Solid solution “softening” in copper-aluminum alloys

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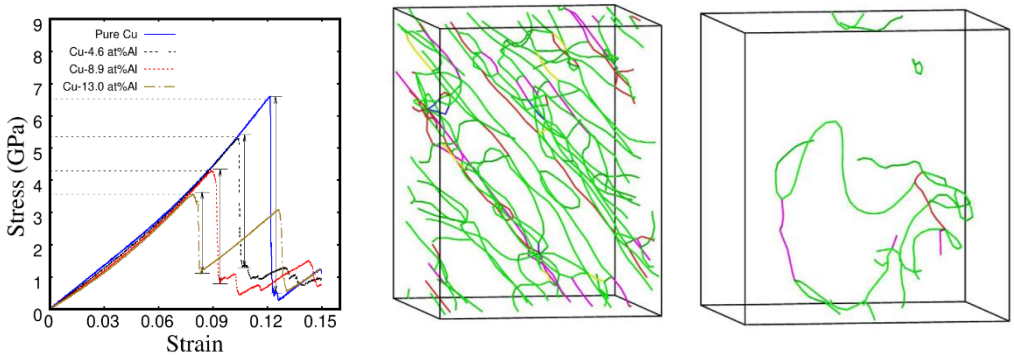
Abstract

Solid solution strengthening is well known in materials science – referring to the increase in strength with the addition of solute. However, this model of strengthening is based on barriers to the movement of existing dislocations. In this study, using Molecular Dynamics (MD) simulations, we show anomalous softening in the dislocation starved regime in Cu–Al alloys deformed at 300 K. There are two reasons for this: (i) heterogeneous nucleation at solute sites, (ii) homogeneous nucleation of partial dislocation loops, which becomes easier as SFE decreases with the addition of Al. We further carry out thermodynamic integration to calculate the SFE as a function of Al at 300 K. Using these SFE values in a continuum model of homogeneous nucleation of partial dislocation loops, and incorporating a reduction in heterogeneous nucleation barrier, we can explain the drop in yield strength in Cu–Al alloys. Thus, our results indicate that deformation experiments of pure copper and copper–aluminium alloys in the dislocation starved regime could show qualitatively and quantitatively different behaviour.



Stress strain curves and dislocation microstructure for Cu and Cu-13 at% Al

Keywords: *Cu and Cu-Al alloys, softening, nucleation limited plasticity*