu.edu by Feb 10, 2023

Contact Dr. Zhe CHENG (zhcheng@fiu.edu) for questions

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Mechanical and Materials Engineering
FLORIDA INTERNATIONAL UNIVERSITY

MME GRADUATE RESEARCH SYMPOSIUM

Friday Feb 24, 2023

MORNING

09:00-09:25 Morning snacks (Panther Pit)

09:25-09:30 Welcome (Panther Pit)

09:30-11:00 Poster presentation & networking (Panther Pit)

AFTERNOON

12:30-13:45 Students oral presentation (EC 2300)

14:00-15:00 Career discussion with panelists (EC 2300/ZOOM)

15:00-15:15 Break

15:15-16:15 Students oral presentation (EC 2300)

16:30-16:45 Award ceremony (EC2300)

Professional Panelists

Dr. Majid Beidaghi
MSE PhD 2012
Auburn Univ

Dr. Shadi Darvish
MSE PhD 2017
Shell

Dr. Rupak Dua
BME PhD 2014
Am Dental Assoc

Dr. Sohail Reddy
ME PhD 2019
Lawrence Livermore NL

2023 MME GRADUATE RESEARCH SYMPOSIUM ABSTRACTS - Feb 24, 2023

Type	1st Author/Presentor	Time	Level	Advisor	Title
P	**Adams, Joel**	**9:30**	PhD	Lagos	Reinforcement learning applied to waste segregation
P	**Chodankar, Abhijeet**	**9:30**	PhD	McDaniel	Particle resuspension simulation of nuclear waste pipe flow using lbm-dem subgrid scale method
P	**Cintas, Brendon**	**9:30**	PhD	Lagos	Validation of slurry rheology in defense waste processing facility (dwpf) sludge batch (sb) 10 using nonradioactive chemical simulants
P	**Das, Suprabha**	**9:30**	PhD	Cheng	Novel processing and fundamentals for high temperature nitride ceramics
P	**Jafarizadeh, Borzooye**	**9:30**	PhD	Wang	Practical piezoresistive sensor for pulse waveform monitoring
P	**Li, Wenhao**	**9:30**	PhD	Cheng	BaCo0.4Fe0.4Zr0.1Y0.1O3-σ cathode performance for proton conducting solid oxide fuel cells with BaZr1-xCexY0.1Yb0.1O3-δ electrolytes
P	**Saha, Anirban**	**9:30**	PhD	McDaniel	Development of methods for real time in-line monitoring of yield stress during the transfer of radioactive waste
P	**Sarker, Md Sharif Ahmed**	**9:30**	PhD	McDaniel	Controller development and virtual simulation of a multi-crawler system for the inspection of small diameter pipes
P	**Sotolongo, Maria Karla**	**9:30**	PhD	Boesl/Lagos	Automating structural inspections at the waste isolation pilot plant (WIPP)
P	**Sozal, Md Shariful**	**9:30**	PhD	Cheng	Fabrication and preliminary testing of silver pattern cathodes for proton conducting IT-SOFC
P	**Viamonte, Edgar**	**9:30**	MS	Boesl	Use of graphical programing for materials analysis and characterization
P	**Zahin, Muhtadi Munawar,**	**9:30**	PhD	Dickerson	Optimized electrospun patch production for structural support and cell guidance in engineered enthesis replacement
O	**Sukumaran, Abhijith**	**12:30**	PhD	Agarwal	Tribological and radiation shielding response of novel titanium-boron nitride coatings for lunar structural components
O	**Chowdhury, Azmal**	**12:45**	PhD	Wang	Converting tissue paper to highly sensitive and linear pressure sensor for pulse waveforms collection
O	**Hu, Beichao**	**13:00**	PhD	McDaniel	Applying physics-informed neural network to solve 2D-incompressible Navier-Stokes equations
O	**John, Denny**	**13:15**	PhD	Agarwal	Profilometry-based indentation plastometry for evaluating bulk tensile properties of aluminum-silicon carbide composites
O	**Orikasa, Kazue**	**13:30**	PhD	Agarwal	Anisotropic radiation shielding and thermal properties of 2D boron nitride nanoplatelet foam via freeze-drying
O	**Rayhan, Md Munim**	**15:15**	PhD	McDaniel	Simulation and experimental validation of collision avoidance of robotic wire and arc additive manufacturing
O	**Mahyawansi, Pratik**	**15:30**	PhD	McDaniel	Investigation of velocity profile in a stratified flow using experiments and analytical methods
O	**Dey, Preyojon**	**15:45**	PhD	Boymelgreen	The impact of selected abiotic factors on zooplankton hatching process through real-time, in-situ observation
O	**Rodrigues De Oliveira, Priscila**	**16:00**	MS	Agarwal	Novel polyimide-hexagonal boron nitride nanocomposites for synergistic improvement in tribological and radiation shielding for aerospace applications

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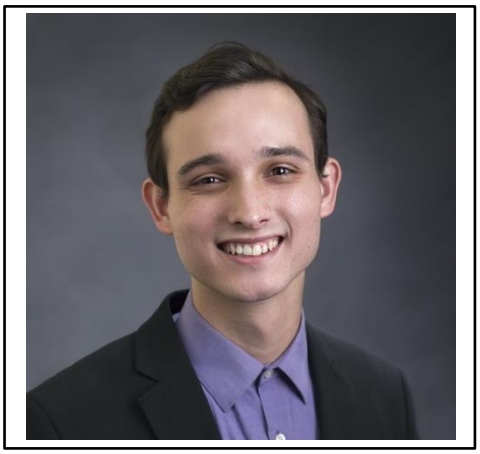

Title: Reinforcement Learning Applied to Waste Segregation

Authors: Joel Adams

Faculty advisor: Dr. Dwayne McDaniel

Format: Poster

Abstract:
Combining reinforcement learning with an integrated vision system can achieve effective autonomous low-level waste segregation. A robot manipulator is trained to sort low level waste into designated bins by utilizing advanced machine learning algorithms. The integrated vision system provides the robot with real-time information about the waste, allowing for precise and efficient sorting. This project showcases the integration of cutting-edge technologies for the automation of complex tasks and contributes to the DOE's mission to develop advanced waste management systems.

Fig 1. Setup of robot manipulator with simulated low level waste inside of bin

Fig 2. Depth camera data being viewed in visualization software

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Title: PARTICLE RESUSPENSION SIMULATION OF NUCLEAR WASTE PIPE FLOW USING LBM-DEM SUBGRID SCALE METHOD

Authors: Abhijeet Chodankar

Faculty advisor: Dwayne McDaniel

Format: Poster

Abstract:

At the end of World War II, a significant amount of solid-liquid radioactive waste was generated due to atomic bomb production. Pipelines were installed to transfer this waste, but operators encountered issues with plugging, resulting in significant financial losses. The main purpose of this research is to understand the physics related to particle deposition, resuspension, and fluid-particle-wall interactions in Newtonian and Non-Newtonian fluids to avoid future plugging. Macroscopic techniques have issues related to grid generation, while microscopic approaches are unable to simulate a large volume of fluid. Therefore, a mesoscopic method such as the Lattice Boltzmann method (LBM) is chosen to simulate the carrier fluid. LBM captures the probabilistic average behavior of a cluster of molecules in a small volume and offers advantages such as simple code implementation, geometry-independent meshing, and compatibility with CPUs and GPUs. However, it also has memory-intensive operations. The particle unresolved method is selected to track particles, allowing for the simulation of particle-particle and particle-wall interactions. The particles are assumed to be point masses, enabling the simulation of millions of particles. However, this technique fails to capture the actual flow around the particles. The OpenLB code will be used to study the one-way (fluid force on particle), two-way (one-way plus particle force on fluid), and four-way (two-way plus particle-particle and particle-wall interactions) coupling phenomena. The knowledge gained from this research effort will improve our understanding of particle dynamics in Newtonian and Non-Newtonian fluids, leading to proactive measures that can prevent future plugging and reduce risk to field engineers and the environment.

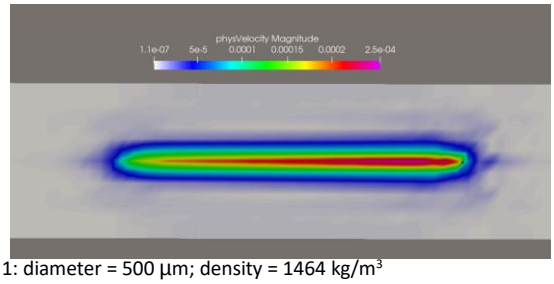

Fig. 1: diameter = 500 µm; density = 1464 kg/m^3

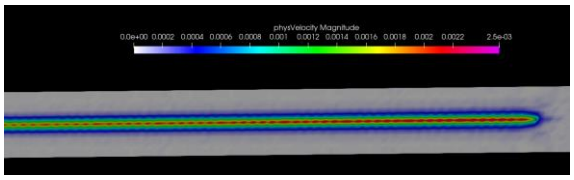

Fig. 2: diameter = 500 µm; density = 5000 kg/m^3

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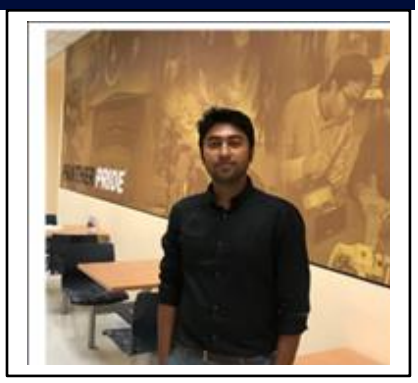
Title: Converting Tissue Paper to Highly Sensitive and Linear Pressure Sensor for Pulse Waveforms Collection

Authors: Azmal Huda Chowdhury, Borzooye Jafarizadeh, Nezih Pala, Chunlei Wang
Faculty advisor: Chunlei Wang

Format: Oral



Abstract:
The sensing technologies for flexible bioelectronics have evolved enormously over recent years leading to advanced but affordable healthcare monitoring devices. The critical components of such flexible wearables are various sensors that have gained excellent sophistication. These sensing devices' wide range of applications ranges from e-skin application to subtle physiological monitoring, such as detecting pulse waveforms from the wrist artery. Pulse waveforms convey much health information regarding the cardiovascular system. Precise monitoring of the pulse waveforms is vital to characterize any abnormalities in the cardiovascular system. Commercial devices such as smartwatches use optical sensing for detecting pulse waveforms that have a dependency on skin tonality, obesity, and light dependency. On the other hand, flexible pressure sensors with high sensitivity have shown excellent performance in obtaining all the intrinsic features of the pulse waveforms. However, obtaining pulse waveforms from the wrist artery requires high sensitivity, linear and broad pressure sensing range, fast response time, and high signal-to-noise ratio (SNR). Achieving all these performance metrics requires a sophisticated and costly fabrication process increasing production lead time and complexity. This study presents an alternative cheap fabrication process for realizing a high-performance capacitive pressure sensor by ensuring all the performance benchmarks for wrist arterial pulse waveforms collection. Using the blade coating method, a solid electrolytic layer is realized using tissue paper as the porous media and PVA-H3PO4 as the electrolyte. Using commercial carbon conductive fabric as the electrodes further increased the fabrication's simplicity. The sensor achieved a high sensitivity of 2.9kPa^{-1}, maintaining a linear pressure sensing range of 20 kPa. Besides, the sensor has a broad pressure sensing range of 100 kPa, excellent pressure resolution of 10Pa, and high SNR. Benefitting from the above performance, the sensor could obtain pulse waveforms from wrist arterial sites (radial and ulnar artery) and carotid artery with the characteristic systolic, diastolic, and tidal peaks. Moreover, the sensor could successfully obtain pulse waveforms during rest and motion. Finally, the sensor could distinguish pulse waveforms from muscular movements proving its efficacy in low-cost pulse waveforms monitoring.

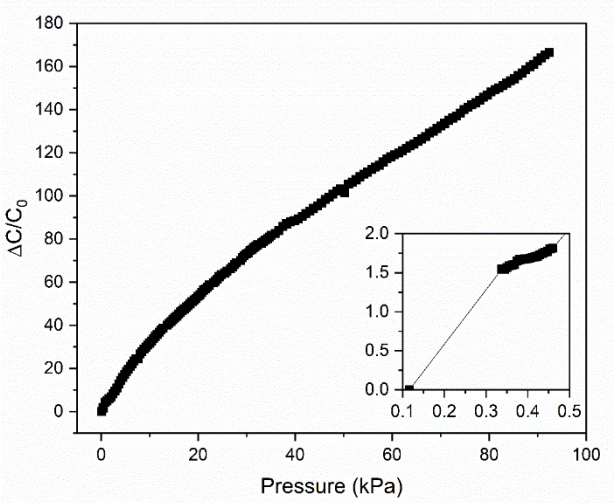


Figure 2: Linear and broad pressure sensing range with excellent pressure resolution

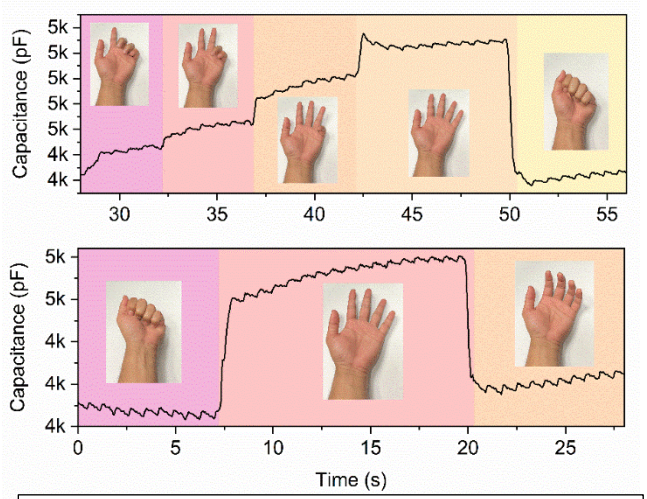


Figure 2: Acquisition of pulse waveforms during muscular movement

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Title: Validation of Slurry Rheology in Defense Waste Processing Facility (DWPF) Sludge Batch (SB) 10 Using Non-radioactive Chemical Simulants

Authors: Brendon Cintas (DOE Fellow)*, Daniel P. Lambert†, Wesley Woodham†
*Florida International University - Applied Research Center (FIU-ARC)
†Savannah River National Laboratory (SRNL)

Faculty advisor: Leonel Lagos, PMP®, Ph.D.

Format: Poster

Abstract:
The Defense Waste Processing Facility (DWPF) treats high-activity radionuclides from sludge through a process called vitrification, which converts radioactive liquid waste currently stored in tank farms into a solid glass form that is suitable for long-term storage and disposal. Due to the complexities involved in vitrifying this waste, waste rheology is studied to characterize the fluid-mechanical properties as it passes through DWPF. To better understand the waste and validate flow behavior, slurry rheology of simulant that represents the waste was studied at various acid stoichiometry percentages and solids concentrations to determine the simulant's yield stress and viscosity using a HAAKE RheoStress 6000 rheometer with the intention of extrapolating the simulant data to real-waste data.

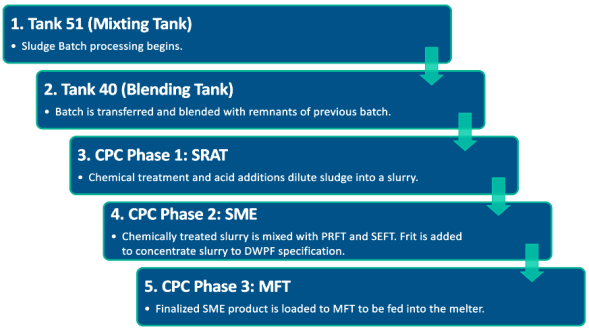

Figure 1: DWPF Chemical Processing Cell (CPC) Process

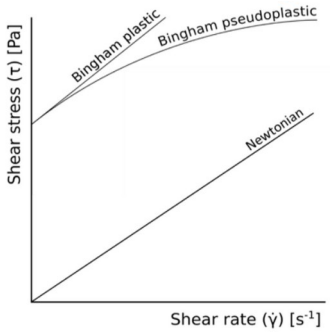

Figure 2: Shear Stress-Rate Relationships for Newtonian and non-Newtonian fluids.

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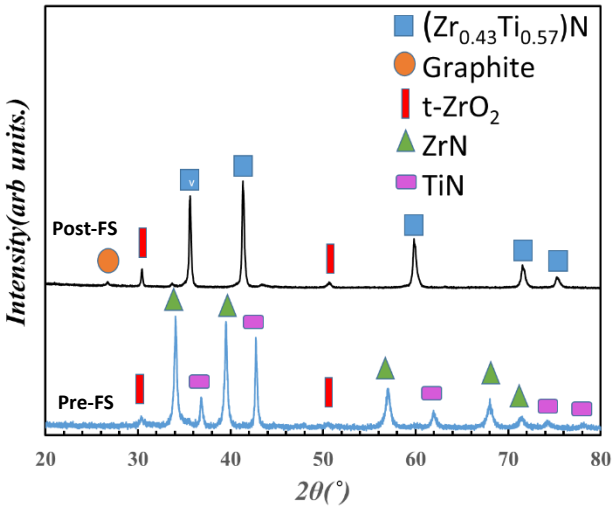
Title: Novel Processing and Fundamentals for High Temperature Nitride Ceramics

Authors: Suprabha Das, Andriy Durygin, Vadym Drozd, Md Shariful Islam Sozal, Jesse S Smith, Zhe Cheng

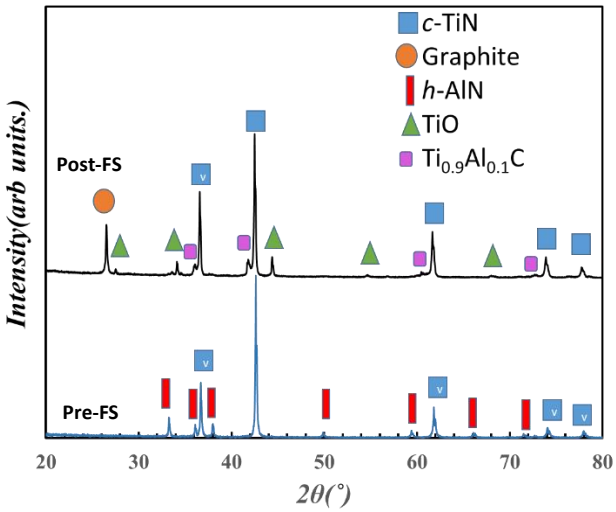
Faculty advisor: Zhe Cheng

Format: Poster

Abstract:
This study aims to demonstrate reaction flash sintering (RFS) for two systems: TiN-ZrN (both conducting) and AlN-TiN (TiN conducting but AlN insulating). Commercial nitride powders (1:1 molar ratio) were mixed by Spex milling and consolidated into dense bulk ceramic/composite with a homemade flash sintering setup. A constant DC electrical field of ~50 V/cm and pressure of ~15 MPa at room temperature triggers RFS without pre-heating, and the entire process finishes in ~350 s. In situ synchrotron XRD is also performed at the Advanced Photon Source to track the phase evolution in both systems during RFS and subsequent cooling. It shows although both systems have a wide miscibility gap extending to high temperature, uniform (Ti, Zr) N solution formed in RFS persists upon cooling, while (Ti, Al) N solid solution formed in RFS at high temperature goes through a quick phase separation in the cooling process. The final products' microstructure, as well as mechanical and oxidation resistance properties, are characterized by SEM/EDS, Vickers indentation, and TGA, respectively.



XRD plot of pre and post reaction flash sintering of $(Ti_{0.5}Zr_{0.5})N$



XRD plot of pre and post reaction flash sintering of TiN-AlN

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Title: The impact of selected abiotic factors on zooplankton hatching process through real-time, in-situ observation

Authors: Preyojon Dey, Terence M. Bradley and Alicia Boymelgreen

Faculty advisor: Alicia Boymelgreen

Format: Oral

Abstract:

Current studies on abiotic impacts on marine microorganisms often focus on endpoint analysis (e.g., hatching rates, survival). Here, we demonstrate that a mechanistic understanding can be obtained through real-time measurement of respiration and morphology in controlled microenvironments over extended time periods. As a demonstration, temperature and salinity are chosen to represent critical abiotic parameters that are also threatened by climate change and a target species of *Artemia*, a prominent zooplankton whose reproduction can affect the marine food pyramid. Different temperatures (20, 35, and 30ºC) and salinities (0, 25, 50, and 75 ppt) are shown to significantly alter the duration of hatching stages, metabolic rates, and hatchability. Higher temperatures and moderate salinity boosted metabolic reactivation of latent cysts, while higher temperatures alone sped up the process. Hatchability is inversely related to the duration of the differentiation stage of hatching, which persisted longer at lower temperatures and salinities. Initial oxygen availability affects respiration but not hatchability owing to temperature and salinity interactions.

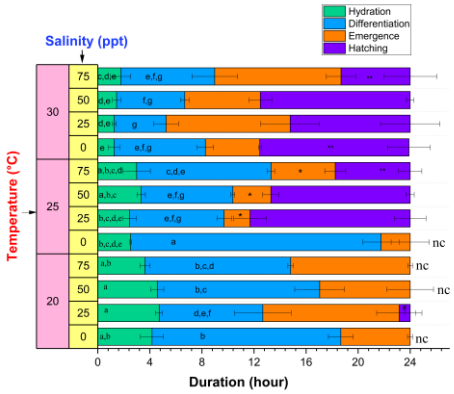

Fig. 1 Duration of different stages of hatching at different water salinities and temperature.

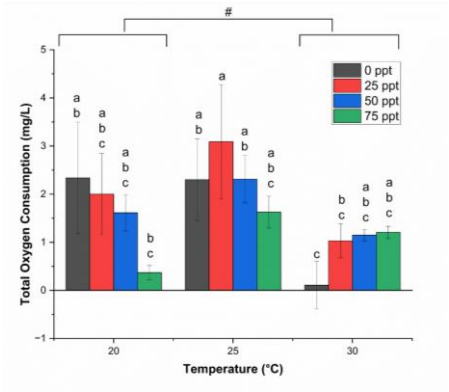

Fig. 2 Oxygen consumption of the *Artemia* cysts under different temperatures and salinities.

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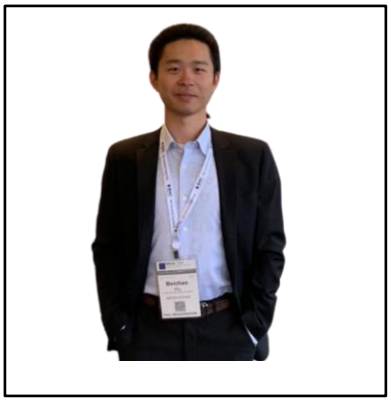
Title: Applying Physics-Informed Neural Network to Solve 2D-Incompressible Navier-Stokes Equations

Authors: Beichao Hu

Faculty advisor: Cheng-Xian Lin, Dwayne McDaniel

Format: Oral



Abstract:
In recent years, the physics-informed neural network has drawn tremendous interest among researchers to solve computational physics problems. Unlike the conventional neural network, which is a black-box model that "blindly" builds a correlation between input and output variables from a huge amount of labeled data, physics informed neural network directly embeds physical laws (mostly partial differential equations) in the loss function of a neural network. By minimizing the loss function, the output variable automatically satisfies the physical equation without any labeled data. One of the most classic engineering problems is to predict a flow field by solving the Navier-Stokes equation. In this study, a physics-informed neural network (PINN) is built to solve Navier-Stokes equations for a 2D incompressible laminar flow problem. The flows passing around a sphere particle is selected as a benchmark case to validate the PINN model. An ellipsoid particle is also tested to enhance the credibility of the work. The velocity and pressure fields are predicted by the neural network and compared with the result of Computational Fluid Dynamics (CFD). The particle drag force coefficient is also calculated to quantify the error of PINN compared to the CFD results.

$$Arg\ min\{\mathcal{F}(u, \nabla u, \nabla^2 u \ldots \mu) = 0\}$$

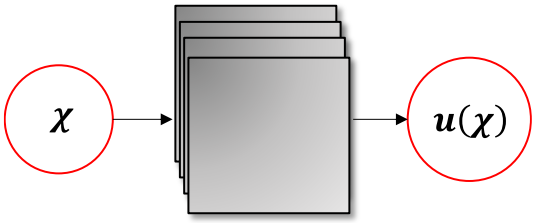


Fig. 1 The PINN framework.

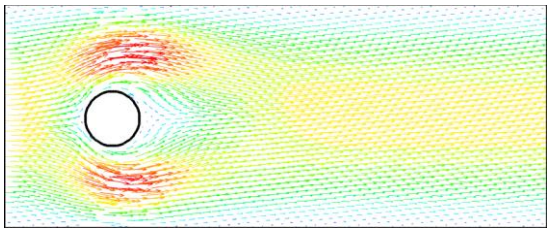


Fig. 2 The velocity vectors of flow passing around a sphere solved by a PINN framework.

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Title: Practical Piezoresistive Sensor for Pulse Waveform Monitoring

Authors: Borzooye Jafarizadeh, Azmal Huda Chowdhury, Nezih Pala, Chunlei Wang

Faculty advisor: Chunlei Wang

Format: Poster

Abstract:

Applications for wearable, flexible piezoresistive pressure sensors include electronic skin, robotic limbs, and cardiovascular monitoring. The introduction of pressure sensors with micro-patterned elastomers is one of the most sensitive recent breakthroughs in arterial full pulse waveform monitoring. However, only a very small portion of these sensors leave the laboratory development stage to reach the clinical trials and the market. High fabrication costs, scaling issues, and uncompatibility with wearable signal collection are a few potential causes of the enormous gap between research advances and actual commercial devices. Here, we present a scalable and simple-to-make piezoresistive sensor that uses two complementary working mechanisms to make the technology ready for market adaptation. This synergic design enables decent sensitivity (1.4 kPa^{-1}) at normal human pulse pressure range (2 – 8 kPa) without the need of intricate materials or manufacturing techniques. Additionally due to its strong signal level during pulse measurement from the wrist (~ 100 µA), it can be connected to simple and compact signal collection devices (mountable on wristband) thus realizing a fully wearable system. Finally, the comparison of wrist pulse waveform between the compact signal collection device and a standard sourcemeter (Keithley 2460) confirmed capability of the wearable system for resolving between the three distinct peaks of the wrist pulse waveform.

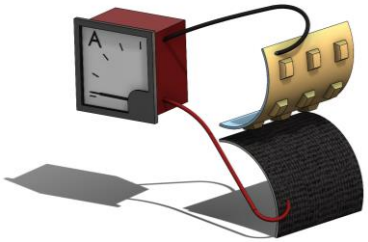

Fig. 1. Schematic of the two layers of piezoresistive pressure sensor realizing synergic mechanism

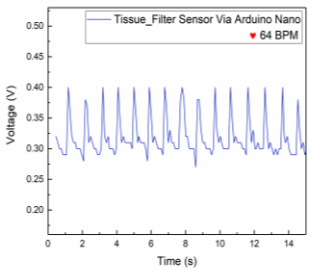

Fig. 2. Wrist pulse waveform acquired by the fully wearable piezoresistive system.

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Title: Profilometry-based Indentation Plastometry for Evaluating Bulk Tensile Properties of Aluminum-Silicon Carbide Composites

Author: Denny John, Tanaji Paul, Sohail M.A.K. Mohammed, Gonzalo Seisdedos, Benjamin Boesl, Arvind Agarwal
Faculty advisor: Dr. Arvind Agarwal

Format: Oral

Abstract:
The need for large samples with specific geometries and the destructive nature of conventional tensile testing pose a challenge in the rapid mechanical characterization of metal matrix composites (MMC). This study investigates the efficacy of a high throughput profilometry-based indentation plastometry (PIP) technique for evaluating bulk tensile properties of SiC-reinforced aluminum MMC with minimum sample volume and preparation. Plastic properties, namely yield strength (YS), ultimate tensile strength (UTS), and elongation up to necking (ε_n) in aluminum composites reinforced with 0, 17.5, and 25 vol.% of SiC from PIP are compared with uniaxial tensile tests. While PIP estimations of YS for all composites and UTS for Al- 17.5 vol.% SiC are accurate within 3- 6%, those of UTS in 25 vol.% and ε_n in all composites show significant deviation from tensile test data. These deviations are attributed to the PIP overestimation of strength due to local SiC crowding beneath the indenter and the limitation of the Voce plasticity-based FEM simulation in capturing brittle behavior of high vol.% reinforcement. This study establishes that the high throughput PIP technique can be reliably extended to MMCs with low volume (~17.5%) of SiC reinforcements, thus harboring potential for advancement in the non-destructive testing of MMCs.

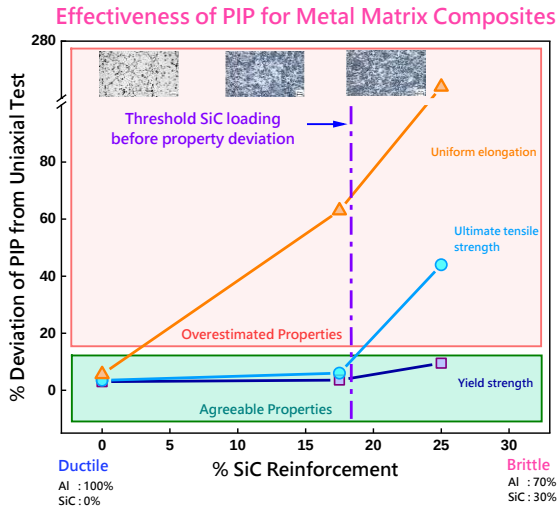

Figure 1. Summary showing the effectiveness of PIP for computing the tensile properties of Al-SiC MMCs. Overall, PIP effectively probes the yield strength and ultimate tensile strength of MMCs with threshold SiC loading of up to 17.5 vol%.

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Title: $BaCo_{0.4}Fe_{0.4}Zr_{0.1}Y_{0.1}O_{3-\sigma}$ Cathode Performance for Proton Conducting Solid Oxide Fuel Cells with $BaZr_{1-x}Ce_xY_{0.1}Yb_{0.1}O_{3-\delta}$ Electrolytes

Authors: *Wenhao Li, Md Shariful Islam Sozal, Vadym Drozd, Andriy Durygin*

Faculty advisor: *Zhe Cheng*

Format: Poster

Abstract:
$BaCo_{0.4}Fe_{0.4}Zr_{0.1}Y_{0.1}O_{3-\sigma}$ (BCFZY) is a proton, oxygen-ion, and electron-hole conducting cathode material for solid oxide fuel cells. Its electrode performance as well as the rate-limiting step in air with moisture are not well understood. Therefore, we fabricated three types of symmetric cells with the same BCFZY cathode and $BaZr_{0.8-x}Ce_xY_{0.1}Yb_{0.1}O_{3-\delta}$ (x = 0.1, 0.4, and 0.7) proton conducting electrolytes. It is observed that the cathode interfacial resistance in dry air is not related to the ionic conductivity of the electrolyte, suggesting the cathode rate-limiting step is related to the oxygen absorption of the cathode. Upon introducing moisture to the air, the cathode interfacial resistance drops for the high-Ce electrolyte, while increases for the high-Zr electrolyte. It is hypothesized that during the cathode firing process, Ce has a stronger tendency than Zr to diffuse from the electrolyte to the cathode. The diffused Ce might increase the hydration capacity of the cathode and improve the proton conductivity and interfacial resistance. Such a hypothesis is supported by Rietveld refinement comparing the volume of BCFZY cathode before and after firing, as well as additional techniques such as energy-dispersive X-ray spectroscopy (EDS) illustrating the element concentration distribution at the cathode/electrolyte interface.

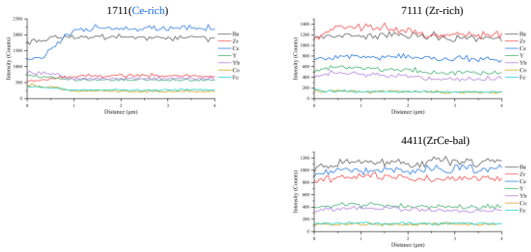

Fig. 1 EDS line scan at the cathode/electrolyte interface showing the intensity change.

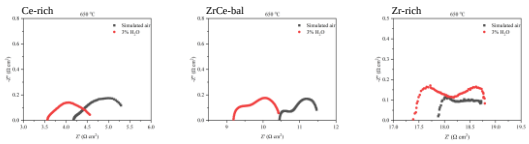

Fig. 2 EIS data for same BCFZY cathode over 3 electrolytes at 650 °C comparing simulated and moist air.

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Title: Investigation of Velocity Profile in a Stratified Flow using Experiments and Analytical Methods.

Authors: Pratik Mahyawansi, Arturo S. Leon, Dwyane McDaniel

Faculty advisor: Prof. Dwayne McDaniel

Format: Oral Presentation

Abstract:
Stratified flow in a horizontal pipe is found in various pipe systems such as oil transport, storm sewer system, and air conditioning system. Due to the large difference in the material properties of the gas and liquid, the velocity profile is highly asymmetric. The large difference in velocity magnitude of gas and liquid can transform stratified flow into a slug flow where the liquid rises and touches the upper surface of the pipe. In this study, first, the velocity of the stratified flow (air and water) just before the formation of slugs is measured using PIV (Particle Image Velocimetry) as shown in Fig.1. However, only the water velocity was measured as it can be easily seeded with the particle to visualize the flow. Second, the velocity profile of air is calculated using the analytical method using the water velocity as a boundary condition, as shown in Fig. 2. The study finds that the velocity profile shows dramatic variation with the interface position for the same pressure gradient. The velocity of air is inversely proportional to the position of the interface. The lower the interface position, the higher the air velocity. This finding shall help in understanding the nature of slugs formed during different operating conditions of the pipe.

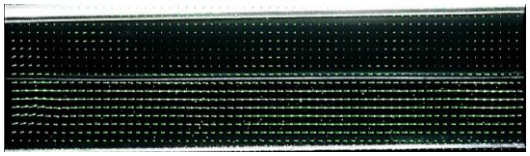

Fig. 1 Stratified flow in horizontal pipe just before the slug arrival.

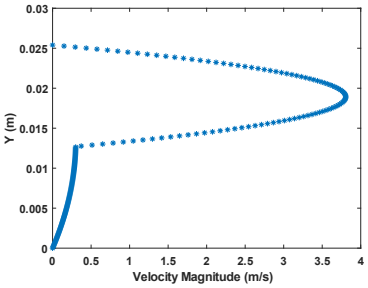

Fig. 2 Velocity profile calculated analytically.

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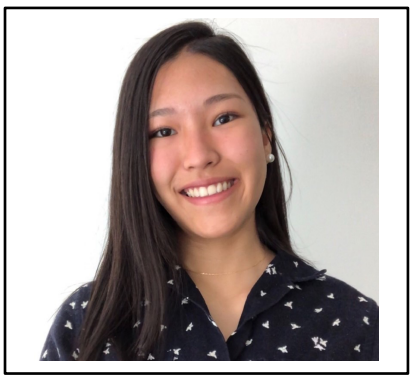

Title: Anisotropic Radiation Shielding and Thermal Properties of 2D Boron Nitride Nanoplatelet Foam via Freeze-Drying

Authors: Kazue ORIKASA, Cheol PARK, Sang-Hyon CHU, Calista LUM, Tony THOMAS, and Arvind AGARWAL

Faculty advisor: Arvind Agarwal

Format: Oral

Abstract:
Neutron radiation exposure and extreme thermal cycling are some of the main challenges faced during various aerospace missions. There is a critical need for advanced lightweight radiation shielding and thermally conductive materials. Polymer composites are commonly used in aerospace technology due to their low density, hydrogen richness, and ease of processing. However, polymers have limitations such as poor thermal conductivity, poor mechanical properties, and low neutron shielding properties. Two-dimensional (2D) Boron Nitride Nanoplatelets (BNNP) are excellent candidates for polymer matrix fillers due to their superior thermal neutron shielding and thermal properties. The 2D material anisotropic behavior unlocks the potential for composite property tailoring. However, the nanomaterial dispersion within polymer matrices is challenging due to their agglomeration tendency. In this study, a highly dispersed and lightweight BNNP foam (density 0.05 g/cm^3 and porosity 97.5%) was fabricated via Freeze-Drying processing. Freeze-Drying overcomes nanomaterial agglomeration challenges and enables the foam microstructure design through the control of the thermodynamic processing parameters such as mold geometry, mold material, and solid loading. The foam microstructure was designed to be lamellar, enhancing the anisotropic behavior of 2D BNNP. Subsequently, neutron radiation shielding, and thermal conductivity tests were performed on the foams with different wall orientations with respect to the probing directions. The neutron radiation test results revealed excellent radiation shielding properties with an orientation-dependent shielding behavior. The neutron shielding effectiveness or mass absorption coefficient of the BNNP foams with walls perpendicular to the radiation source was significantly higher than those with a parallel configuration. Similarly, Flash Diffusivity studies revealed that the thermal conductivity of the foam with walls parallel to the heat source was much greater than those with a perpendicular configuration. The BNNP foam in this study has the potential to benefit advanced tailorable radiation shielding and thermal management for future aerospace missions.

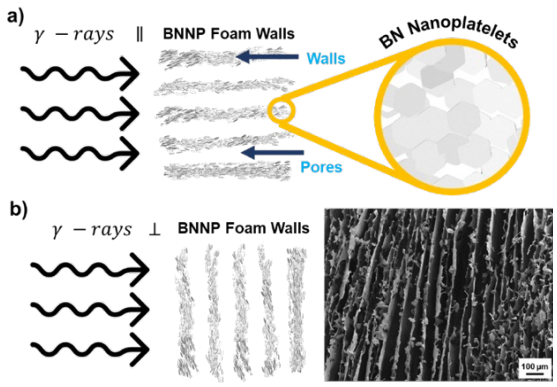

Fig. 1 Thermal Neutron Radiation Shielding Tests of BNNP Foams with Walls of a) Parallel and b) Perpendicular Orientation with respect to the Radiation Source

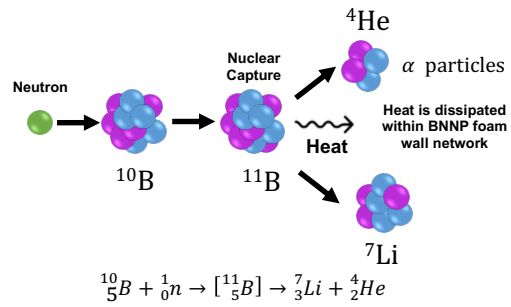

Fig. 2 Neutron Absorption Radiation Shielding Mechanism of Boron

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Title: Simulation and Experimental validation of collision avoidance of robotic wire and arc additive manufacturing

Author: Md Munim Rayhan

Faculty advisor: Dwayne McDaniel

Format: Oral

Abstract:

The research project explores using a ROS2-based motion planning module, a simulator, and sensor integration to avoid the collision of a robotic arm inside a vacuum enclosure for wire and arc additive manufacturing (WAAM) of CP-titanium. The use of the ROS2 framework and Gazebo ignition provides a flexible and reliable platform for simulating the robotic arm in the manufacturing process. The effectiveness of the collision avoidance algorithm is validated using an experimental setup. The setup includes a UR3e robotic arm and a MIG welder for generating parts. The robotic arm is programmed to follow the same path as in the simulation, and LiDAR camera data are used to detect potential collisions in real time. The results of the experiments show that the collision avoidance algorithm effectively prevents collisions between the robotic arm and its environment. Cp-titanium is commonly used in industries such as aerospace, marine, etc. Thus, this research will aid in developing a safer and more efficient manufacturing process. Overall, this research demonstrates the potential of using sensors and a ROS2-based motion planning framework to deploy collision avoidance algorithms for WAAM.

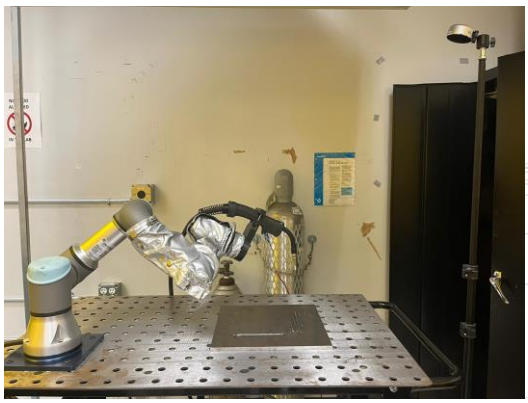

Figure 1: Experimental Setup

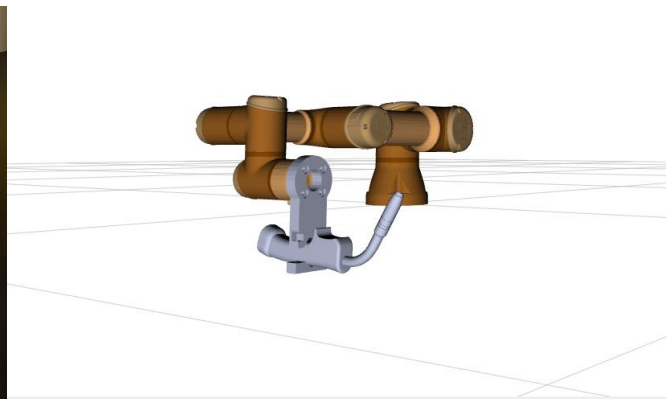

Figure 2: Robot model simulation

Mechanical and Materials Engineering
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Title: Novel Polyimide-Hexagonal Boron Nitride Nanocomposites for Synergistic Improvement in Tribological and Radiation Shielding for Aerospace Applications

Authors: Priscila Rodrigues De Oliveira, Abhijith Kunneparambil Sukumaran, Luiza Benedetti, Denny John, Arvind Agarwal

Faculty advisor: Arvind Agarwal

Format: Oral

Abstract:

Polyimide (PI), with its high strength-to-weight ratio, thermal stability up to 330°C, and chemical resistance, has been used significantly in aerospace applications. However, their poor tribological performance at elevated temperatures and radiation-induced brittle fracture threaten the durability of PI materials. To counter these threats, a novel hexagonal boron nitride (h-BN) based PI nanocomposite was prepared at 2wt.% and 5 wt.% of h-BN by direct forming. The uniform dispersion of h-BN in the PI matrix was facilitated using the ball milling technique. The PI-2 and 5wt.% h-BN composites showed 5% and 6% enhancement in thermal stability compared to neat PI in DSC analysis. Tribological characterization using a ball-on-disk tester revealed an improvement in wear rate of 55.9% and 75.9% for PI-2wt.% and 5wt.% h-BN, respectively, at room temperature, compared to neat PI. Whereas an improvement of 55.8% and 70.3% were observed at high temperature (300°C) tests. The novel polymer composites were subjected to radiation shielding analysis with a neutron radiation source. The mass absorption coefficient of PI-2wt.% and 5wt.% h-BN enhanced significantly by 1.8 and 2 times, respectively, compared to neat PI. The developed nanocomposites, with their excellent tribological behavior and neutron shielding capacity, are potential multifunctional materials for future aerospace applications.

Keywords: Polyimide (PI), hexagonal Boron Nitride (h-BN), Tribology, wear resistance, neutron shielding, aerospace applications.

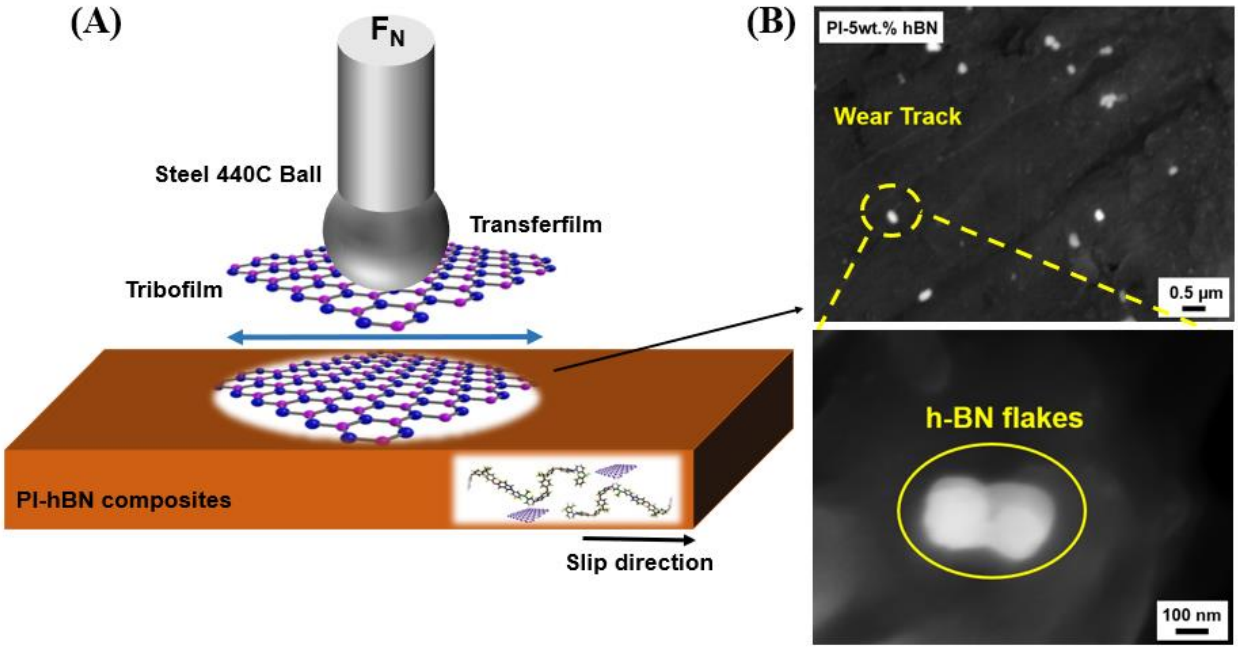

Fig. 1: (A) Schematic of tribofilm formation as a shearing mechanism of h-BN in PI nanocomposites. (B) BSE images of h-BN flakes on the wear track of PI-5wt.% h-BN at a high-temperature (300°C).

Mechanical and Materials Engineering
FLORIDA INTERNATIONAL UNIVERSITY

Title: Development of methods for real time in-line monitoring of yield stress during the transfer of radioactive waste

Author: Anirban Saha

Faculty advisor: Dwayne McDaniel

Format: Poster

Abstract:

Radioactive waste slurries at the Savannah River Site (SRS) and Hanford often behave as non-Newtonian fluids with a yield stress. The yield stress increases the size of equipment needed to transport or mix these slurries and can increase the risk of process upsets. This property is often measured by collection of samples and transportation to a laboratory, which can increase the risk of personnel exposure and even change the rheology. In addition, slurry rheology has been observed to change with time. Real-time in-line monitoring (RTIM) of yield stress of slurries can have substantial benefits to critical processes which are currently in operation or will be part of future plans at Department of Energy (DOE) complex sites. This research focuses on addressing the need for a reliable RTIM technology at US Department of Energy sites. The objective of this work is to investigate and develop appropriate and reliable technologies that can perform accurate and easy measurements of yield stress in real time with minimal changes to the flow conditions at US Department of Energy sites. Two different in-line methods for characterizing yield stress in real time is proposed: pressure differential (liquid rise) method and pressure loss method. The pressure differential method is based on balance of forces that act across a column of liquid slurry in both static (no-flow) and dynamic (flowing) conditions. The pressure loss method is based on the loss of pressure between two points in a fully developed laminar flow of slurry. An experimental setup with a one-inch diameter standard steel pipe loop was constructed for evaluation of the pressure differential and pressure loss methods. Kaolin-water mixtures are used as a yield stress fluid for the experiments and data obtained from the proposed methods was compared with baseline data obtained from a table-top rheometer.

For the pressure differential method, experiments were conducted in a range of yield stress from 2 Pa (28.54% wt) to 21.7 Pa (39.04% wt) where real time measurement of yield stress was conducted using the experimental setup. An error analysis was performed which shows good agreement with pressure differential method data and rheometer data. For the pressure loss method, experiments were conducted in a range of yield stress from 6 Pa (34.47% wt) to 30.11 Pa (41.28% wt) and yield stress was calculated using different equations of which the Swamee-Agarwal (SA) equation provides a better match with rheometer data.

Mechanical and Materials Engineering
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Title: Controller development and virtual simulation of a multi-crawler system for the inspection of small diameter pipes

Authors: Md Sharif Ahmed Sarker

Faculty advisor: Dr. Dwayne McDaniel

Format: Poster

Abstract:

The majority of the world's electrical energy is generated by fossil fuel power plants. These power plants are complex systems containing multiple components that require periodic health monitoring. Failures in these systems can result in an increase in plant downtime, a decrease in power production, and substantial repair costs. Inspections of the plant's super-heater tubes are typically manual, laborious, and extremely time consuming due to their small diameter and the coiled structure of the tubing. Utilizing robots to inspect fossil fuel power plants is a viable alternative to human inspections, especially for small diameter pipes. An electrically powered pipe crawler system has been developed and tested inside 2-inch diameter tubes that can navigate both straight and curved sections. This research aims to create a framework for developing a multi-crawler system and its controller for maximizing navigation length inside the pipe. In addition, a high-fidelity virtual simulation of the multi-crawler system is developed in a 3D multibody dynamics simulation software (MSC Adams) to assist in generating a controller for the crawler. The software is also being used to improve the crawler's performance by optimizing the design and maximizing the pull force of the crawler.

Figure 1: Engineering scale testing

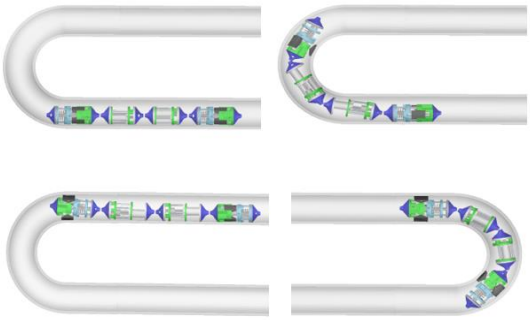

Figure 2: Virtual simulation model of the crawlers

Mechanical and Materials Engineering
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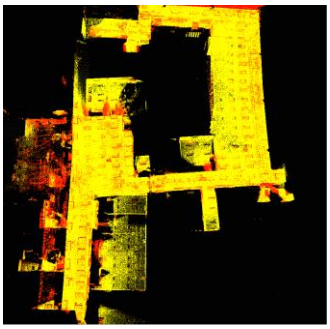
Title: Automating Structural Inspections at the Waste Isolation Pilot Plant (WIPP)

Authors: Maria Karla SOTOLONGO, Hiba KHALIL, Anthony ABRAHAO, Leonel LAGOS

Faculty advisor: Benjamin Boesl

Format: Poster

Abstract:
The objective of the research is to create an agnostic sensor package to automate daily structural inspections at the Waste Isolation Pilot Plant (WIPP). WIPP is a salt mine repository 2150 feet (655.32 meters) underground and holds tons of TRU nuclear waste. A characteristic of this environment is the salt growth occurring sporadically; due to the pressure of the earth, stress is applied to the tunnels and cause a shift of the salt and the salt rock's self-healing properties allow for gaps to be filled. This aspect causes an irregular closure of the tunnels of around 6 inches (15.24 cm) per year. Currently, sensors, mainly strain gauges, are used to detect these changes; however, due to the sudden shift, they are expensive and break during the closure. This study uses non-destructive evaluation methods to assist inspectors in monitoring and predicting changes occurring at WIPP. This sensor package consists of a Light Detection and Ranging (lidar) sensor, four (Red Green Blue) RGB cameras, and an embedded computer. The lidar creates a digital twin of WIPP using SLAM algorithms. Surrounding the lidar are the four RGB cameras which colorize the point cloud to detect visual changes that cannot be detected with the lidar. This poster will show the data collected by the sensor package as well as the results of the comparison between maps over time of the environment scanned. This project was developed by Florida International University in collaboration with Los Alamos National Laboratory, Pacific Northwest National Laboratory, and the University of New Mexico.



Mechanical and Materials Engineering
FLORIDA INTERNATIONAL UNIVERSITY

Title: Fabrication and Preliminary Testing of Silver Pattern Cathodes for Proton Conducting IT-SOFC

Authors: Md Shariful Islam Sozal, Wenhao Li, Suprabha Das, Borzooye Jafarizadeh, Azmal Huda Chowdhury, Andriy Durygin, Vadym Drozd, Chunlei Wang, Zhe Cheng*

Faculty advisor: Zhe Cheng

Format: Poster

Abstract:
Dense silver (Ag) cathodes with different triple phase boundary (TPB; the interface of gas, electrolyte and electrode) length (L_{TPB}) and electrode area (A_{ELT}) were fabricated by photolithography and E-beam evaporation over different proton-conducting electrolytes such as $BaZr_{0.4}Ce_{0.4}Y_{0.1}Yb_{0.1}O_{3-\delta}$ (BZCYYb4411). A bi-layer lift-off resist method appears more versatile than single layer for successful pattern cathode fabrication. The electrochemical behaviors of Ag pattern cathodes over the BZCYYb4411 electrolyte were tested with counter electrode such as $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ and correlated against geometric features such as L_{TPB} and A_{ELT} to understand the oxygen reduction kinetics and mechanism for proton conducting solid oxide fuel cells.

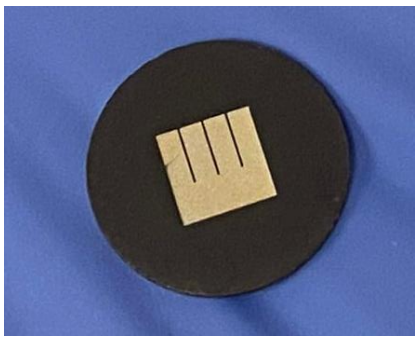


Figure 1: Photograph showing patterned Ag cathode over BZCYYb4411 proton conducting electrolyte

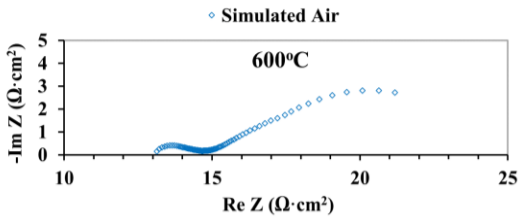


Figure 2: EIS of cell with patterned Ag cathode over BZCYYb4411 proton conducting electrolyte at 600°C in simulated air

Mechanical and Materials Engineering
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Title: Tribological and Radiation Shielding Response of Novel Titanium-Boron nitride Coatings for Lunar Structural Components

Author: Abhijith Kunneparambil Sukumaran

Faculty advisor: Dr. Arvind Agarwal

Format: Oral

Abstract:

Lightweight alloys of Aluminum (Al) and Titanium (Ti) are significant components of space systems because of their high strength-to-weight ratio. However, their poor tribological response in the presence of lunar regolith and lack of neutron shielding ability can result in premature failures. Hexagonal Boron Nitride (hBN) reinforced titanium coatings were produced by atmospheric plasma spray at low and high-volume concentrations of hBN to counter these undesirable effects. The microhardness results showed that coating hardness was 3 times that of conventional Ti6Al4V (335 HV) substrate in the case of low vol.% hBN (900 HV) concentration and 1.5 times in the case of high vol.% hBN coating (516 HV). Furthermore, tribological characterization by ball-on-disk tests in the presence of JSC-1A lunar regolith simulant revealed a 70% reduction of wear volume on the Ti/low vol.% hBN coatings compared to conventional material. Developed coatings were subjected to the simulated extreme lunar condition of neutron radiation. The coatings exhibited effective radiation shielding ability up to 10 % with minimal effective % hBN content. The coatings will be subjected to harsh erosive conditions on a custom-made high-velocity dust impact setup to evaluate erosion performance.

Keywords: Titanium, Boron-Nitride, Plasma Spray, Tribology, Abrasive wear, Neutron shielding

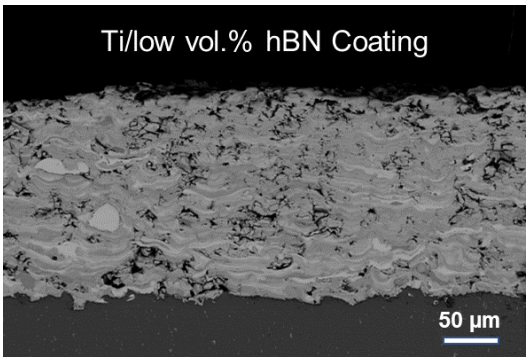

Figure 1: SEM image of plasma sprayed Ti/low vol.%hBN composite coating

Mechanical and Materials Engineering
FLORIDA INTERNATIONAL UNIVERSITY

Title: Use of Graphical Programing for Materials Analysis and Characterization

Authors: Edgar Viamontes, Gonzalo Seisdedos, Eduardo Salazar, Benjamin Boesl

Faculty advisor: Benjamin Boesl

Format: Poster

Abstract:

Graphical programming environments are becoming increasingly popular in research, experimental design, and instrumentation automation. These environments allow scientists and engineers to combine graphical elements, such as blocks and diagrams, with text-based programming languages to create systems that are easy to understand and modify. They are particularly useful in the areas of data acquisition, data processing, and process control, as they allow users to rapidly develop and debug programs. Additionally, graphical programming software often provide a variety of tools and libraries that allow users to access hardware, analyze data, and create visualizations. Their use has enabled researchers, engineers, and technicians to create complex systems in a fraction of the time it would take to program the same system in a text-based language. Recently, FIU has used these systems toward developing non-destructive evaluation techniques for materials characterization, detection of materials through other media, and monitoring of dynamic processes in materials science.

Mechanical and Materials Engineering
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Title: Optimized Electrospun patch production for structural support and cell guidance in engineered enthesis replacement

Authors: Muhtadi Munawar, Zahin; Benjamin B., Boesl; Darryl A., Dickerson

Faculty advisor: Darryl A. Dickerson

Format: Poster

Abstract:
The entheses are interfaces between soft tissues (tendons, muscles, ligament, meniscus) and hard tissues (bone) in animal bodies. These structures dissipate stress borne from complex loading (tensile, compressive, shear) and thus prevent structural failure from occurring in a junction where there is a logarithmic increase in stiffness. The enthesis does so by a number of mechanism, which includes a structural gradation from highly organized fibers to a relatively isotropic arrangement of fibrocartilage and bone tissue. In this work we have used electrospinning technique to create a synthetic patch made of PCL dissolved in Hexafluoroisopropanol that mimics part of this structural gradation. We have optimized the production process to produce patches with nanoscale fibers, which have not been achieved in a solution with viable long-term shelf life. We have also identified a transition region within the patches, equivalent to the fibrocartilage zones of the entheses, and quantified the change in orientation from the organized region to the disorganized region. The results from this work will serve as a means to produce effective smartly engineered enthesis replacements that can be modified based on the specific entheses to be replaced.

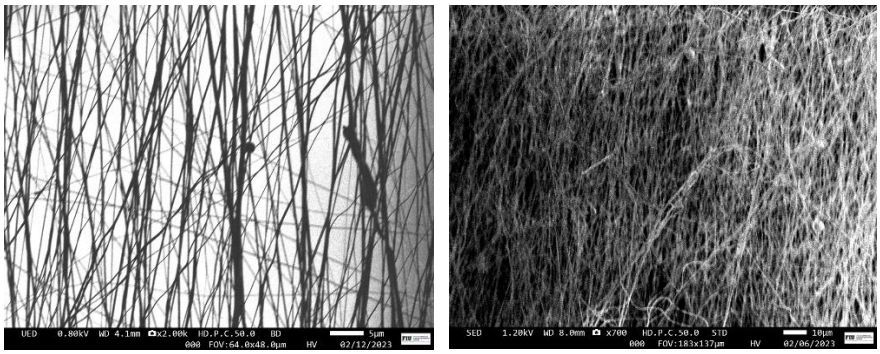

Fig: PCL patches with submicron thickness (Left) and transition zone of PCL patch (right)