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The CIVE 6111 Graduate Seminar Series

Growing Pains: Ductile Damage Evolution in Layered Materials

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Abstract

Ductile failure is a multi-scale phenomenon. In metals, atomic deformation mechanisms interact with micromechanical length-scales defined by the size and distribution of microscopic defects to trigger damage through void nucleation and growth. Coarser length-scales appear with inter-void interactions that coalesce to form mesoscopic damage zones. Finally, the interaction of damage zones with component scale causes macroscopic failure. Coupling between these scales is complicated by the anisotropic nature of plasticity, which is governed by dislocation slip and twinning. The latter are special type of defects that result in a multilayered motif at the grain scale of a polycrystalline metal. Interesting exemplars of this kind are nanotwinned materials whose microstructures are engineered to host copious number of nanoscale twins. These nanoscale twins often play a dual role as agents of material yield strengthening (by acting as barriers to dislocation motion) and softening (via twin boundary migration). Our ongoing focus is on understanding the interaction between these plasticity mechanisms and voids in such layered engineered materials.

We present the deformation stability and failure of nanotwinned materials whose grain-scale anisotropy is brought about by size-effects associated with fine-scale growth twins**.** Using a length-scale dependent crystal plasticity finite element framework, we investigate the role of twin boundary mediated microstructural evolution in the damage due to nano-void evolution. The interaction between the rates of twin boundary migration and void growth is discussed from the vantage point of macroscopic deformation stability. While the investigation pertains to nanotwinned materials, the observations and analysis may be relevant to analogous situations in multi-layered materials with moving interfaces.

Bio

Shailendra Joshi is Bill D. Cook Assistant Professor in the Department of Mechanical Engineering at University of Houston (UH). Prior to joining UH, he was an associate professor at the National University of Singapore (2008-2018). During 2005-2008, he was a post-doctoral fellow in the Department of Mechanical Engineering at Johns Hopkins University. He earned his PhD in Civil Engineering from Indian Institute of Technology Bombay in 2002. After a short stint as a visiting scientist at the University of Stuttgart (2002), he worked as a research engineer at GE-India Technology Center in Bangalore, India (2003-2005). His research interest is in understanding, modeling and controlling material responses through the mechanics of defects and failure processes at multiple length-scales and time-scales. He is an avid amateur squash player.