ME PhD Thesis Colloquium

MECHANICAL ENGINEERING
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Numerical Studies on Plastic Deformation, Notch Sensitivity and Fracture Behavior of Bulk Metallic Glasses and Composites

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Meeting link: Click here to join meeting **(Microsoft Teams)**

ABSTRACT

Bulk metallic glasses (BMGs) exhibit attractive properties such as high strength and resilience. However, they display negligible tensile ductility due to catastrophic crack propagation inside a dominant shear band (SB). By contrast, nano-scale metallic glass samples show pronounced plastic deformation and necking, which can be further influenced by the presence of notches. An important approach to enhance the ductility and toughness is to employ in-situ BMG composites (BMGCs) consisting of soft crystalline dendrites embedded in a BMG matrix. Experiments and MD simulations show that spatial distribution, volume fraction and mechanical properties of the dendrites can affect the deformation and fracture response of BMGCs. However, SB development, plastic deformation and failure mechanisms in BMGCs and notched nano-scale BMG specimens under tensile loading are not well understood.

In this thesis, plastic deformation response of nano-scale double edge notched (DEN) BMG specimens under plane strain tension is first studied using a combination of finite element (FE) and molecular dynamics (MD) simulations. A non-local plasticity theory for BMGs is employed in the FE analyses, while CuZr BMGs with different compositions are modeled in the MD simulations. The effects of notch acuity and BMG composition on plastic flow development and possible failure mechanisms are examined. Both simulations show similar, multiple transitions in deformation behavior. In order to gain insights on tensile response of in-situ BMGCs, FE analyses are carried out using the above mentioned constitutive model to represent the BMG matrix and von Mises plasticity theory to characterize the dendrites. It is found that closely spaced elongated dendrites along loading direction cause profuse and more homogeneous plastic flow. The sensitivity of tensile behavior of BMGCs to the presence of notches is investigated by plane strain FE and MD simulations of DEN specimens. Both the analyses show that the ratio of the notch root radius to its distance from the nearest dendrite controls the behavior of the BMGC specimens. Finally, FE analyses of Mode I loading of stationary cracks in in-situ BMGCs are performed under plane strain, small scale yielding (SSY) conditions. Here, the BMGC is modeled by using a homogenized plasticity theory everywhere as well as by a multi-scale approach in which discrete dendrites are simulated in the fracture process zone near the tip, while the background region is represented by the homogenized theory. The predicted trend of the fracture toughness versus volume fraction of dendrites corroborates well with experiments.

ABOUT THE SPEAKER

Tanmay Dutta is a PhD student enrolled in the Dept. of Mechanical Engineering, IISc Bangalore. He has a Bachelor's and a Master's degree in Mechanical Engineering from Jadavpur University. His research interests include, numerical analysis of plasticity and fracture of bulk metallic glasses and composites.