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Exploring dislocation networks for continuum modeling

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The striving for advanced materials with well-defined microstructures has led to an increasing effort towards a physically based description of the motion of dislocations as the cause of plastic deformation. Several dislocation-based continuum theories have been introduced, but only recently rigorous techniques have been developed for performing meaningful averages over systems of moving, curved dislocations and their interactions, yielding evolution equations based on dislocation density. Regarding a self-consistent coarsening of dislocation microstructures in order to construct an efficient numerical implementation, several issues have to be solved including calculation of the internal stress field of a system of dislocations, dislocation nucleation and interaction, as well as boundary conditions for internal interfaces. The understanding and development of predictive modelling techniques to capture the plastic flow and hardening behaviour of a material in a physically based formulation is a central aspect for the design of new materials and the optimization of microstructures.

In this presentation, we discuss the challenges as well as the potential of a dislocation based continuum theory of plasticity. We present and analyse homogenization techniques to represent the formation and evolution of dislocation microstructures including dislocation interaction and multiplication. The introduced formulations are discussed in the context of work hardening mechanisms in the stage II regime in face-centered cubic crystalline materials. The relevance of an interplay of dislocations between slip systems for dislocation multiplication mechanisms and dislocation reactions leading to work hardening is presented in comparison with discrete dislocation dynamics simulations as well as experimental investigations.

Category

Other

Author: Prof. SCHULZ, Katrin (Karlsruhe Institut für Technologie / Hochschule Karlsruhe)

Presenter: Prof. SCHULZ, Katrin (Karlsruhe Institut für Technologie / Hochschule Karlsruhe)

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