Abstract

Two types of stress-strain behavior have been observed during tensile deformation of Cu-Zr based melt-spun ribbons at room temperature and at strain rates varying between 10^{-3} s^{-1} and 10^{-5} s^{-1}. In one case (Type-I) the stress continuously rises, with gradual and insignificant decrease in the slope ($d\sigma/d\varepsilon$), until the specimen fractures. In other words distinct regions of elastic and plastic deformation are not apparent. Type-II behavior is characterized by a drastic and significant decrease in $d\sigma/d\varepsilon$, exhibiting distinct regime of plastic deformation. In case of Type-II the total strain or ductility is higher. The variation in the stress-strain behavior with strain rate is unexpected. This unexpected trend has been explained in terms of nano-crystallization. Addition of Al reduces the flow stress and enhances the tensile ductility of Cu-Zr ribbon.

Molecular dynamics simulations (MD) have been carried out for wide range of strain rates and states of stress. The atomic path is diffusive and random for all strain rates and states of stress. The diffusive path is characterized by the ratio of net displacement to the total distance travelled by the atoms (R) which increases with strain rate. The movement of atoms in the shear transformation zone (STZ) is diffusive and STZs translate as well as exchange atoms during the plastic deformation. MD simulations further suggest that shear banding is not occurring in the length scale of 10 nm and segregation of free volumes do not contribute to shear bands. Rather they occur by flow softening due to adiabatic heating during the intense plastic deformation accompanying crack propagation. The MD simulations also suggest that the presence of nano-crystals impede the plastic flow in glass matrix.

Keywords: Metallic glasses, Molecular dynamics, Strain rate, Nano-crystals