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A Gibbs-potential-based framework for ideal plasticity of crystalline solids treated as a material flow through an adjustable crystal lattice space and its application to three-dimensional micropillar compression

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Abstract

We propose an Eulerian thermodynamically compatible model for ideal plasticity of crystalline solids treated as a material flow through an adjustable crystal lattice space. The model is based on the additive splitting of the velocity gradient into the crystal lattice part and the plastic part. The approach extends a Gibbs-potential-based formulation developed in [21] for obtaining the response functions for elasto-visco-plastic crystals. The framework makes constitutive assumptions for two scalar functions: the Gibbs potential and the rate of dissipation. The constitutive equations relating the stress to kinematical quantities is then determined using the condition that the rate of dissipation is maximal providing that the relevant constraints are met. The proposed model is applied to three-dimensional micropillar compression, and its features, both on the level of modelling and computer simulations, are discussed and compared to relevant studies.

Keywords: crystal plasticity, Gibbs potential, constitutive behaviour, micropillar compression, finite elements

1. Introduction

Severe plastic deformation experiments [30, 31] reveal that a crystalline material at yield can be seen as an anisotropic, highly viscous fluid. A structural

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