Permanent deformation of amorphous alloys : Energy absorption view point study

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Experiments in binary alloys demonstrate that metallic glasses exhibiting a larger amount of permanent deformation during homogeneous deformation tend to show lower global plasticity during inhomogeneous deformation. Testing of Cu-Zr binary alloys supports the hypothesis that the microstructural aspects related to the atomic packing density of the alloys that control the global plasticity of metallic glasses in the light of difference in the structural disordering, softening, shear localization and energy absorption during homogeneous deformation. A structural parameter, normalized relaxation heat, which allows the prediction of the global plasticity of bulk amorphous alloys is introduced.

To investigate the sole effect exerted by the packing density of amorphous alloys on their homogeneous deformation and subsequent inhomogeneous deformation, we selected $Cu_{50}Zr_{50}$ as the model alloy. Of various bulk forming Cu-Zr binary alloys, it exhibits the largest plastic strain prior to failure. More importantly, $Cu_{50}Zr_{50}$ has the lowest packing density (or equivalently the largest free volume) in its as-cast condition. Such alloy characteristics enable the systematic control of the relative packing density in a quantitative manner by simply annealing the alloy below the glass transition temperature, T_g, for varying time.

We explore the sole effect exerted by the packing density of an amorphous alloy on its homogeneous deformation and subsequent inhomogeneous deformation. The experiments demonstrated that an alloy with higher packing exhibits higher degree of homogeneous deformation, whereas the same alloy exhibits lower global plasticity associated with inhomogeneous deformation in a typical compression test. We clarify this paradoxical relationship between the homogeneous and inhomogeneous deformation by exploring the relationship between the homogeneous flow rate and its effect on shear localization.

Keyword : amorphous alloy, annealing below Tg, shear softening, atomic packing density, plasticity, energy absorption