Accepted Manuscript

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PII: S0022-5096(18)30049-8
DOI: https://doi.org/10.1016/j.jmps.2018.09.020
Reference: MPS 3451

To appear in: *Journal of the Mechanics and Physics of Solids*

Received date: 18 January 2018
Revised date: 14 August 2018
Accepted date: 17 September 2018

Please cite this article as: Edgar Husser, Swantje Bargmann, Modeling twinning-induced lattice reorientation and slip-in-twin deformation, *Journal of the Mechanics and Physics of Solids* (2018), doi: https://doi.org/10.1016/j.jmps.2018.09.020

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Modeling twinning-induced lattice reorientation and slip-in-twin deformation

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Abstract

The deformation behavior of hexagonal close packed (hcp) materials involves dislocation slip as well as deformation twinning, including a competition between those two. This is due to the limited number of easy to activate slip modes. We present a model that captures dislocation slip, dislocation interaction, size-dependent hardening and deformation twinning. It also accounts for the sudden change of the crystal lattice orientation at the very final stage of the twinning shear process which allows to describe dislocation glide deformation within a twinned region. Along with this, the model further considers the change in the elastic properties associated with the new lattice orientation. Finite element results are presented for the specific example of magnesium (Mg) and for different characteristic loading conditions in order to mimic local stress distributions as they occur in different regions within a single crystal or grain, e.g., close to a boundary and far off. In addition, the impact of twinning on the mechanical response of Mg single crystal during microcompression is investigated. We show that the suggested model is well capable of predicting the complex microstructural deformation behavior in Mg and compare our numerical results to experimental data.

Keywords:
twinning, gradient crystal plasticity, hcp, magnesium, single crystal

1. Introduction

Magnesium (Mg) has attracted considerable attention in the early past due to its enormous potential for weight reduction within a wide range of

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