Size Effects on Strength and Plasticity of Metallic Glasses

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ABSTRACT

The effects of changes in size scale on the strength and plasticity of metallic glasses are considered in this work. Metallic glassy ribbons, with thicknesses in the range 20-80 µm, were tested in tension. By testing samples of these sizes, several characteristic phenomena are observed: bending plasticity, plastic zone size, critical shear offset, and shear band embryos. Samples with an effective thickness (smallest dimension) larger than plastic zone size exhibit compressive plasticity but are brittle in bending and tension. Bending plasticity is significantly enhanced when the effective thickness decreases below the plastic zone size. Shear bands become further stabilized when the sample size becomes comparable to the critical shear offset. Below the shear band embryo size, shear band initiation may be completely suppressed, as the deformation made changes from shear localization to homogeneous deformation. This poster summarizes work investigating the effects of changes in size scale on the strength and plasticity of these systems.

INTRODUCTION

Metallic glasses are of interest for structural applications because their strength can be higher than any reported bulk alloys. Plasticity of bulk metallic glasses is shear band mediated, rather than dislocation mediated as in conventional crystalline alloys. Initiation of shear bands in metallic glasses requires more energy than initiation of dislocation slipping in conventional metals or alloys. Therefore, metallic glasses have much higher strength than conventional alloys. Plastic deformation of metallic glasses is localized into shear bands with nanoscale thickness. The viscosity of shear bands is only on the order of 1000 Pa⋅s during shear sliding. These weak bands are preferential sites for crack opening that lead to catastrophic fracture without obvious tensile ductility.

MATERIALS & METHODS

• Metallic glassy ribbons were prepared by arc melting and melt spinning methods.
• Two chemistries of ribbons were tested: Al87Gd6Ni7 and Al87Gd6Ni6Fe1.

RESULTS: METALLIC GLASS RIBBONS

• Metallic glass ribbons were polished to an hourglass shape. Tension testing was performed on Instron 1130.
• Fracture behavior of nanowires

RESULTS: METALLIC GLASS NANOWIRES

• Tensile testing future of metallic glassy nanowires
• Shear offset across entire fracture surface of metallic glassy nanowires indicates stabilization of shear bands
• Size reduction of metallic glasses results in graceful failure

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REFERENCES


CONCLUSIONS

• Size reduction of metallic glasses results in graceful failure
• Viscoplastic deformation at fracture surface of nanoscale metallic glasses
• Shear offset across entire fracture surface of metallic glassy nanowires indicates stabilization of shear bands

METALLIC GLASS RIBBONS

Al87Gd6Ni7

Tensile testingfuture of metallic glassy nanowires

No flaws present

Cavity present

Alternation of slip planes

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