

# Midwest Mechanics Seminar

## A Reassessment of Rubber Elasticity Via Full-Field X-Ray Measurements

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Monday, October 7th, 2024  
4:00 PM to 5:00 PM  
4231 LEC GM Conference Room  
Reception to Follow with Light Refreshments

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**Abstract:**

Engineering polymers, including rubbers, find extensive applications across diverse industries, from aerospace to medicine. From Hooke's law in the 1660s to the 1930s and 1940s work of Flory on polymer chains (1974 Nobel prize), the understanding of rubber elasticity was formalised in the 1940s 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. Here, we suggest that this fundamental concept might need to be revisited. Using innovative X-ray measurements capturing the three-dimensional spatial volumetric strain fields, we demonstrate 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 X-ray tomographic observations and high-speed radiography to track the motion of the mobile phase we have revised classical thermodynamic frameworks of rubber elasticity.

**References:**

Z. Wang, S. Das. A. Joshi, A.J.D. Shaikeea and V.S. Deshpande (2024), 3D observations provide striking findings in rubber elasticity, *Proceedings of the National Academy of Sciences*, 121 (24), e2404205121.

**Commentary:**

C. Hartquist, S. Wang and X. Zhao (2024), Local volume changes in deformed elastomers with mobile chains, *Proceedings of the National Academy of Sciences*, 121 (30), e2410811121.

**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. 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).