2025 Southern Society for Experimental Mechanics (SEM) Student Symposium

The University of Texas at Austin

May 13-14, 2025

Agenda & Presentation Abstracts

Organizers: Jin Yang (UT-Austin), Kshitiz Upadhyay (LSU)

Contact: jin.yang@austin.utexas.edu

Attending Universities:

Acknowledgements:

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1. Synopsis

The Southern Society for Experimental Mechanics Student Symposium (SSEMSS) is a new regional symposium event that started in 2024. It aims to provide a vital platform for students to present their research and foster professional connections and collaborations in the areas of mechanics, materials, and structures, with a particular emphasis on experimental mechanics. This includes developing new experimental methods, discovering new physics, and improving our current state-of-the-art materials and structures. Historically, similar symposia have been held in other regions in the United States, such as the Midwest Mechanics Symposium and the Southeastern area, but southern states lacked local access to such opportunities. With growing research activities in experimental mechanics within these southern states, the need for a dedicated regional symposium has become clear.

Building on the success of the 2024 Southern SEM Student Symposium at LSU, which received positive feedback from both students and faculty, the University of Texas at Austin proposes to host the 2025 Southern SEM Student Symposium, furthering this new tradition of fostering collaboration among students and faculty in the southern U.S. We plan to further expand the symposium's reach this year by bringing together participants from Texas A&M University, University of Houston, University of Texas at Dallas, University of Texas at Arlington, Louisiana State University, and so on. By establishing this collaborative platform, the symposium seeks to contribute to advancements in experimental mechanics while addressing national priorities in STEM education and workforce development.

We would like to acknowledge the great support from the Oak Ridge Associated Universities (ORAU), the Society for Experimental Mechanics Education Foundation (SEMEF), Department of Aerospace Engineering and Engineering Mechanics (ASE/EM), Texas Materials Institute (TMI), Center for Mechanics of Solids, Structures and Materials (CMSSM), National Science Foundation (NSF CMMI-2232428, 2441460). We would also like to thank UT-Austin ASE/EM staff event coordinator Libby Spencer, TMI associate director Dr. Raluca Gearba-Dolocan, UT-Austin EER building managers Jim Smitherman, Brittney Moore, and Jason Pannell, UT-Austin graduate students from Yang research group--Jacob Baker, Junyoung Kim, Danila Frolkin and Sicong Wang--for their significant help! We also acknowledge all the faculty and students who support this event by submitting oral and poster presentation abstracts and attending this event in person.

2. Agenda

Day 1		
Time	**Speaker**	**Title**
1:00—1:10 pm	Dr. Jin Yang (UT-Austin)	Welcome & Introduction
Session 1: Machine learning/data analytics/visualization		
1:10—2:00 pm	Dr. Kshitiz Upadhyay (LSU)	**Keynote talk #1:** Constitutive Modeling of Soft Materials: Past, Present, and Future
2:00—2:15 pm	Siddharth Sriram (LSU)	(O01) Visco-Hyperelastic Calibration of Bovine Brainstem Using a One-Shot Indentation Approach with Inverse Finite Element Method
2:15—2:30 pm	Nihar Moghe (LSU)	(O02) Physics-Informed Cokriging: An Intuitive and Efficient Technique for Imputing Missing Data in DIC
Session 2: Fracture/interface/adhesive mechanics		
2:30—2:45 pm	Mohammad Aaquib Ansari (UT-Austin)	(O03) Rotation Control with Dual Actuators: A New Device to Extract Mixed-Mode Traction-Separation Relations
2:45—3:00 pm	Jinlong Guo (UT-Austin)	(O04) Crack Nucleation and Propagation of Elastomers in the Poker-chip Experiment
3:00—3:15 pm	Brandon Clarke (UT-Austin)	(O05) Characterization of Photo-switchable Liquid Crystal Elastomer Adhesives via Flat-probe Tack Testing with Direct Contact Area Measurement
3:15—3:30 pm Coffee break		
Session 3: Nanomaterials/nanomechanics		
3:30—3:45 pm	Minoo Tayefeh Kazemi (UT-Dallas)	(O06) Nonwoven Electrospun Nylon Nanofibers as Thermally Stable and Mechanically Durable Battery Separators
3:45—4:00 pm	Logan Kirsch (UT-Austin)	(O07) Measuring Tip Wear in Atomic Force Microscopy with Inverse Force Curve Analysis
Session 4: Polymers, hyperelasticity, biomechanics & mechanobiology		
4:00—4:15 pm	Gustavo F. Perruci (UT-Dallas)	(O08) Optimizing Thermo-Responsive Polymers for Enhanced Mechanical Behavior
4:15—4:30 pm	Jyoti Shivaji Sonawane (UH)	(O09) Squishy Granular Mechanics
4:30—4:45 pm	Collin Haese (UT-Austin)	(O10) In Vitro Measures of Tricuspid Valve Leaflet Strains and Annular Forces
4:45—5:00 pm	Luc Nguyen (TAMU)	(O11) The Stress Relaxation Response of the Porcine Descending Aorta under Combined Normal and Torsional Loadings
5:00—5:15 pm	Yogesh Chandrashekar (LSU)	(O12) Tension–Compression Failure Asymmetry in Soft Materials Using Logarithmic Strain Invariant-Based Hyperelasticity
5:15—7:00 pm: Poster session & social happy hour (After 7:00 pm: dinner on your own)		

Day 2		
Time	**Speaker**	**Title**
8:00—9:00 am	Breakfast and coffee time	
9:00—10:00 am	Dr. Shailendra Joshi (UH)	**Keynote talk #2:** Houston, We Have a Problem to Solve: Foundations for Predicting Material Failure
Session 5: Additive manufacturing/Composites		
10:00—10:15 am	Austin Zeringue (LSU)	(O13) High Strain Rate Characterization of Regolith–Shape Memory Polymer Composites for Lunar Applications
10:15—10:30 am	Muhammed Jawaad Zulqernine (UT-Arlington)	(O14) Design and Experiments of Conch Shell Inspired Multi Material Composites with Enhanced Damage Tolerance
10:30—10:45 am	Pooyan Javadzadeh (UT-Dallas)	(O15) Surface Deformation Measurements of Particulate Idoxuridine Crystals Filled with Estane under Quasi-Static and Dynamic Loading
10:45—11:00 am	Ehsan Mehrdad (UT-Dallas)	(O16) In-situ X-ray Computed Tomography Characterization of IDOX/Estane Polymer Composite Using Digital Volume Correlation
Session 6: Metallic materials		
11:00—11:15 am	Neha Arora (UH)	(O17) An Analysis of Anisotropic Material Failure under Shear and Tension
11:15—11:30 am	Jianing Xie (UT-Austin)	(O18) Exploration of Ductile Failure Processes in Aluminum and Its Alloy through X-ray CT Scan and Microscopy
Session 7: Mechanics of materials under extreme loading conditions		
11:30—11:45 am	Junyoung Kim (UT-Austin)	(O19) Evaporation-Induced Cavitation: A Controlled Study Using PDMS Gels
11:45 am—12:00 pm	Fateme Feijani (UT-Dallas)	(O20) Sustainable Drag Reduction Using Superhydrophobic Polyurea Aerogels in Turbulent Flow Conditions
12:00—12:15 pm	Sicong Wang (UT-Austin)	(O21) Laser-Induced Cavitation in Anisotropic Biological Materials
12:15—1:00 pm	**Lunch**	
1:00—1:15 pm	**Group photo (in front of EER)**	
1:15—3:00 pm	**Texas Materials Institute lab tour**	
After 3:00 pm	Dinner on your own and have a safe trip back	

3. Oral Presentations

Keynote Talk #1:

Constitutive Modeling of Soft Materials: Past, Present, and Future

Kshitiz Upadhyay, Ph.D.

Assistant Professor
Department of Mechanical and Industrial Engineering,
Louisiana State University, Baton Rouge, LA, USA

Abstract

Soft materials are ubiquitous in nature, biological systems, and engineering applications, characterized by their ability to undergo large deformations in response to external thermo-mechanical stimuli. Constitutive modeling aims to understand and mathematically describe the thermo-mechanical response of these materials for any geometry and under various loading conditions. In the context of soft materials, these models are essential for the design and analysis of soft robots, computational surgical planning and training, and understanding trauma-induced pathologies such as traumatic brain injuries (TBI), among many other applications. In this talk, I will explore the evolution of constitutive modeling, from empirical stress–strain relations to continuum-thermodynamics-based models, and, more recently, to data-driven models incorporating scientific machine learning (ML). I will particularly focus on the short-time visco-hyperelastic response of soft materials, which is critical in injury biomechanics (e.g., simulations of crashes, blasts, and ballistic impacts) and protective equipment design. Specific examples from my research in this area will illustrate the different paradigms of constitutive modeling and their practical applications.

Bio:

Kshitiz Upadhyay is an Assistant Professor in the Department of Mechanical and Industrial Engineering at Louisiana State University, where he directs the Soft Materials Mechanics Laboratory. His research lies broadly in the mechanics of soft materials, with emphasis on constitutive modeling, experimental solid mechanics, data-driven methods, and injury biomechanics. Current projects in Dr. Upadhyay's lab are supported by the National Science Foundation (NSF), the Office of Naval Research (ONR), the National Aeronautics and Space Administration (NASA), and the Louisiana Board of Regents (LABoR). He received the 2022 Early Career Research Award from the World Council of Biomechanics for his work on the mechanics of the human brain. Before joining LSU, he was a postdoctoral fellow at the Hopkins Extreme Materials Institute at Johns Hopkins University (2020–2022). He earned his Ph.D. and M.S. in Mechanical Engineering from the University of Florida (2020, 2019), and a B.Tech. from the National Institute of Technology–Bhopal, India (2014).

Keynote Talk #2:

Houston, We Have a Problem to Solve: Foundations for Predicting Material Failure

Shailendra Joshi, Ph.D.

Kalsi Associate Professor
Department of Mechanical and Aerospace Engineering,
University of Houston

Abstract

The view of materials as systems has paved the path for a hierarchical approach to materials-by-design. The emergence of powerful cyberinfrastructure has created unprecedented opportunities to develop data-driven approaches to material design and discovery. In the context of predicting microstructure-sensitive mechanical behaviors of materials, a core challenge is to perform high-fidelity computations with low computational cost. By way of consequence, high throughput approaches are emerging to project mechanical behaviors from finer scale calculations to a coarser scale, and augmenting them with data-driven (e.g., machine-learning (ML)) framework.

The remarkable crystallographic plastic anisotropy, tension-compression asymmetry and strong texture effects in low symmetry hexagonal close packed (HCP) materials are often referred to as origins of damage intolerance. While experimental forensics indicate ductile processes at play, the role of microstructure in damage accumulation remains elusive. In this talk, we inspect potential linkages between structure (grain size and texture) and damage tolerance (property) in magnesium alloys. Emergent interactions between void growth with deformation mechanisms leading to void coalescence are discussed with implications on the damage tolerance.

Bio:

Shailendra Joshi is Kalsi Associate Professor of Mechanical & Aerospace Engineering at the University of Houston (UH). Prior to joining UH, he was an associate professor at the National University of Singapore (2008-2018). During 2005-2008, he was a post-doctoral fellow in the Department of Mechanical Engineering at Johns Hopkins University. He earned his PhD in Civil Engineering from Indian Institute of Technology Bombay in 2002. After a short stint as a visiting scientist at the University of Stuttgart (2002), he worked as a research engineer at GE-India Technology Center in Bangalore, India (2003-2005). His research interest is in understanding, modeling and controlling material responses through the mechanics of defects and failure processes at multiple length-scales and time-scales.

[O01] Visco-Hyperelastic Calibration of Bovine Brainstem Using a One-Shot Indentation Approach with Inverse Finite Element Method

Siddharth Sriram[1], *Kshitiz Upadhyay*[1], *Nihar Moghe*[1], *Curtis Johnson*[2], *Michael D Shields*[3], *Dimitris Giovanis*[3]

[1] *Louisiana State University*
[2] *University of Delaware*
[3] *Johns Hopkins University*

Abstract

Traumatic brain injury (TBI) is a major contributor to morbidity and mortality worldwide. To better understand the mechanical origins of TBI, it is critical to characterize brain tissue behavior under dynamic, high strain rate loading conditions—often on the order of 10^2 s^{-1}. Traditional mechanical testing methods for soft tissues, however, require numerous specimens and often induce significant damage during testing, making them impractical for rate-sensitive and fragile biological materials. To address these limitations, we employ a one-shot indentation approach that minimizes both the number of required specimens and the extent of tissue damage. Indentation presents a complex loading condition involving tension, compression, and shear beneath the indenter, making closed-form stress–stretch relationships analytically intractable. Therefore, we implement an inverse finite element (FE) framework where the entire FE simulation serves as the functional form for model calibration. The simulation iteratively updates visco-hyperelastic parameters until the residual between experimental and simulated data converges to an acceptable threshold. We focus on the bovine brainstem, a critical region relevant to blast- and impact-induced brain injury. Samples are subjected to indentation across a range of loading rates (10^{-2} to 1 s^{-1}), and force–displacement data is collected. To enhance calibration accuracy and improve solution uniqueness, we additionally extract strain data beneath the indenter from Digital Image Correlation (DIC) and compare it against FE-predicted nodal strains. The constitutive response is modeled using a combination of hyperelastic (Neo-Hookean) and viscoelastic (Prony series) formulations. This integrated experimental–computational framework provides a robust path for characterizing soft tissue mechanics under impact-relevant conditions, and lays the groundwork for future modeling of injury mechanisms in the human brain.

[O02] Physics-Informed Cokriging: An Intuitive and Efficient Technique for Imputing Missing Data in DIC

Nihar Moghe[1], Siddharth Sriram[1], Dimitris Giovanis[2], Michael Shields[2], Curtis Johnson[3], Kshitiz Upadhyay[1]

[1] Louisiana State University
[2] Johns Hopkins University
[3] University of Delaware

Abstract
Full-field kinematic measurements such as Digital Image Correlation (DIC) play a crucial role in solid mechanics, enabling observation of local deformations, strain and stress concentrations, and heterogeneity in material behavior. They are particularly valuable for model calibration, failure characterization, and in inverse finite element (FE) method, offering richer data from fewer experiments. In recent data-driven material modeling, full-field strain maps have even enabled stress predictions without assuming constitutive models. However, DIC data suffers from noise and missing information, especially near material boundaries, geometric discontinuities like holes, and regions of large deformation. This introduces uncertainty and limits characterization in complex deformations or materials. As modeling becomes more data-driven, and with DIC central to both traditional and modern workflows, addressing missing data is crucial, yet underexplored. Prior work often overlooked incompleteness by using complete fields synthetic data instead of real experimental DIC. In those using experimental DIC, boundary conditions were reformulated on the data boundary instead of material boundaries—a workaround effective only for simple geometries or deformations. Rare efforts tackling missingness used data-intensive statistical tools or machine learning methods that require training time datasets. To address this, we present a physics-informed, data-efficient cokriging framework to impute missing full-field data. We treat DIC as the primary field and generate a secondary field through inverse FE modeling on the same experiment. This secondary field captures physical trends, and its strong spatial correlation with the primary field enables meaningful imputation via cokriging. Our approach requires no extra experiments and generalizes complex materials and geometry. We validated our method on synthetic DIC-like fields generated from FE simulations with controlled noise and missingness. Compared to statistical methods like ordinary kriging and model-based extrapolation methods like bivariate polynomial fitting, our framework improved accuracy near critical regions like contact boundaries for indentation. While ordinary kriging showed mean errors up to 30% and maximum errors of 800%, and bivariate fitting exceeded 100% mean error, our framework achieved under 5% mean error and below 20% maximum error.

[O03] Rotation Control with Dual Actuators: A New Device to Extract Mixed-Mode Traction-Separation Relations

<u>Mohammad Aaquib Ansari</u>[1], Rui Huang[1], Kenneth Liechti[1]

[1] The University of Texas at Austin

Abstract

The study of the fracture of interfaces is critical in many industries, including automotive, aerospace, semiconductor packaging, etc. The classical J-integral approach rests on a one-parameter characterization of such interfaces, where fracture is said to ensue when its value exceeds the interfacial fracture toughness. Cohesive zone modelling goes further by accounting for nonlinear effects in the fracture process zone. As a result, interfacial interactions are more fully accounted for by traction-separation relations that account for their stiffness, strength and range. However, this modelling approach is limited to the veracity of the extracted traction-separation relations, which are often dependent on the fracture mode-mix. Laminated beam specimens loaded in displacement control by a single actuator have classically been used to extract traction-separation relations, but they require different specimen geometries and loading configurations to access a suitable range of mode-mix ratios. Furthermore, even dual-actuator devices operating in displacement control have drawbacks. To this end, a dual-actuator device that prescribes rotation on laminated beam specimens has been designed and developed. Such a configuration has a lower sensitivity of the loading ratio on mode-mix, and most importantly, a much smaller change of mode-mix angle as the crack propagates. The analytical expressions for the J-integral also significantly simplify for this case. Furthermore, the configuration features self-similar crack growth in Mode I, thereby allowing the crack tip to be located in opaque specimens using digital image correlation. The normal and shear traction-separation relations between aluminum and epoxy interface are then explored as a function of fracture mode-mix and, in this case, challenge commonly assumed forms and criteria.

[O04] Crack Nucleation and Propagation of Elastomers in the Poker-chip Experiment

Jinlong Guo[1], *Krishnaswamy Ravi-Chandar*[1]

[1] *The University of Texas at Austin*

Abstract
We present the results of an investigation of crack nucleation and propagation in a transparent polydimenthylsiloxane (PDMS) elastomer. The main objective of the investigation is to characterize quantitatively the evolution of crack nucleation and propagation behavior not just through the usual macroscopic load and displacement data, but with synchronized optical images at high spatial and adequate temporal resolution that will resolve the evolution of the failure processes. This is augmented with X-ray computed tomography (CT) scans to characterize the three-dimensional geometry of the cracks nucleated in the interior of the elastomer. Toward this goal, we reproduce the classical poker-chip experiment of Gent and Lindley (Proc R Soc Lond A 249(1257):195–205, 1959). These experiments are performed on transparent PDMS with different compositions, first in a specially built loading machine that is fitted with a high-magnification microscopic camera that permits the measurement of the load while simultaneously providing images of the specimen configuration and subsequently in an apparatus built for in situ observations using an X-ray CT scanning system. These experiments reveal that nucleation of multiple microcracks dominates when the diameter-to- thickness aspect ratio α is sufficiently large. In contrast, specimens with smaller aspect ratio tend to nucleate fewer cracks, and are dominated by the growth of these cracks. At even smaller α, the hydrostatic stress is significantly lowered and failure is dominated by surface flaws. This result indicates that the cavity/crack nucleation is not driven by the hydrostatic tension alone but also by its complement, the deviatoric strain energy. We explore the nucleation of cracks through a nonlocal criterion.

[O05] Characterization of Photo-switchable Liquid Crystal Elastomer Adhesives via Flat-probe Tack Testing with Direct Contact Area Measurement

Brandon D. Clarke[1], Yudian Wu[1], Tori A. Hassmann[1], Zachariah A. Page[1], Kenneth M. Liechti[1]

[1] The University of Texas at Austin

Abstract
As the transistors in integrated circuits continually shrink with evolving technology, the demand for smaller features in these transistors grows in tandem. Owing to their unique optoelectronic properties, 2D materials such as graphene offer significant potential to improve semiconductor performance with their incorporation into silicon-based electronics technology. However, the challenge of physically depositing pristine 2D materials onto silicon limits their application. To address this challenge, we proposed a two-step dry transfer process to cleanly and efficiently transfer graphene from a growth substrate to a target substrate via a reusable intermediate substrate made of a photo-switchable liquid crystalline elastomer (LCE) adhesive. In this study, a novel LCE formulation is presented in which the liquid crystalline state, and hence the properties, of the adhesive can be reversibly switched between sticky and non-sticky states by irradiating with either ultraviolet (365 nm) or blue (470 nm) light at room temperature. Flat-probe tack tests were performed on Poker chip-type samples to observe the interfacial fracture behavior of the LCE adhesive when bonded to a glass substrate. In the tack tests, in situ measurements of the contact area were recorded by a digital camera situated below the transparent glass substrate in the experiment set-up. Following a novel Poker chip fracture analysis, a reduction in the strength and fracture toughness of the adhesive is observed upon switching the LCE from the nematic to the isotropic states by irradiating with ultraviolet (365 nm) light. Upon reestablishing adhesive contact, the properties reverted to those of the stronger and tougher nematic state by irradiating with blue (470 nm) light. We conclude by discussing how the results from these experiments influence our development of a two-step dry transfer process for graphene.

[O06] Nonwoven Electrospun Nylon Nanofibers as Thermally Stable and Mechanically Durable Battery Separators

Minoo Tayefeh Kazemi[1], Jin Luo[1], Gustavo Felicio Perruci[1], Igor Emri[2], Yue Zhou[1], Hongbing Lu[1]

[1] *The University of Texas at Dallas*
[2] *University of Ljubljana*

Abstract

The performance, reliability, and safety of lithium-ion batteries (LIBs) are strongly governed by the properties of their separators—components that must effectively prevent internal short circuits while enabling efficient ion transport. In this work, we present a comprehensive study on nonwoven electrospun nylon nanofiber membranes engineered as next-generation battery separators. These membranes combine the mechanical and thermal advantages of nylon with the tunable architecture provided by electrospinning to meet the requirements of high-performance LIBs. The membranes were thermally compressed close to their glass transition temperature to densify the fiber network, thereby reducing thickness and porosity and enhancing inter-fiber bonding. Field emission scanning electron microscopy (FESEM) revealed a transition from loosely packed to tightly bound fibers, suggesting improved mechanical resilience and shear resistance. Electrochemical performance was assessed using Li|Li symmetric cells. The nylon-based separators demonstrated superior long-term stability, sustaining a consistent overpotential of ~11.2 mV over 270 cycles—significantly outperforming commercial polypropylene (PP) separators, which exhibited early voltage instability due to lithium dendrite formation and poor interfacial contact. Mechanical durability was evaluated through puncture resistance testing and stereo digital image correlation (DIC). all monolayer and multi-layer nylon membranes showed improved ductility and strength compared to commercial membranes. DIC strain maps confirmed more uniform deformation patterns and higher strain tolerance at critical points, indicating enhanced resistance to localized failure such as puncture by lithium dendrites. These findings support the potential of electrospun nylon nanofiber membranes to be counted as reliable, scalable, and high-performing separators in next-generation LIBs. Their combination of thermal stability, mechanical integrity, and electrochemical performance positions them as strong candidates for use in electric vehicles, grid storage, and portable electronics where safety and longevity are essential.

[O07] Measuring Tip Wear in Atomic Force Microscopy with Inverse Force Curve Analysis

Logan J. Kirsch[1], *Jason Killgore*[2], *Gregory J. Rodin*[1], *Timothy S. Weeks*[2], *Filippo Mangolini*[1]

[1] *University of Texas at Austin*
[2] *National Institute of Standards and Technology*

Abstract
Atomic Force Microscopy (AFM) is commonly used to assess mechanical properties at the nanoscale, but accurately calculating quantitative values remains a significant challenge. Factors such as sample roughness, depth-dependence, viscoelasticity, adhesion, and the inherent assumptions in calculations all contribute to overall error. Researchers are therefore currently limited to making qualitative comparisons between regions in nanomechanical maps. To derive intrinsic material properties from these measurements, the AFM tip geometry must be known. One major source of error for these calculations lies in assuming a constant spherical or conical geometry, which often fails to accurately capture AFM tip geometry. Specifically, this assumption fails to account for the drastic geometry changes that can occur during the scanning required for nanomechanical mapping. While some work has been done to model tip wear during mapping (Gotsmann & Lantz, 2008; Liu et al., 2010; Vahdat et al., 2014), these models struggle to accurately identify the current geometry at any specific instance in time. In this work, we present a method for measuring the current tip geometry using indentions on well-characterized hyperelastic samples. Here, we investigate a number of numeric techniques for calculating the parameters describing the current tip geometry. Additionally, we develop an analytic solution based on the local slope of the applied force versus indentation curve. This technique offers the advantage of calculating the power law exponential term without prior knowledge of the reference sample material properties. These procedures are validated by applying them to experimental indentations preformed on polydimethylsiloxane (PDMS) between scans on a hard-wearing surface. Our findings provide guidelines for accounting for tip wear and increasing the accuracy of AFM nanomechanical measurements.

[O08] Optimizing Thermo-Responsive Polymers for Enhanced Mechanical Behavior

Gustavo Felicio Perruci[1], *Leshi Feng*[1], *Swapnil Vaidya*[2], *Chengqian Huang*[1], *Paul Mayer*[2], *Shuang Cui*[1], *Hongbing Lu*[1]

[1] *The University of Texas at Dallas*
[2] *National Renewable Energy Laboratories*

Abstract

Thermo-responsive polymers (TRPs) present significant potential for applications such as desalination, dehumidification, and oil recovery, by offering energy-efficient solutions for water management and separation. However, for these polymers to be viable in such demanding environments, they must exhibit a combination of mechanical strength, elasticity, and durability while maintaining their water-absorption and release capabilities under dynamic mechanical loads. This investigation focuses on the optimization of the formulation of TRPs targeted to applications where mechanical integrity and functionality under stress are crucial. The TRP developed herein was engineered to balance mechanical strength and elasticity while efficiently managing water absorption and release in response to thermal stimuli. A parametric study of the polymer's formulations, implemented through a systematic variation of its constituents, was conducted to identify formulations that enhance their mechanical properties to meet the demands in various applications. Mechanical characterization was conducted through a series of tensile and compressive tests in compliance with ASTM standards. Digital Image Correlation (DIC) was used to monitor strain distribution of a specimen in its gage length and the failure behavior in real-time, to reach measurements of deformation and stress concentration with high precision. Additionally, dynamic mechanical analysis (DMA) was performed to measure viscoelastic properties, which are analyzed to predict long-term durability. The TRP's endurance was further evaluated via a fatigue tension test, where it was subjected to forty thousand cycles. The results demonstrated that the optimized TRP has demonstrated increased mechanical stability and structural integrity, while maintaining the water absorption and desorption capabilities, making it a promising material for applications that involve cyclic mechanical loading.

[O09] Squishy Granular Mechanics

Jyoti Shivaji Sonawane[1], *Shailendra P. Joshi*[1]

[1] *University of Houston*

Abstract

Soft granular assemblies are encountered in many natural systems and are important motifs in many engineered applications, from powder compaction to pharmaceuticals and biosystems. Understanding the mechanical behaviors of such granular systems is essential for their translational applications. It is understood that the mechanics of these systems is fundamentally rooted in the inter-particle interactions associated with deformable contact mechanics. Yet, full-scale discrete element method (DEM) simulations become important as complex multi-particle interactions can occur in such assemblies. We study the nonlinear mechanics of two-dimensional hyperelastic granular packings using finite element-based DEM under compressive loading. The focus is on developing a statistical mapping between the macroscopic force-displacement relations and the porosity evolution as a function of the particle compressibility. The macroscopic behaviors are correlated with the emergent micromechanical features of pore size and shape distributions and their orientation distributions. These micromechanical features offer insights into potential failure behaviors of such assemblies under tensile loading states.

[O10] In Vitro Measures of Tricuspid Valve Leaflet Strains and Annular Forces

Collin E. Haese[1], *Trace G. LaRue*[1], *Diego Guajardo*[1], *Tomasz A. Timek*[2], *Manuel K. Rausch*[1]

[1] *The University of Texas at Austin*
[2] *Corewell Health West, Michigan State University*

Abstract
The heart is an essential organ that pumps blood throughout the body. Its valves maintain proper blood flow by sealing and thereby preventing backflow. However, a variety of diseases can impair valve function and lead to regurgitation, i.e., blood leakage. The tricuspid valve, which regulates flow through the right atrium and right ventricle, leaks in over 80% of the population. When leakage becomes severe, patients' quality of life and life expectancy are significantly reduced. Fortunately, numerous valve repair and replacement therapies have been developed to address tricuspid regurgitation. The success of these approaches is highly dependent on a thorough understanding of the tricuspid valve's anatomy, physiology, and mechanical environment. For example, biomaterial-based replacements must be designed to sustain the valve's complex loading, while repair devices should be placed in regions of low strain to minimize the risk of failure. Unfortunately, our understanding of the tricuspid valve's complex loading conditions remains limited. The tricuspid valve is often referred to as the "forgotten valve" due to the limited attention it has historically received. Prior efforts to explore the mechanics of the valve resulted in data with low spatial resolution or required explanation of the valve complex. Our work aims to provide spatially and directionally resolved information on the mechanics of the tricuspid valve. Specifically, we will answer the following questions: What are the heterogeneity and anisotropy of strains within and between leaflets? What are the magnitudes and directions of the forces at the annulus? To understand potential changes in leaflet strains and annular forces with disease, we will record these changes as a function of transvalvular pressure and degree of annular dilation. To this end, we will use 3D digital image correlation (DIC) to measure leaflet strains and custom force transducers to measure annular forces in whole-heart porcine preparations. This will provide a novel and comprehensive in vitro analysis of tricuspid valve mechanics. By providing spatially resolved strain and force data, we will offer a foundation for the development of improved valve replacements and optimized repair strategies. Future studies should incorporate these mechanical insights to improve durability, biocompatibility, and clinical outcomes.

[O11] The Stress Relaxation Response of the Porcine Descending Aorta under Combined Normal and Torsional Loadings

Luc Nguyen[1], *Calvin Nguyen*[1], *Kirtan Patel*[1], *Jackson Luce*[1], *Chandler Benjamin*[1]

[1] *Texas A&M University*

Abstract

Understanding the mechanical properties of aortic tissue is crucial for improving future medical interventions related to cardiovascular diseases. Our group has previously investigated the uniaxial, bi-axial, and shear responses of the porcine thoracic aorta. In this study, we explore the stress relaxation of the porcine aorta under torsional shearing while maintaining a constant normal compressive load. Circular samples, measuring 0.5 inches in diameter, were extracted from the descending section of porcine thoracic aortas. Stress relaxation experiments were conducted at a constant shear strain ranging from 10 to 50% while maintaining a compressive strain ranging from 5 to 25%. We observed that the stress relaxation behavior differs between the normal and torsional shear directions. Moreover, results suggest that neither the normal nor shear stress relaxation behavior of the porcine aorta is significantly influenced by the degree of compressive strain or shear strain applied.

[O12] Tension–Compression Failure Asymmetry in Soft Materials Using Logarithmic Strain Invariant-Based Hyperelasticity

Yogesh Chandrashekar[1], *Kshitiz Upadhyay*[1]

[1] *Louisiana State University*

Abstract
Several soft materials and biological tissues exhibit distinct damage accumulation and failure behaviors between tensile and compressive loading—a phenomenon known as tension–compression asymmetry (TCA). Accurately modeling this inherent asymmetry in the softening response is critical for understanding the mechanical behavior of soft materials but remains a significant challenge within the framework of finite elasticity. Traditional damage models, while simplifying the representation of deformation-induced softening and failure, often fail to capture the directional dependence of damage, thereby limiting their applicability to TCA-dominated responses. To address this gap, we propose a novel hyperelastic constitutive model formulated using a free energy density function based on logarithmic strain invariants (k1,k2,k3), characterizing the amount of dilatation, the magnitude of distortion, and the mode of distortion respectively, thereby enabling a physically interpretable and tractable basis for introducing phenomenological fitting functions that capture experimental trends. The model incorporates distinct energy limiters (∅+, ∅-) and sharpness parameters (m+, m-) for tension and compression, enabling independent control over the respective softening contributions without introducing additional internal damage variables. Agarose hydrogels at concentrations ranging from 1–3% w/v serve as the model material. To calibrate the model, experimental tension-compression responses were simultaneously fitted at 1%, 2%, and 3% w/v, leveraging full-field strain mapping obtained via 3D DIC under a quasi-static loading rate of 10^{-2}/s. The constitutive response is captured through an energy-limited hyperelastic formulation governed by three physically interpretable parameters—initial shear modulus (μ), a scaling constant (C0), and an exponent parameter (p) representing higher-order distortional effects, alongside four failure-related parameters. These include tensile and compressive sharpness and energy-limiting parameters, modulated by the third logarithmic strain invariant (k3), which characterizes the deformation mode and enables representation of TCA. To assess the model's predictive capabilities, we validated a held-out dataset using a 2.5% w/v gel concentration, which was excluded during model calibration. The proposed framework displays excellent predictive accuracy across deformation modes and effectively links macroscopic failure to microscale characteristics.

[O13] High Strain Rate Characterization of Regolith–Shape Memory Polymer Composites for Lunar Applications

Austin Zeringue[1], Kingsley Yoboah[2], Guoqiang Li[1], Kshitiz Upadhyay[1]

[1] Louisiana State University
[2] Southern University

Abstract
Understanding the behavior of materials under dynamic loading is essential for designing structures capable of withstanding extreme extraterrestrial environments. In this study, we investigate the high-strain-rate compressive response of 3D-printable regolith–shape memory polymer (SMP) composites using a Split-Hopkinson Pressure Bar (SHPB) apparatus. This system enables characterization of materials at strain rates exceeding 10^3 s^{-1} by measuring strain wave propagation through incident and transmission bars while a small cylindrical specimen is loaded by a striker bar. The goal of this work is to assess the feasibility of using regolith-based SMP composites for potential lunar infrastructure, particularly in environments involving impact or blast-like loading. Composites are fabricated with two types of lunar regolith simulants—Lunar Highlands Simulant (LHS) and Lunar Mare Simulant (LMS)—at varying weight fractions ranging from 5% to 20%. As of now, we have completed high strain rate testing on 5 wt.% LHS–SMP composites. Preliminary results indicate strain rate–induced softening behavior, a notable deviation from the rate-dependent stiffening typically observed in the bulk SMP matrix. This suggests that the addition of regolith alters the energy dissipation and deformation mechanisms in dynamic conditions. These results are being compared against quasi-static compression data to quantify the rate sensitivity of these composites and guide material optimization for lunar structural applications.

[O14] Design and Experiments of Conch Shell Inspired Multi Material Composites with Enhanced Damage Tolerance

Muhammed Jawaad Zulqernine[1], Mahatab Bin Rashid[1], Shiyao Lin[1]

[1] *Mechanical and Aerospace Engineering, The University of Texas at Arlington*

Abstract
Conch shells, characterized by their remarkable impact toughness, are one of the most impressive armor materials appearing in nature. The complex hierarchical architecture and unique material composition of conch shells both contribute to its unique capabilities of deflecting and arresting cracks, resulting in structures with excellent damage tolerance. In this study, a conch-shell inspired biomimetic composite is designed and fabricated using multimaterial additive manufacturing. The toughening mechanisms in conch structures were investigated through systematic 3-point bending experiments. To emulate the unique structure and behavior of conch shells, the biomimetic samples combined materials from two different groups (categorized as "Stiff" and "Soft") and were 3D printed in [0/90/0] and [90/0/90] stacking sequences. Experiments revealed significantly different groups of mechanical behavior across the samples. Stiffer samples exhibited brittle fracture with rapid crack propagation prior to failure. In the soft samples, cracks were propagated and deflected along the soft inclusions, enabling excellent toughening mechanisms similar to conch shells. To better understand the underlying damage tolerance mechanisms in conch shells, parametric studies were conducted by varying the following: support span length (1 inch/2 inch), misalignment of patterning (high/low), and notch inclusion (yes/no). With the inclusion of a notch, peak load and deformation were greatly reduced in the stiffer samples. In contrast, the softer samples were still capable of withstanding significant deformation before failure, indicating the presence of effective crack deflection mechanisms and reduced notch sensitivity. The most notable result was observed for soft samples with a low misalignment pattern. This type demonstrated outstanding damage tolerance, characterized by a distributed damage network in the failure region. During loading, a network of crack propagation pathways were generated, enabling mechanisms for enhanced energy-dissipation and allowing the material to deform significantly before failure. The results prove that, highly damage-tolerant composites may be designed by effectively mimicking the conch shell structure. However, this requires incorporating the correct material combination, and optimizing the structural design for specific applications. This research paves the way for the development of advanced armors and protective equipment using biomimetic materials.

[O15] Surface Deformation Measurements of Particulate Idoxuridine Crystals Filled with Estane under Quasi-Static and Dynamic Loading

Pooyan Brandon Javadzadeh[1], *Yao Ren*[1], *Ehsan Mehrdad*[1], *Nathan Peterson*[2], *Amy Clarke*[2], *Hongbing Lu*[1]

[1] *The University of Texas at Dallas*
[2] *Colorado School of Mines*

Abstract
Particulate idoxuridine crystals with particle sizes in the range of 75-150 μm are embedded in Estane polymer matrix to form a particulate composite cylinder specimen of 5 mm diameter. A metallic ink marker is applied to the surface of the composite cylinder, and volumetric images of the specimen are obtained using micro-computed tomography (μCT) at approximately 4.0 μm/pixel resolution to determine the internal microstructure, including any voids. The metallic ink markers are distinguishable in each μCT volumetric image, and also in the surface images of the same specimen, allowing for the correlation of internal microstructure to the surface speckles. The μCT pre-scanned specimen is compressed under quasi-static loading condition, where a stereo-microscope with a resolution of 4.0 μm/pixel is used to acquire the surface stereo images of the specimen undergoing deformation. The surface stereo images are analyzed using stereo (or 3D) digital image correlation to determine the surface axial, circumferential, and shear strains. These strain results are correlated to the internal microstructure for validation of meso-scale simulations of the specimen under compression. Concurrently, at high strain rates, a 25-meter-long split Hopkinson pressure bar is used to apply compression while an ultra-high speed camera is used to acquire surface images at ambient temperature. Digital image correlation is used to determine the surface strains of the specimen. The markers again allow for correlation of the surface deformations to the microstructure. These experimental results provide detailed internal microstructure of the particulate composite specimen, which is correlated to the measured surface strains under both quasi-static and dynamic loading conditions. The results can be used for verification and validation of simulations of the mechanical response of particulate materials by direct numerical simulation (DNS), and to assist in the development of a computational multiscale micromorphic continuum mechanics framework.

[O16] In-situ X-ray Computed Tomography Characterization of IDOX/Estane Polymer Composite Using Digital Volume Correlation

Ehsan Mehrdad[1], *Pooyan Brandon Javadzadeh*[1], *Yao Ren*[1], *Hongbing Lu*[1]

[1] *The University of Texas at Dallas*

Abstract

The internal deformation behavior of a particle-reinforced composite was investigated using digital volume correlation (DVC) applied to volumetric images obtained through in-situ X-ray micro-computed tomography (μCT). A composite material was fabricated by embedding idoxuridine (IDOX) crystals, ranging in size from 75 to 150 μm, into a polyurethane binder (Estane). The composite cylinder was subjected to unconfined compression while μCT scans were performed at multiple loading stages. Incremental DVC was carried out to quantify internal deformations throughout the loading process. Delamination at grain-binder interfaces, crack initiation and growth, and the coalescence of larger internal defects were identified. Through this approach, the structural evolution of the composite was captured in detail. The findings are intended to support the validation of numerical simulations aimed at modeling internal damage mechanisms.

[O17] An Analysis of Anisotropic Material Failure under Shear and Tension

Neha Arora[1], *Shailendra P. Joshi*[1]

[1] *University of Houston*

Abstract

Upon mechanical loading, the true stress-strain response of a polycrystalline metallic material traverses key stages, which include (i) an elastic-to-plastic transition, (ii) occurrence of peak stress, followed by (iii) gradual stress softening, and (iv) degradation culminating into a complete loss of load carrying capacity that is synonymous with ultimate failure or ductility. Predicting how the macroscopic failure process (stages (ii)-(iv)) is connected to the multiscale mechanics of anisotropic plasticity remains a thorny challenge. From a mechanistic standpoint, a challenging question is: What determines the ductility of a polycrystalline material - void coalescence or material instability? The former refers to a local failure process whereby generic mechanisms of void nucleation, growth, and link-up operate. Material instability here refers to the formation of shear bands, which manifests in the form of intense localization of plastic deformation in thin bands. In this work, we aim to address the following questions by means of three-dimensional unit cell finite element calculations of voided unit cells: • How does the material plastic anisotropy of the matrix affect the two failure modes? • Beyond plastic anisotropy, what roles do crystallographic deformation mechanisms (slip and twinning) play in determining the failure modes? • Are the failure modes cooperative or competitive? We adopt a computational methodology based on static condensation to efficiently compute the loss of ellipticity of the macroscopic tangent modulus that enables on-the-fly evaluation of strain localization. The efficacy of this method is assessed for isotropic and anisotropic materials under various controlled tensile and shear stress states.

[O18] Exploration of Ductile Failure Processes in Aluminum and Its Alloy through X-ray CT Scan and Microscopy

Jianing Xie[1], *Krishnaswamy Ravi-Chandar*[1]

[1] *The University of Texas at Austin*

Abstract
The mechanism of ductile failure in structural materials has been of great interest for a long time, both from a theoretical and a practical perspective. Various failure models have been proposed and their ability to predict failure is still being tested and refined. In this work, we explore the failure of several aluminum materials (Al-6061-T6, pure Al) through interrupted tests, x-ray tomography and scanning electron microscopy. A series of interrupted loading experiments were performed on compact tension specimens containing a fatigue pre-crack or a notch. Digital image correlation was used to monitor the macroscopic load-displacement response. During the interrupted testing procedure, three-dimensional X-ray computed tomography was used after each loading increment to explore the three-dimensional geometry of the specimen. The specimens were scanned in slices with a 5 μm spatial resolution and then reconstructed into a 3D model to reveal the geometry of the crack front and crack surface. Plastic strain localization was observed near the outer surface of the specimen, while no internal damage or voids were detected by the X-ray at the scale of 5 μm and above. A regular compact tension test was performed on a pure aluminum specimen as well, for comparison with the Al-6061 specimen. Fracture surfaces from different materials were scanned by SEM, and the differences were revealed. High-resolution optical and scanning electron microscopic images were coupled with x-ray images to interpret the path of the crack in the microstructure. Higher X-ray resolution was used to observe the internal void nucleation, growth, and coalescence on Al-6061 shear test specimens as well as on previous compact tension specimens. No evident existence of void nucleation is observed in the vicinity interior of the crack at a resolution of 0.8 μm. We examine the implications of these results for modeling ductile failure.

[O19] Evaporation-Induced Cavitation: A Controlled Study Using PDMS Gels

Junyoung Kim[1], *Jin Yang*[1]
[1] *The University of Texas at Austin*

Abstract
Evaporation-induced cavitation (EIC) occurs when thermal evaporation of a liquid droplet under confinement leads to sufficient pressure to trigger cavity formation. In this study, we embedded water droplets within polydimethylsiloxane (PDMS) samples to create a minimal, well-controlled platform for investigating the mechanics of EIC. This approach isolates temperature as the sole driving force, avoiding confounding effects from external stimuli such as laser-induced plasma, mechanical impact, or chemical reactions. The simplicity of this system allows for clean observation of pressure trends, cavity nucleation, and post-cavitation deformation behavior. By removing multi-physics complications, this model enables focused exploration of instability and damage evolution in soft materials under evaporation-induced stress. The PDMS matrix provides a tunable viscoelastic environment, and real-time imaging captures dynamic transitions during evaporation. This work offers new insight into how negative pressure drives mechanical failure in confined soft systems, with implications for understanding cavitation in polymers, gels, and other deformable media.

[O20] Sustainable Drag Reduction Using Superhydrophobic Polyurea Aerogels in Turbulent Flow Conditions

Fateme Najafkhani Feijani[1], Esteban Leonardo Trevizo[1], Nir Saar Maor[1], Yaqing Jin[1], Hongbing Lu[1]

[1] *University of Texas at Dallas*

Abstract
Superhydrophobic surfaces are known for their ability to reduce drag in fluid environments, offering a passive and energy-efficient solution for flow control. In this project, we synthesized and tested nanoporous polyurea aerogels designed to lower friction drag in turbulent water flow. The aerogels were prepared through a sol-gel process using polyisocyanate and water in acetonitrile, with triethylamine added as a catalyst. SEM analysis confirmed that the material had a consistent porous structure and surface features supporting superhydrophobicity throughout the bulk. A monolithic aerogel plate (30 cm × 20 cm × 1 cm) was fabricated and tested in a recirculating water tunnel under turbulent boundary layer conditions at a freestream velocity of 1.3 m/s. In the initial trial, the aerogel plate showed approximately 20% drag reduction compared to a polycarbonate control. However, repeated testing revealed a loss in performance, likely caused by the removal of surface-trapped air over time. These results highlight both the effectiveness and challenges of using aerogels for sustainable drag reduction, and suggest further work is needed to improve long-term performance under realistic flow conditions.

[O21] Laser-Induced Cavitation in Anisotropic Biological Materials

Sicong Wang[1], Jin Yang[1]

[1] The University of Texas at Austin

Abstract

Laser-induced cavitation (LIC) provides a controllable means of subjecting soft biological tissues to extreme, transient deformation rates that are difficult to achieve with conventional mechanical tests. In this study, we use chicken breast muscle as an inexpensive, readily available tissue example for LIC experiments by infusing it with the food-grade dye tartrazine, which reduces optical scattering and renders samples quasi-transparent. A frequency-doubled, nanosecond Nd:YAG laser pulse (λ = 532 nm, E ≈ 0.2–0.5 mJ) is focused inside the dyed tissue to nucleate cavitation bubbles whose expansion and collapse are captured via high-speed videography (up to 1 million fps). From the experimentally captured bubble dynamics, we extract spatially and temporally resolved strain rates on the order of 10^3–10^5 s-1 and quantify the resulting stress field through inverse-dynamics modeling. Complementary oscillatory shear tests on a rotational rheometer characterize the linear viscoelastic moduli of chicken breast with and without tartrazine over 1–100 rad/s. The dye causes less than a 5 % change in storage (G′) and loss (G″) moduli across the tested frequency range, confirming that optical clearing does not measurably alter quasi-static rheological properties. Combining LIC-derived high-rate data with rheometer measurements yields a unified, strain-rate-dependent constitutive description of chicken breast tissue, suitable for validating soft-tissue damage models and informing medical or food-processing applications that involve rapid energy deposition.

4. Poster Presentations

[P01] Superhydrophobic Nanostructured Ductile Aerogel for Sustainable Drag Reduction Under Water Flow

Esteban Trevizo[1], Fateme Najafkhani Feijani[1], Nir Saar Maor[1], Yaqing Jin[1], Hongbing Lu[1]

[1] *The University of Texas at Dallas*

Abstract

There is an ongoing challenge of making lighter and stronger materials which is considered by microstructure, length scale, and material composition. However, the scalability and mechanical performance under extreme conditions continues to pose a problem for nanostructured materials. Methods like sol-gel synthesis show promise, along with aerogels, who are known for their low-density and high surface area, who have become a focus for the industry. As we see a rise in X-aerogels occur, we can link it to the numerous improvements being made in polymer-cross-linking with traditional silica aerogels that dramatically enhance mechanical properties without compromising density. Aerogels made from Polybenzoxazine-(PBO), polyurethane, polyimide, and polyamide have demonstrated impressive mechanical properties. The focus then shifts over to the polyurea-(PUA) aerogel, a type of material that presents low water retention, high temperature resistance, and exceptional mechanical properties. What we plan to research is a scalable, room temperature, ambient-drying method that has been developed that tackles the high-temperature gelation and supercritical drying problem that previously hindered commercialization. This new process allows for the full characterization of the PUA's mechanical properties, which has not been thoroughly investigated under different environments and loading conditions, creating a path towards commercial scalability of low-cost PUA aerogels. The PUA aerogel was made as they explain in Taghvaee, Tahereh, et al. 13.3 (2019): 3677-3690. To measure the level of hydrophobicity, water tunnel testing is used to observe the drag force of the material and the water-angle. The goal of this research is to ultimately create a product that is superhydrophobic that can be used in marine applications and water transfer pipes. The preferred process of synthesization would occur in room temperature environments and include an ambient-drying approach. The purpose of this objective is to further contribute to the scalability of PUA aerogels and commercialize scalable and low-cost aerogels.

[P02] Energy Thresholds for Laser-Induced Cavitation

Jacob Baker[1], Sicong Wang[1], Zixiang Tong[1], Binita Shrestha[1], Dan Frolkin[1], Jin Yang[1]

[1] University of Texas at Austin

Abstract

There has been considerable interest in studying the dynamics of cavitation as it pertains to numerous applications in medicine, engineering, and nature. In parallel, gold nanoparticles (AuNPs) have received critical attention for their biocompatibility, capability for attachment to functional groups, optical customizability, and finally their ability to attenuate energy towards plasmonic nanobubble cavitation. Plasmonic nanobubble cavitation has the potential to be used in conjunction with lasers or ultrasound as a trigger for microscale sonoporation of surrounding cells and therefore localized drug delivery for gene therapy or cancer treatment. This has motivated our investigation of LIC dynamics present at the microscale. Using a high speed (10M fps) camera and a 532 and 1064 nm pulsed Nd:YAG laser, we compared LIC energy and radii for DI Water, 3% polyacrylamide (PAAm) gel, and AuNP solutions of different shapes and absorption wavelengths. We have observed that when AuNPs are present in a solution, there exist three different cavitation regimes: no bubble, small bubble (~1-20 µm), and large bubble (100-1000 µm). Each AuNP solution exhibited a unique energy "threshold" in which large LICs had a chance of propagating instead of clusters of small LICS. As laser energy increased, the ratio of large LICs to small LICs in each AuNP solution increases linearly until plateauing at 50%. When comparing AuNPs with different absorption peaks, we noticed that the threshold for large cavitations in our 520 nm absorption peak AuNPs was around 700 µJ, while our ~1000 nm AuNPs far out of range of our 532n nm laser had absorption peaks between 100 uJ and 300 uJ. We attribute this difference in energy threshold to shift in the ratio of the two dominant mechanisms that trigger laser-induced photothermal nanoparticles: thermal expansion and plasma generation. When AuNPs absorb Laser energy from their absorption peak, thermal expansion is dominant, and small cavitations persist for higher energy levels. However, when AuNPs absorb off-peak laser energy, such as in the ~1000 nm peak AuNPs plasma generation is dominant and large AuNPs are created at lower energy levels, just as large plasma-dominated LICs are the only LICs in water and 3% PAAm. We expect this insight into the dynamics present in LIC for AuNPs to inform the design of AuNP-guided drug delivery systems and other applications requiring precise activation of AuNPs for sonoporation.

[P03] Radiation-Induced Mechanical Property Change in 2D Metal Halide Perovskites

Shengjia Zhang[1]*, Merlyn Pulikkathara*[2]*, Eugenia Vasileiadou*[3]*, Ioannis Spanopoulos*[4]*, Mercouri Kanatzidis*[3]*, Richard Wilkins*[2]*, Qing Tu*[1]

[1] *Texas A&M University*
[2] *Prairie View A&M University*
[3] *Northwestern University*
[4] *University of South Florida*

Abstract

Two-Dimensional Metal Halide Perovskites (2D MHPs)-based solar cells hold great promise for space exploration. Their long-term durability is significantly deteriorated by the radiation in the space environment yet the radiation effects on the mechanical properties of 2D MHPs remain elusive. To fill this knowledge gap, we used X-ray to mimic the high energy photons in the Space and quantitatively investigated the effect of X-Ray on the out-of-plane elastic modulus E and hardness H of prototypical 2D MHPs crystals, with a general formular of (C4H9-NH3)2(CH3NH3) n-1PbnX3n+1, (X = Cl, Br or I and n = 1 to 3), by instrumental nanoindentation. Both E and H were found to decrease quickly as the radiation dosage increases from 0 to 1.42 Mrads but then plateaus. Samples with a higher n number exhibited more pronounced degradation in mechanical properties after irradiation. X-ray diffraction showed the emergence of PbI2 peaks after x-ray irradiation and photoluminescence (PL) revealed a red-shift of the emission peak position and a significant change of the peak shape, which suggests that the x-ray radiation induced decomposition of the 2D HOIPs into PbI2 and associated defect formation are responsible for the radiation-induced deterioration of mechanical properties of 2D HOIPs. We further showed that as the halide composition is changed, Br-based materials exhibit better resistance to radiation-induced mechanical degradation. These findings provide valuable insights into the underlying mechanisms of radiation-induced damage.

[P04] Low Friction of Annealed Medium Entropy MXene

Jiaoli Li[1]*, Yuwei Zhang*[2]*, Congjie Wei*[1]*, Yanxiao Li*[3]*, Risheng Wang*[2]*, Brian Wyatt4, Babak Anasori*[4]*, Kelvin Xie*[1]*, Chenglin Wu*[1]

[1] *Texas A&M University*
[2] *Missouri University of Science and Technology*
[3] *National Energy Technology Laboratory*
[4] *Purdue University*

Abstract

The adhesion and friction of medium entropy (ME) MXenes (TiVNbMoC3 and TiVCrMoC3) were characterized for the first time and compared with those of the titanium carbide (TiC) MXenes (Ti2C and Ti3C2) using the SiO2 colloidal atomic force microscope (AFM). The effects of surface terminating groups and the intrinsic atomic structures were revealed. The surface terminating groups conversion from -OH to -O groups was observed under 200 °C ambient annealing, which reduced the adhesion energy and friction force of all MXenes characterized. The higher in-plane stiffness of the ME MXenes further reduces the puckering effects and promotes low friction. The superlubricity was observed for the first time in ME MXenes for the annealed TiVCrMoC3 with a coefficient of friction (CoF) at 0.0022, lower than graphene, MoSe2, and other MXenes characterized by the identical approach. This shows the promising future of compositionally complex MXenes as solid lubricants.

[P05] Simplifying PDE-Constrained Inversion: A GUI for DIC-Driven Property Recovery

Joseph Kirchhoff[1], Habsa Aydid[1], Eden Gezehagn[1], Dingcheng Luo[1], Thomas O'Leary-Roseberry[1], Omar Ghattas[1], Jin Yang[1], Zixiang Tong[1]

[1] The University of Texas at Austin

Abstract

We present a streamlined inversion workflow that leverages full-field displacement data from digital image correlation (DIC) together with scalar load-cell measurements to recover heterogeneous property fields. By imposing boundary conditions directly from DIC data and incorporating a force-misfit term, our approach obviates the need for complex Neumann boundary modeling. We formulate the inverse problem as an infinite-dimensional PDE-constrained optimization, regularized with total variation to promote piecewise-constant reconstructions, and solve it efficiently using an inexact Newton–CG method that is mesh-independent. In synthetic tests with 2% noise, we accurately recover layered modulus fields (relative error < 3%) and match load predictions to machine precision. Experimental validation on multi-material PolyJet coupons successfully resolves stiff inclusions within a compliant matrix, and a vector-TV extension enables joint inversion of elastic modulus and Poisson's ratio. To further lower the barrier for experimentalists, we are developing a user-friendly graphic user interface (GUI) that makes our inversion workflow accessible with minimal coding. It supports streamlined data import, boundary condition assignment from DIC inputs, parameter tuning, and real-time visualization. Designed for usability and extensibility, the interface simplifies the adoption of advanced inverse modeling tools in experimental solid mechanics. We welcome feedback to guide its ongoing development.

[P06] Microbes, Minerals, and Moduli: Mechanical Behavior of Microbially Induced Carbonate Precipitation in Hydrogel Beads

Julia Gancayco[1], Mert Kavala[1], Alexandra Clara Saracho[1], Berkin Dortdivanlioglu[1]

[1] The University of Texas at Austin

Abstract
Alginate hydrogels encapsulating bacteria and leveraging microbial-induced calcium carbonate precipitation (MICP) present a promising, energy-efficient, and environmentally friendly approach to soil stabilization—provided the stiffness of carbonate precipitates within the gels can be reliably quantified. This study investigates the evolving mechanical behavior of MICP hydrogels by measuring key properties such as Young's modulus and shear modulus under controlled displacement loading. Using the MicroTester G2, a 5% strain is applied to observe elastic responses over time. Gel stiffness is tracked across various MICP chemical triggering conditions over two timeframes: 24 hours and 10 days. Additionally, the effects of alginate concentration on stiffness are evaluated. Results show that 2% and 3.6% alginate hydrogels exhibit increasing Young's modulus over time and visible precipitation occurring in the gel.

[P07] Surface Characterization and Biointerface Potential of Post-Detoxified Titanium

Anthony Reyes[1], *Danieli C. Rodrigues*[1],

[1] *The University of Texas at Dallas*

Abstract

Dental implants show high success rates, but failures may rise with aging populations and increased procedures. Peri-implant disease—primarily due to plaque—is the main cause, progressing from peri-mucositis to peri-implantitis inducing bone loss. Standard detoxification uses chemicals like citric acid, saline, and chlorhexidine (CHX) with mechanical debridement. While effective, these methods can damage the implant's tailored surface properties vital for implant integration. This study investigates how citric acid, CHX, and saline affect titanium implant surfaces to inform clinical practices. Commercially pure titanium (Ti) disks were sandblasted and acid-etched (SLA). To mimic oral conditions, disks were inoculated with commensal (S. oralis, A. naeslundii, V. parvula) and pathogenic bacteria (A. actinomycetemcomitans, F. nucleatum, P. gingivalis). Disks were treated via cotton swabs soaked in 0.9% saline (S), 40% citric acid (CA), or 1% CHX for 8 min. Surfaces were then characterized. SEM visualized topography, EDS identified residual chemicals and bacteria, Contact angles were measured using Ramé-Hart goniometer, atomic force microscopy (AFM) analyzed arithmetic mean height (Sa), and statistical analysis helped determine the ideal detoxification method for osseointegration. SEM showed major surface changes post-bacterial exposure and detoxification. Sonication revealed smoother textures and pore formation, implying higher corrosion risk. CHX-treated surfaces retained SLA-like roughness but had larger, denser pores. Saline-treated surfaces were smoother, correlating with potentially lower cell growth. EDS confirmed residual chemicals and bacteria—e.g., NaCl deposits from saline. Citric acid left widespread residue embedding bacterial colonies. Contact angles dropped post-detoxification, from 97° (control) to 12–17°, indicating greater hydrophilicity. CA reduced surface roughness by 14% (461 nm vs. 535.5 nm). Ongoing AFM and statistical analysis will clarify surface features favorable for re-osseointegration. This study supports selecting effective detox methods and highlights the need for a protective coating. Future research will explore a novel dicationic imidazolium-based ionic liquid developed in our lab.

[P08] Modeling and Standardizing Push-out Tests for Biomechanical Assessment of Implant Osseointegration in Diabetic and Non-diabetic Lewis Rats

Sumedha Guha[1], Rohan Raja[1], Anthony Reyes[1], Danieli Rodrigues[1]

[1] The University of Texas at Dallas

Abstract

Introduction Orthopedic implantations are performed annually in the United States with an anticipated life span of 15-25 years. Alarmingly, 40,000 of these implantation surgeries require revision due to implant loosening driven by chronic inflammation at the bone-implant interface. This failure rate is disproportionately higher in immunocompromised individuals, particularly those with diabetes. Diabetes impairs bone healing through dysregulated immune responses, elevated osteoclastic activity, and reduced anabolic signaling. Consequently, implant failure rates are 10–15% in diabetic patients, compared to 1–3% in non-diabetics. These disparities highlight the need to improve implant integration in diabetic populations by developing reliable, mechanically-informed testing platforms. Although regenerative proteins like High Mobility Group Box 1 (HMGB1) are being explored to promote bone regeneration, a validated and reproducible mechanical testing model is needed to assess their functional impact on implant stability. Methods This study focuses on the development and standardization of a push-out test setup to quantify the interfacial mechanical properties of titanium implants placed in the proximal tibiae of diabetic Lewis rats. Push-out testing provides key measurements such as interfacial stiffness, maximum force at failure, and total energy to failure—each offering insight into the mechanical integrity of bone-implant integration. Given the absence of an established standard for metaphyseal push-out testing in small animal models, a custom approach was designed ensuring consistent specimen preparation and bone alignment on 3D-printed polylactic acid (PLA) mounts to minimize off-axis loading. Standardization was performed using rat tibiae harvested from diabetic rats at day 0 post-surgery. Results and Future Work The resulting force-displacement curves exhibited high reproducibility with coefficients of variation under 15% across all mechanical parameters, demonstrating the robustness and reliability of this protocol for evaluating implant integration. This validated push-out test platform lays the groundwork for future comparative studies between diabetic and non-diabetic groups and for testing regenerative interventions such as HMGB1-coated implants. Studies at 28 days post-implantation, as well as complementary tests like 3-point bending, are planned to provide a complete understanding of mechanical recovery and bone quality in diabetic conditions.

[P09] Tricuspid Valve Leaflet Remodeling in Sheep with Biventricular Heart Failure

Colton J. Kostelnik[1], Shreya Sreedhar[1], Chien-Yu Lin[1], Tomasz A. Timek[2], Manuel K. Rausch[1]

[1] University of Texas at Austin
[2] Cardiothoracic Surgery, Corewell Health (Grand Rapids, MI)

Abstract
Tricuspid regurgitation (TR), a condition affecting over 1.6 million Americans, is characterized by incomplete coaptation of the tricuspid valve leaflets, leading to the backward flow of blood. This disease is associated with leaflet remodeling, including changes in geometry, stiffness, and extracellular matrix structure, which alter valve mechanics and function. However, limited work has explored how remodeling differs across the three individual tricuspid valve leaflets (anterior, septal, and posterior). This study investigates leaflet-specific remodeling in a well-established ovine model of biventricular heart failure induced by tachycardia-induced cardiomyopathy (TIC). We evaluated leaflet area, α-smooth muscle actin (α-SMA) expression, and collagen fiber orientation as key markers of maladaptation in TIC and control (CTL) sheep. Leaflet areas were measured under stress-free conditions. α-SMA expression, indicative of valvular interstitial cell activation, was quantified through immunohistochemistry. Collagen fiber dispersion was quantified via second harmonic generation (SHG) imaging and quantitative image processing to obtain the concentration parameter κ, which reflects the structural alignment of collagen. Our results revealed that the septal and anterior leaflets in TIC animals exhibited significantly increased area ($p = 0.009$ and $p = 0.002$), suggesting tissue growth in response to altered mechanical loading. Conversely, the posterior leaflet area remained unchanged. α-SMA expression increased regionally in all TIC leaflets, particularly near the annulus and belly of the anterior and septal leaflets, indicating active remodeling. Collagen fibers in TIC anterior and septal leaflets exhibited greater dispersion near the atrial surface (lower κ values, $p = 0.005$ and $p = 0.011$), further suggesting heightened matrix turnover in response to elevated mechanical strain. The posterior leaflet showed minimal changes in area and fiber organization, indicating a more stable mechanical state despite increased α-SMA expression near the annulus. These findings highlight a heterogeneous remodeling response among tricuspid valve leaflets under pathological conditions. Integrating morphological, cellular, and structural metrics offers new mechanical insight into leaflet-specific adaptations to heart failure. This work contributes to a more complete mechanobiological understanding of TR progression and can enhance therapeutics.

[P10] J-Integral Framework for Determining Optimum 3D Printing Parameters for Fracture Resistance of Shape Memory Polymers

Ethan Blackwell[1], *Yogesh Chandrashekar*[1], *Kshitiz Upadhyay*[1]

[1] *Louisiana State University*

Abstract

Shape memory polymers (SMPs) are a relatively new class of materials capable of switching between rubbery and glassy phases depending on temperature. This work focuses on a UV-curable SMP suitable for 3D printing via Digital Light Processing (DLP). Given the wide range of process parameters that influence mechanical performance—such as layer height, layer angle, UV exposure time, and printing temperature—this research seeks to identify optimal combinations that maximize structural strength. To evaluate mechanical performance, we perform three-point bending tests on pre-cracked specimens and capture force-displacement data during crack propagation. These tests are complemented by high-speed imaging using a Phantom Miro M110 camera at 20,000 frames per second. The footage is processed with Digital Image Correlation (DIC) software (MatchID), which tracks deformation by analyzing surface speckle patterns and computing full-field strain maps during failure. The combined force and DIC data enable J-integral analysis, which quantifies the strain energy release rate near the crack tip and serves as a metric for material toughness. Preliminary results indicate that 3D printing parameters have a significant influence on the critical J-integral values of the SMP, underscoring the importance of optimized processing in achieving high-strength prints. To efficiently explore the high-dimensional parameter space, we will employ Bayesian Active Learning for iterative experimental design. Rather than exhaustively testing all combinations, this approach leverages a probabilistic model trained on an initial set of experiments to guide the selection of new parameter combinations. With each iteration, the model updates its predictions and uncertainty estimates, gradually converging toward the optimal printing configuration.

[P11] Artificial Intelligence–Based Automated Neural Cell Phenotype Identification

S. M. Abid Anam Shovon[1], Jessica Park[2], Jing Zhang[2], Christian Franck[2], Kshitiz Upadhyay[1]

[1] Department of Mechanical and Industrial Engineering, Louisiana State University
[2] Department of Mechanical Engineering, University of Wisconsin-Madison

Abstract
Introduction: Traumatic Brain Injury (TBI) is commonly linked to mechanical trauma, but Directed Energy (DE) exposure can also cause cellular-level injury. Unlike blunt impacts, DE induces localized stress-strain responses in individual brain cells. However, quantifying these mechanical effects is challenging due to the brain's structural complexity and the limitations of traditional imaging, which often relies on labor-intensive immunostaining. This study presents a high-throughput framework for automated cell identification from 2D confocal micrographs, enabling not only phenotype classification but also the foundation for mechanical analysis—such as measuring deformation gradients and shape changes of individual cells under applied stress. The goal is to bridge cell classification and biomechanics to study neural tissue response at the cellular level. Materials and Methods: The framework includes five stages: imaging, preprocessing, extraction, augmentation, and classification. Cortical cells are cultured in a collagen matrix and stained with Calcein-AM (general), NeuO (neurons), and GFAP (astrocytes). High-resolution confocal images (1024×1024, 20 µm z-stack) are denoised and enhanced using Gaussian blurring, median filtering, thresholding, binarization, and edge detection. An unsupervised tracing algorithm extracts cells based on intensity gradients, recording their shape, centroid, and spatial properties—key parameters for later mechanical tracking. To enhance classification, the data is augmented via rotations and transpositions. Extracted cells are resized and reduced in complexity using multidimensional scaling, preserving 90% of information. A Gaussian Process Classifier (GPC) with a Radial Basis Function (RBF) kernel is trained on 80% of the data (with k-fold cross-validation) and tested on the remaining 20%, simulating Calcein-AM-only inputs. Results: The dataset included 312 astrocytes and 288 neurons, augmented to 1248 and 1152, respectively. Cross-validation accuracy ranged from 0.936 to 0.975; test accuracy ranged from 0.928 to 0.953, confirming the effectiveness of augmentation. Conclusion: This framework enables accurate cell phenotype identification and retains spatial geometry for each cell, allowing future analysis of stress-induced changes such as deformation gradients. This lays the groundwork for integrating image-based classification with cell-level mechanical studies in TBI and DE research.