Interacting Effects of Strengthening and Twin Boundary Migration in Nanotwinned Materials

Kartikey Joshi, Shailendra P. Joshi

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Interacting Effects of Strengthening and Twin Boundary Migration in Nanotwinned Materials

Kartikey Joshi and Shailendra P. Joshi *
Department of Mechanical Engineering, National University of Singapore, Singapore 117576

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Abstract

Twin boundaries play a governing role in the mechanical characteristics of nanotwinned materials. They act as yield strengthening agents by offering resistance to non-coplanar dislocation slip. Twin boundary migration may cause yield softening while also enhancing the strain hardening response. In this work, we investigate the interaction between strengthening and twin boundary migration mechanisms by developing a length-scale dependent crystal plasticity framework for face-centered-cubic nanotwinned materials. The crystal plasticity model incorporates strengthening mechanisms due to dislocation pile-up via slip and slip-rate gradients and twin boundary migration via source-based twin partial nucleation and lattice dislocation-twin boundary interaction. The coupled effect of the load orientation and initial twin size on the speed of twin boundary is discussed and an expression for the same is proposed in terms of the relevant material parameters. The efficacy of finite element simulations and the analytical expression in predicting evolution of nanotwinned microstructures comprising size and spatial distributions of twins is demonstrated.

Keywords: Nanotwinned materials; Size effects; Twin boundary migration; Interaction effect; Crystal plasticity

*Corresponding author: shailendra@nus.edu.sg