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AN EXTENDED CONTINUUM CRYSTAL PLASTICITY THEORY WITH GEOMETRICALLY NECESSARY DISLOCATION DENSITIES

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In this contribution, a computational approach to modeling size-dependent self- and latent hardening in polycrystals is presented. Latent hardening is the hardening of inactive slip systems due to active slip systems.

We focus attention on the investigation of glide system interaction, latent hardening and excess dislocation development. In particular, latent hardening results in a transition to patchy slip as a first indication and expression of the development of dislocation microstructures. To this end, following Nye, Kondo, and many others, local deformation incompatibility in the material is adopted as a measure of the density of geometrically necessary dislocations. Their development results in additional energy being stored in the material, leading to additional kinematic-like hardening effects. In contrast to conventional crystal plasticity models, this model incorporates size effects and is capable of mapping size-depending macroscopic hardening due to a heterogeneous microstructure. Our model accounts for dislocation densities and allows for the influences of one slip system onto another.

A large-deformation model for latent hardening is introduced following [2]. This approach is based on direct exploitation of the dissipation principle to derive all field relations and (sufficient) forms of the constitutive relations as based on the free energy density and dissipation potential, see also [4]. Consequently, it is established within a thermodynamic setting.

REFERENCES

[1] S. Bargmann, M. Ekh, K. Runesson, B. Svendsen, *Modeling of polycrystals with gradient crystal plasticity a comparison of strategies*, Phil. Magazine 90, 1263-1288, 2010

[2] S. Bargmann, B. Svendsen, M. Ekh, *An extended crystal plasticity model for latent hardening in polycrystals*. Computational Mechanics, 48, 631–645, 2011

[3] M. Ekh, S. Bargmann, M. Grymer, *Influence of grain boundary conditions on modeling of size-dependence in polycrystals*. Acta Mechanica, 218(1-1),103–113, 2011

[4] B. Svendsen, S. Bargmann, *On the continuum thermodynamic rate variational formulation of models for extended crystal plasticity at large deformation*, Journal of the Mechanics and Physics of Solids, 58, 1253–1271, 2010