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DISLOCATION-GRAIN-BOUNDARY INTERACTIONS WITHIN A GRADIENT CRYSTAL PLASTICITY THEORY BASED ON A DISCONTINUOUS ACCUMULATED PLASTIC SLIP

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In oligocrystalline materials, dislocation-grain-boundary interactions provide an explanation for a size-dependent mechanical overall behavior. In order to consider this work-hardening behavior, [1] introduced the density of geometrically necessary dislocations (GND) which is assumed to scale proportionally with the amount of plastic slip on each slip system. Taking the gradient of plastic slip on each slip system for the GND modeling into account, however, an additional degree of freedom for each slip system is required. To reduce the degrees of freedom in crystal simulations, [2] proposed a simplified gradient plasticity framework based on the gradient of an accumulated plastic slip. In this work an approach is formulated in order to regain the computational benefit of accumulated field variables within a physically motivated framework based not only on multiplication and annihilation effects of statistically stored dislocations but also on dislocation transport.

In order to model the interactions of dislocations with and their transfer through grain boundaries, a grain boundary yield condition is proposed. This allows to simulate grain boundary behavior in between the limits of full transparency and impenetrability on the continuum scale. As introduced in [3], the grain boundary discretization is based on sharp interfaces by using discontinuous trial functions in the finite element implementation, thereby allowing for a discontinuous distribution of the accumulated plastic slip at grain boundaries.

By three-dimensional finite element simulations of laminate microstructures, the influences of model parameters are investigated for various grain structures and loading conditions. An analytical solution for a one-dimensional single slip supports the numerical results.

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