Atomic mobility inside shear bands and the impact on tracer diffusion, nanocrystal nucleation and growth

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Abstract

Deformation in glasses proceeds differently than in crystalline materials due to the absence of defined lattice planes and due to the absence of line defects with discrete Burgers vectors. Experiments have shown that deformation exceeding the elastic range is mostly localized in plate-like mesoscopic defects, so-called shear bands. Although the occurrence of shear bands during plastic deformation of metallic glasses is well known, their actual physical properties remain fairly unknown. Here, experimental data on the rate of atomic diffusion within shear bands has been obtained using the radiotracer method on post-deformed specimens. The experimental results indicate unambiguously that the diffusivity is largely enhanced as compared to volume diffusion in metallic glasses.

Moreover, nanocrystal formation has been observed in metallic glasses during different deformation processes. This finding has generated great interest as well as controversial discussions concerning the underlying mechanism. Here, different deformation methods with largely different strain and pressure levels have been applied on metallic glasses to investigate the deformation-induced nanocrystallization reaction with the strain as a metric for the transformation. The experimental results are discussed with respect to the underlying mechanism, utilizing also the first experimentally determined values of the diffusivity within a shear band.