MECHANICAL BEHAVIOR OF BULK METALLIC GLASSES

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In recent years, certain amorphous metallic alloys which can be solidified in relatively large section sizes under moderate cooling rates have been developed. Such disordered metals are referred to as *bulk metallic glasses*.

When a metallic glass is deformed at ambient temperatures, well below its glass transition temperature, its inelastic deformation is characterized by strain-softening which results in the formation of intense localized shear bands; fracture typically occurs after very small inelastic strain in tension, but substantial inelastic strain levels can be achieved under states of confined compression, such as in indentation experiments. The micro-mechanisms of inelastic deformation in bulk metallic glasses are not related to dislocation-based mechanisms that characterize the plastic deformation of crystalline metals. The plastic deformation of amorphous metallic glasses is fundamentally different from that in crystalline solids because of the lack of long-range order in the atomic structure of these materials. Computer simulations in the literature show that at a micromechanical level, inelastic deformation in metallic glasses occurs by local shearing of clusters of atoms ($\approx$ 30 to 50 atoms), this shearing is accompanied by inelastic *dilatation* that produces strain-softening, which then leads to the formation of shear bands. An important consequence of the micro-mechanism of inelastic deformation in amorphous metals is that at the macroscopic level, experimentally-determined yield criteria for inelastic deformation are found not to obey the classical pressure-insensitive forms, but show a significant pressure sensitivity of plastic flow, which may be approximated by the Coulomb-Mohr yield criterion.

In this talk I will present a complete three-dimensional constitutive model for the elastic-viscoplastic response of pressure-sensitive and plastically-dilatant isotropic materials. The flow-rule in this model is a generalization of a two-dimensional (plane-strain) “double-shearing” constitutive model (used in soil mechanics) to three-dimensions. The constitutive model has been implemented in a finite element program, and the numerical capability is used to study the deformation response of amorphous metallic glasses. Specifically, the response of an amorphous metallic glass in tension, compression, strip-bending, and indentation is studied, and it is shown that results from the numerical simulations qualitatively capture major features of corresponding results from physical experiments available in the literature.