Abstracts

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Research Presentations

Title: Non-Invasive Acoustic Emissions Sensing of Partial Discharge for Electric Motors

Colin Sim
University of Arkansas Fayetteville

Partial discharge is a phenomenon that can deteriorate insulation in high-voltage devices, leading to failures that may compromise system reliability safety. Early detection of partial discharge within electric motors and supporting equipment is particularly paramount for the safety and lifetime of electrified vertical takeoff and landing (eVTOL) aircraft. Compared to electrical partial discharge detection methods, acoustic emissions sensing has the potential to enable and non-intrusive partial detection in high-voltage devices during regular operation. In this work, an initial set of experiments are carried out on power modules and twisted pair specimens in which an acoustic emissions sensor is used and compared to electrical techniques for detecting partial discharge. The end goal of this work is to develop methods and models for quantifying partial discharge in motors and predicting the voltage level in the device past the point of partial discharge inception.

Probing Boiling Heat Transfer Using Multimodal Sensing and Machine Learning

Han Hu
University of Arkansas Fayetteville

Boiling is crucial for spacecraft thermal control owing to its ability to dissipate a large volume of heat with a small temperature difference. To advance the understanding of boiling heat transfer, we have developed a coupled multimodal sensing and data-driven modeling platform to address technical challenges induced by the high dimensionality, stochasticity, and dynamicity of phase-change processes. The sensing system collects synchronized optical, thermal, and acoustic signals during pool boiling tests using different surface textures, including flat surfaces, microchannels, and copper foams. A multimodal boiling dataset has been organized and shared with the research community. Moreover, we have developed machine learning models to enable boiling heat flux predictions and bubble identification and tracking using the collected data. Our results demonstrate that signals from non-destructive sensing technologies, such as acoustic and optical sensing, not only inform the boiling regime but also lead to quantitative measurement of boiling heat transfer. Our work also enables the detection and tracking of individual bubbles using boiling videos, which lead to quantitative analysis of the bubble dynamics metrics, such as the bubble size, count, and interface velocities.

ASTROSS (Active Spectrometer with Small Satellites) Description for ARKSAT-3 Mission

Edmond Wilson
Harding University

A new method of open-path spectroscopy between satellites is being explored. A radiation source, mounted in a small satellite, identified as ARKSAT-3E (E = light emitter), flying in Low Earth Orbit, LEO, will project a collimated beam of ultraviolet, visible, or near infrared radiation (light) towards another small satellite, containing light detectors to form an open-path atmospheric spectrum. The detector containing satellite is called ARKSAT-3C (C = chaser). Modeling of this process, using the HITRAN database has been carried out. The Kármán line, an altitude of 100 km is generally taken as the edge of space. Assuming a constant altitude of 400 km for the satellites requires they be 4588 km to 4240 km apart to cover altitudes of 0 km to 62 km above the atmosphere. This straight-line optical path has many obstacles to maneuver through to abstract meaningful results, such as cloud cover, sunlight interference, moonlight interference. A discussion of mitigation of obstacles is presented.

Additively Manufactured Thermoplastic Composites in Aerospace: Research Gaps, Challenges, and Design Strategies for Enhanced Durability

Dr. Mohammad Amjadi, Ph.D.
Fatigue and Fracture Lab, Arkansas Tech University, mamjadi@atu.edu

Abstract: Additive manufacturing (AM), commonly known as 3D printing, has revolutionized the production of lightweight, customizable, and cost-effective components across various industries, including aerospace. Over the past decade, AM metals and polymers have gained traction in aerospace design due to their unique manufacturing capabilities. However, challenges remain, including manufacturing defects, numerous processing parameters, the absence of standardized ASTM/ISO mechanical testing protocols, and limited experimental data for durability analysis. Fatigue failure accounts for approximately 90% of all mechanical failures, making cyclic loading a critical consideration in aerospace applications. The presence of defects in AM parts exacerbates fatigue susceptibility, posing significant risks in critical applications where failure is not an option. This study investigates the fatigue behavior of thermoplastic composites, specifically nylon reinforced with glass and carbon fiber, fabricated using the material extrusion technique. These materials show promise for lightweight aerospace components such as mini drones and satellite structures, where corrosion resistance and high mechanical performance are essential. This research establishes a standardized workflow integrating manufacturing, destructive testing, non-destructive evaluation, and design, enabling systematic evaluation of 3Dprinted polymers independent of printer brand. As part of an ongoing study at the ATU Fatigue and Fracture Lab, specimens were fabricated using material extrusion, and the effects of key printing parameters such as infill density, layer height, and test frequency were systematically analyzed under cyclic loading. To enhance testing accuracy, a novel specimen geometry was developed to ensure precise stress calculations and consistent testing conditions. This geometry, combined with multiaxial fatigue testing and componentlevel analysis, underscores a comprehensive approach to evaluating AM materials. Among the infill patterns investigated, the gyroid structure exhibited superior fatigue performance due to its isotropic mechanical properties and optimized strength-to-weight ratio. Higher infill densities correlated with extended fatigue life, while variations in testing frequency provided insights into material behavior under dynamic loading. These results are aligned with those observed in conventionally manufactured injection-molded specimens, supporting the feasibility of 3D-printed thermoplastics for aerospace applications. This research highlights the critical role of advanced manufacturing technologies in addressing engineering challenges and demonstrates a systematic methodology illustrated in Figure 1 that integrates CAD-based design, 3D printing, fatigue testing, computer simulation, and life prediction modeling. By tailoring manufacturing parameters to specific application requirements, this study contributes to advancing sustainable and highperformance engineering solutions for aerospace. In this presentation, preliminary experimental results on the fatigue behavior of AM thermoplastic composites will be discussed alongside modeling and analysis approaches. Additionally, key strategies for improving material processing, mechanical testing, and modeling will be presented to address existing challenges related to the durability of AM polymers and composites.

Poster Presentations

Sulfur-Infiltrated Lignosulfonate Carbon Material for High-Energy Li-S Batteries

Adeniyi Oyebade
Department of Chemistry
Donaghey College of Science, Technology, Engineering and Mathematics (DCSTEM)
University of Arkansas at Little Rock

Abstract

Lithium-sulfur (Li-S) batteries have gained significant attention due to high theoretical capacity (1675 mAh/g) and natural abundance of sulfur. In this study, we synthesized lignosulfonate-based phosphorus-nitrogen-doped carbon (PNDC) materials using a microwave-assisted method to serve as a sulfur host for Li-S battery electrodes. The synthesized materials were characterized using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) to evaluate pore size distribution and sulfur infiltration. Electrochemical measurements, including cyclic voltammetry, electrochemical impedance spectroscopy, and charge-discharge cycling, were conducted to assess the material's performance. Results demonstrate promising cycling stability and fast charge-discharge capability, indicating the potential of PNDC materials in enhancing sulfur utilization and mitigating polysulfide dissolution. Further optimization, including binder selection, electrolyte concentration studies, and advanced characterization techniques, will aid in improving overall battery performance. This research contributes to the advancement of Li-S battery technology, offering a pathway towards efficient and sustainable energy storage systems critical to meeting the increasing energy demands of modern society.

Phylogenetic analysis of microbial CP-lyase cluster genes for bioremediation of phosphonate

Ike Precious Richard
University of Arkansas at Little Rock
Qingfang He, Ph.D.

The ever-increasing use of phosphonates and their derivatives has resulted in the discharge of large quantities of these materials into the ecosystem, causing pollution and harmful shifts in microbiome composition. We conducted an extensive phylogenetic analysis to address this mounting problem and to help determine suitable microbes for bioremediation in specific environments. The 84 microorganisms included in our study span the gamut of species and occupied habitats. They degrade phosphonates by expressing an enzyme complex; CP-Lyase transcribed from 14 cistrons. Of the organisms studied, 12, 39, and 25 are singularly suitable for mostly freshwater, marine, or terrestrial habitats, respectively. Others adapted to multihabitats include Calothrix sp. PCC 7507 (both freshwater and marine habitats), Escherichia coli, Kaistia soli, Limoniibacter endophyticus, Marivita sp. and Virgibacillus dokdonensis (both marine and terrestrial habitats), Acidithiobacillus ferrooxidans (both freshwater and terrestrial habitats), with Paenibacillus contaminans suitable for freshwater, marine, and terrestrial habitats. All organisms were statistically rooted to glutathione peroxidase for phylogenetic perspective with tree topology dependent upon 50% or greater support. Clustered genes have been shown to have co-evolved based on striking nucleotide similarity and clade groupings within the tree topologies generated. Because phosphorus compounds (including phosphonates), crucial for supporting life, were found in the oceans beneath the icy surfaces of moons like Enceladus and Europa, our studies are also important for space exploration.

Glancing Angle Deposited Nanostructured Tellurium Layer Against Dendrite Formation and Side Reactions in Aqueous Zn-ion Battery Anode

Salim Hussain[1,*], S. M. Sayem[1], Assem Basurrah[1,2], Tahany Rashed[1], Noureen Siraj[1], and Tansel Karabacak[1,]

[1] School of Physical Sciences, University of Arkansas at Little Rock, Little Rock, AR 72204

[2] Department of Chemistry at Khulais, University of Jeddah, Jeddah, Saudi Arabia

* Correspondence: shussain@ualr.edu

Aqueous zinc-ion batteries (AZIBs) have a significant potential for energy storage owing to their affordability, safety, and environmental sustainability. However, issues such as dendrite formation, hydrogen evolution reaction (HER), and corrosion of the bare zinc (B-Zn) anode lead to performance decline and premature failure. In this study, tellurium nanostructures (TeNS) were grown on B-Zn for varying durations using the glancing angle deposition (GLAD) method within a DC magnetron sputtering system to enhance the charging/discharging (i.e. plating/stripping) reversibility of the Zn anode. The consistent distribution of tellurium nanoparticles with efficient isolation was validated by scanning electron microscopy (SEM) analysis, providing adequate Zn^{2+} flow and promoting consistent Zn deposition. X-ray diffraction (XRD) analysis confirmed the high crystallinity of the deposited TeNS on B-Zn, improving the surface-electrode contact and contact angle measurements demonstrated their enhanced hydrophilicity compared to that of B-Zn. Under Zn||Zn symmetric cell conditions, the anode sample prepared by depositing Te nanostructures on Zn for 10 minutes (Te@Zn_10min), showed significantly better cycling stability than the B-Zn anode with ~350 h vs 225 h, respectively, at 1 mA/cm² and 60 min/cycle, which corresponds to an arial capacity of 0.5 mAh/cm^2. This enhanced cycling stability is believed to originate from isolated GLAD Te nanostructures that inhibit the dendrite formation, yet still allowing charging/discharging reactions with the Zn anode through the gaps among them. Also, the nucleation overpotential of the Te@Zn electrode symmetric cell was lowest value of 10.65mV than the B-Zn cell and also others Te@Zn electrode symmetric cells, demonstrating that reduced the energy barrier for Zn^{2+} plating/stripping at the electrode/electrolyte interface. Furthermore, the Te@Zn_10min electrode exhibited a lower HER potential of -1.1901 V compared to -1.1497 V for the B-Zn electrode, and a higher corrosion potential of -1.0569 V compared to -1.2264 V for B-Zn in a three-electrode setup. By forming a nanostructured Te protection layer on the B-Zn surface, act as both a protective layer and zincophilic sites for the Zn metal surface, this work presents an easy and promising approach for suppressing Zn dendrites, lowering side reactions such as HER and corrosion, and paving the way for the development of durable AZIBs.

Animation of ARKSAT-3 Science Mission Goal

Landen Wilson
Harding University

Edmond Wilson

This presentation is a summary of the ARKSAT-3 mission that provides an animation of the mission goals. The animation is in a video format and will be presented and explained to viewers. The goal of the video is to show a dramatized and easy to understand representation of the mission. The video describes the space environment in which the mission takes place, and the approximate positions of the satellites in relation to Earth. Also shown is the mechanics of the mission, which is to collect atmospheric data from the Earth's atmosphere using a light beam located on one satellite (ARKSAT-3E) and a spectrometer located on another satellite (ARKSAT-3C). The video will also show the problems associated with the mission such as dealing with sunlight and moonlight, cloud cover, and aerosols when measuring atmospheric composition.

Light Source Aiming Mechanism Development and Testing for ARKSAT-3

Austin Wilson
Harding University

Edmond Wilson

The science goal of ARKSAT-3 is to measure, along a straight line path, the composition of Earth's Atmosphere. Gases to be measured are water vapor, oxygen, carbon dioxide, methane, and ozone. Light sources evaluated are tungsten-halogen, xenon flash lamps (20 Watt & 2 Watt), diode lasers, and LEDs. Detectors include a StellarNet Black Comet SR for 200 nm to 1080 nm and a StellarNet Dwarf-Star for the 900 nm to 1700 nm spectral ranges. Problems encountered for the mission include sunlight and moonlight, long path lengths, aerosols, and clouds. Results obtained to date will be displayed.