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A 3-D Dislocation Dynamics Model for Polycrystal Plasticity

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A 3-dimensional dislocation dynamics (DD) model for simulating the plasticity in polycrystals is developed. By the application of a version of superposition principle and a homogenization theory, the DD model can accurately account for the elastic anisotropy of crystal grains, and can derive the macroscopic stress-strain behavior of polycrystals from the microscopic dislocation dynamics. In order to show the potential of the DD model for the simulation of polycrystal plasticity, the DD model is applied to the simulation of plastic deformation of copper polycrystal with various crystal grain diameters. In the numerical results, complex dislocation interactions can be found, and the stress-strain behavior strongly depends on the crystal grain diameter, which is consistent with the Hall-Petch relationship. Therefore, the DD model can be a promising candidate as a numerical investigation tool for the size effect in the polycrystal plasticity.

Keywords: Parametric dislocation dynamics, Superposition, Homogenization theory, Polycrystal plasticity