ME Seminar

Engineered multifunctionality: from metamaterials to bio-hybrid composites

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ABSTRACT

Materials that can sense, respond to, and adapt to their environment need functionality that is designed, not just dictated by their chemical composition. Piezoelectricity is a strong foundation for such functionality. It is a ubiquitous coupling between mechanical and electrical fields that is critical to many natural processes and engineering applications. Yet conventional piezoelectric materials face several limitations. The crystal symmetry of a material fixes the anisotropy of its response, and the most widely used piezoelectrics are brittle, lead-based ceramics that raise toxicity concerns. In this talk, I will present my research addressing these challenges. First, I will discuss my work on designing and 3D-printing piezoelectric truss metamaterials with customizable anisotropic responses. Generative machine learning is used to optimize truss topology and geometry to achieve target piezoelectric properties, while a newly developed in-gel 3D printing method fabricates polymer-ceramic structures from a photo-curable resin and lead-free piezoelectric particles. Second, I will present my ongoing work on bio-hybrid piezoelectric composites. This approach brings piezoelectric function into biological materials and opens pathways toward sustainable, bio-based transducers. Together, these efforts lay the groundwork for a new generation of multifunctional, animate materials that combine engineered and biological components. I will conclude with future directions, including miniaturization, computational design, and scalable fabrication.

ABOUT THE SPEAKER

Dr. Saurav Sharma is a postdoctoral researcher in the Faculty of Aerospace Engineering at Delft University of Technology (TU Delft). He has held an Alexander von Humboldt Fellowship at the Institute of Structural Mechanics, Bauhaus University Weimar, and a Marie Skłodowska-Curie Postdoctoral Fellowship at TU Delft. He received his Ph.D. in Mechanical Engineering from the Indian Institute of Technology Mandi in 2021.

His research combines computational mechanics, machine learning, and additive manufacturing to design multifunctional materials, from architected metamaterials to bio-hybrid composites. For his Ph.D., he developed isogeometric frameworks for flexoelectricity in composites and micro-architected solids. More recently, his work introduced a generative machine learning framework for the inverse design of piezoelectric truss metamaterials, together with an in-gel 3D printing process to fabricate them (npj Metamaterials, 2025). His current work brings piezoelectric function into biological materials through bio-hybrid composites.

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