ME Seminar

Microballistics: Dynamic Creation of Nanostructures in Metals to Engineering Energy Dissipation in Nanostructured Materials

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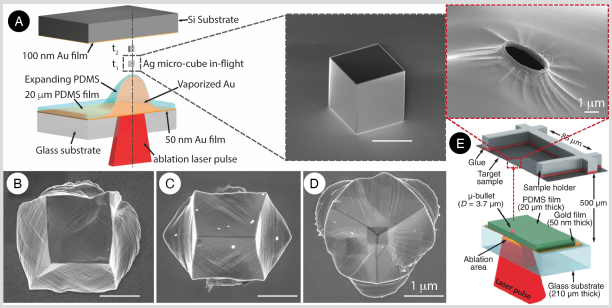
ABSTRACT

Impact and shock compression have long been used to modify the mechanical properties of metals, for example, in shot peening and laser shock peening processes. We demonstrate using defect-free single-crystal silver microcubes as a model system and by using an advanced laser-induced projectile impact testing (LIPIT) technique that an extreme gradient-nano-grained structure with favorable martensitic phase transformation can be created in metals via high-velocity (400 m/s) impacts [1, 2]. The gradient-nano-grained structure with favorable phase transformations show promising pathways to developing ultra-strong metals that are also tough enough to resist failure. Creating lightweight materials with superior specific properties is critical for protective applications in extreme environments. Using LIPIT, we study the distinct deformation mechanisms that emerge in polymer thin films when they are subjected to high velocity (100 m/s to 1 km/s) microprojectile impacts. We demonstrate that polymers exhibit superior specific energy dissipation characteristics when their thickness is reduced to nanoscale because of the geometric-confinement-induced morphological changes [3, 4]. Understanding the fundamental dynamic deformation mechanisms in nanostructured materials will enable the development of next generation protective systems.



[1] R. Thevamaran et al. Dynamic creation and evolution of gradient nanostructure in single-crystal metallic microcubes. *Science*, 354(6310):312–316, 2016.

[2] R. Thevamaran et al. Dynamic martensitic phase transformation in single-crystal silver microcubes. *Acta Materialia*, 182:131–143, 2020.

[3] J. Cai and R. Thevamaran. Superior energy dissipation by ultrathin semicrystalline polymer films under supersonic microprojectile impacts. *Nano Letters*, 2020.

[4] J. Hyon et al. Extreme energy absorption in glassy polymer thin films by supersonic micro-projectile impact. *Materials Today*, 21(8):817–824, 2018.

ABOUT THE SPEAKER

Prof. Ramathasan Thevamaran obtained his B. Sc. Eng. (Hons.) in Civil Engineering from the University of Peradeniya (Sri Lanka) in 2008, and his M.S. and Ph.D. in Mechanical Engineering from the California Institute of Technology (USA) in 2010 and 2015. Before joining the University of Wisconsin-Madison (USA) as an Assistant Professor in 2017, he has been a Postdoctoral Research Associate at the Department of Materials Science and NanoEngineering of the Rice University (USA). His research interests are in the structure-property relations of structured materials such as carbon nanotube foams, gradient-nano-grained metals, polymer nanocomposites, and non-Hermitian metamaterials.

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