ME Seminar

Shock-driven Pore Collapse in PMMA: Deformation, Failure, and Interaction

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ABSTRACT

Porous materials are important in engineering applications, from structural components to energetic systems. Their porosity spans scales from microns to millimeters and arises in additive manufacturing defects, engineered foams, and architected metamaterials. Under shock compression, pores collapse rapidly, causing intense localized deformation and potential spall failure. Traditional experimental methods offer limited insight, relying on continuum measurements and post-mortem analysis. This study introduces a novel technique for internal, full-field strain measurements during shock loading of transparent materials, applied to PMMA with shock stresses from 0.4 to 1.0 GPa. Using a normal plate impact setup, targets with single or interacting pores are embedded with internal speckle patterns for digital image correlation (DIC). High-speed imaging captures pore collapse geometry, while DIC provides time-resolved strain fields. A critical stress threshold is identified where adiabatic shear bands (ASBs) initiate, marking the first in-situ observation of ASB formation during pore collapse. At higher stresses, ASBs evolve into dominant shear bands, leading to dynamic shear fracture. Experiments also explore interactions between pores and their influence on collapse and failure. Elasticity theory and finite element simulations help interpret the observed behavior, offering deeper insight into the physics of pore collapse under extreme conditions.

ABOUT THE SPEAKER

Guruswami (Ravi) Ravichandran is the John E. Goode, Jr. Professor of Aerospace and Mechanical Engineering at Caltech. He previously served as Otis Booth Leadership Chair of the Division of Engineering and Applied Science (2015–2021) and Director of GALCIT (2009–2015). He earned his B.E. in Mechanical Engineering from the University of Madras (Regional Engineering College, Trichy) and his Sc.M. and Ph.D. in Solid Mechanics and Structures from Brown University. He is an elected member of the U.S. National Academy of Engineering, a foreign fellow of the Indian National Academy of Engineering and Academia Europaea, and a Chevalier of the Palmes Académiques (France). He is a Fellow of ASME, SEM, AAM, and InSIS. His honors include the Timoshenko Medal (ASME), Eringen Medal (SES), and Murray Award (SEM). His research spans mechanics of materials, shock wave physics, active materials, biomaterials, cell mechanics, and experimental methods.

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