Finite-strain crystal plasticity-phase field modeling of twin, dislocation and grain boundary interactions

Chuanlai Liu[a], Franz Roters[a], Dierk Raabe[a]

[a] Max-Planck-Institut für Eisenforschung GmbH, Max-Planck-Str. 1, Düsseldorf 40237, Germany

[a]c.liu@mpie.de

The nucleation, propagation, and growth of deformation twins and their interaction with dislocations, and grain boundaries in typical hexagonal engineering materials, such as Mg and Ti, has an important influence on the materials' mechanical properties. The development of a microstructure-sensitive and spatially resolved constitutive model for these plastic deformation mechanisms is the key to the design of high-strength, ductile, and light-weight alloys. In this work, we will present an integrated mechanical formulation within the finite strain framework for modeling the concurrent dislocation slip-induced plasticity and heterogeneous twinning behaviour in hexagonal materials [1-3]. A dislocation density-based crystal plasticity model is employed to describe the dislocation activities and spatial distribution of stress and strain. This model is coupled with a multi-phase-field model using non-conserved structure variables to predict the nucleation, propagation, and growth of deformation twins. The model developed has been employed to explore the complex twinning-detwinning behaviour, twin-twin, twin-slip, and twin-grain boundary interactions in Mg single crystal and polycrystals during large monotonic and cyclic plastic deformation.

Keywords: Deformation twinning; Grain neighbor effects; Dislocation accommodation; Magnesium alloys; Micromechanical model

References:

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