Zhang, F., Bower, A., Mishra R., and Boyle, K., Numerical simulations of necking during tensile deformation of aluminum single crystals, International Journal of Plasticity, 25, no. 1, 2009, pp. 49–69

Abstract

Finite element simulations are used to study strain localization during uniaxial tensile straining of a single crystal with properties representative of pure Al. The crystal is modeled using a constitutive equation incorporating self- and latent-hardening. The simulations are used to investigate the influence of the initial orientation of the loading axis relative to the crystal, as well as the hardening and strain rate sensitivity of the crystal on the strain to localization. We find that (i) the specimen fails by diffuse necking for strain rate exponents $m < 100$, and a sharp neck for $m > 100$. (ii) The strain to localization is a decreasing function of m for $m < 100$, and is relatively insensitive to m for $m > 100$. (iii) The strain to localization is a minimum when the tensile axis is close to (but not exactly parallel to) a high symmetry direction such as [1 0 0] or [1 1 1] and the variation of the strain to localization with orientation is highly sensitive to the strain rate exponent and latent-hardening behavior of the crystal. This behavior can be explained in terms of changes in the active slip systems as the initial orientation of the crystal is varied.

Keywords

Localization, Crystal plasticity, Finite element