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A dislocation dynamics model of the plastic flow of fcc polycrystals

ABIGAIL HUNTER, Los Alamos National Laboratory

Describing material strength at very high strain rates is a key component for investigating and predicting material deformation and failure under shock loading. However, accurately describing deformation physics in this strain rate regime remains a challenge due to the break down of fundamental assumptions that apply to material strength at low strain rates. We present a dislocation dynamics model of the plastic flow of fcc polycrystals from quasi-static to very high strain rates (10^6 s^{-1} and above), pressures from ambient to 1000 GPa, and temperatures from zero to melt. The model is comprised of three coupled ordinary differential equations: a kinetic equation, which relates the strain rate to the stress, mobile and immobile dislocation densities, mass density, and temperature using a mean first passage time (MFPT) framework, and two equations describing the evolution of the mobile and immobile (network, forest) dislocation densities.