

Midwest Mechanics Seminar



Laboratory X-Ray Measurements in Solid Mechanics: Any New Insights?

Dr. Vikram Deshpande
Department of Engineering
University of Cambridge
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Abstract: A range of laboratory-based X-ray techniques ranging from energy dispersive X-ray diffraction to measure elastic strains in metals, high speed tomography of the dynamic deformation of architected solids to 3D deformation fields within rubbers will be discussed. Do these novel measurements provide any new insights into the mechanics of these materials? One example will be discussed in detail. From Hooke's law in the 1660s to the 1930s work of Flory on polymer chains, the understanding of rubber elasticity was formalised via the Neo-Hookean model. This established the idea that, under isothermal conditions, stress is (non)linearly related to strain and no other state variable. Using innovative X-ray measurements capturing the three-dimensional spatial volumetric strain fields, we demonstrate that this idea may need to be revisited. We show that rubbers and indeed many common engineering polymers, undergo significant local volume changes. But remarkably the overall specimen volume remains constant regardless of the imposed loading. This strange behaviour, which also leads to apparent negative local bulk moduli, is due to the presence of a mobile phase within these materials. Using a combination of these tomographic observations and high-speed radiography to track the motion of the mobile phase we present a revision of the classical thermodynamic frameworks of rubber elasticity.

Bio: Vikram Deshpande is a professor of Materials Engineering at the University of Cambridge. He has also served on the faculties at the University of California, Santa Barbara and at the Technical University of Eindhoven. With his students and collaborators, he has worked primarily in experimental and theoretical solid mechanics and currently serves as the editor-in-chief of the Journal of the Mechanics and Physics of Solids (JMPS). His recognitions include the 2020 Rodney Hill Prize in Solid Mechanics, the 2022 Prager Medal, the 2022 ASME Koiter medal and the 2024 Bazant medal ASCE. He has been elected Fellow of the Royal Society, London, the UK Royal Academy of Engineering, and an International Member of the US National Academy of Engineering (NAE).