Fracture in amorphous alloys

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Abstract:

The mechanical properties of amorphous alloys have proven both scientifically unique and of potential practical interest, although the underlying deformation and fracture physics in them remain less firmly established as compared with crystalline alloys. In this presentation, I shall review the recent advances we made in understanding the fracture behaviour of metallic glasses. In crystalline metals and alloys, the term 'ductile' is synonymous with 'tough,' as they both are linearly correlated. However, the non-existence of such correlation in metallic glasses poses a conundrum. For example, bulk metallic glasses (BMGs) with no tensile ductility whatsoever can exhibit extraordinarily high fracture initiation toughness values. "What is the physical reason for such high toughness?" is a question that we set out to answer. A related issue is the following: A material physics-based condition, at which fracture will initiate, is essential for reliable design of components and structures. Fracture criteria for brittle materials like ceramics are stress based whereas those in ductile materials like metals and alloys are strain based. But, both need the identification of a critical length scale, l*, which is related to some microstructural length scale, to be prescribed *apriori*. A suitable fracture criterion is needed to identify l* at which plastic to brittle transition takes place. Mixed-mode fracture experiments coupled with detailed finite element simulations are conducted identify the fracture criterion in a nominally ductile BMG. These results show that fracture in amorphous alloys is controlled by the attainment of a critical strain and that a stable crack grows inside a shear band at the notch root before attaining criticality at $l^* \approx 60$ μm. The Argon and Salama model, which is based on meniscus instability phenomenon at the notch root, has been modified to rationalize the physics behind this length scale. This model suggests that the mean ridge heights on fractured surfaces were found be correlated to the toughness of the BMG. In contrast, the fracture mechanism in brittle metallic glasses is elusive. Some interesting morphologies observed on brittle fracture surfaces will be presented.