On modeling micro-structural evolution using a higher order strain gradient continuum theory - DTU Orbit (08/11/2017)

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Published experimental measurements on deformed metal crystals show distinct pattern formation, in which dislocations are arranged in wall and cell structures. The distribution of dislocations is highly non-uniform, which produces discontinuities in the lattice rotations. Modeling the experimentally observed micro-structural behavior, within a framework based on continuous field quantities, poses obvious challenges, since the evolution of dislocation structures is inherently a discrete and discontinuous process. This challenge, in particular, motivates the present study, and the aim is to improve the micro-structural response predicted using strain gradient crystal plasticity within a continuum mechanics framework. One approach to modeling the dislocation structures observed is through a back stress formulation, which can be related directly to the strain gradient energy. The present work offers an investigation of constitutive equations for the back stress based on both considerations of the gradient energy, but also includes results obtained from a purely phenomenological starting point. The influence of model parameters is brought out in a parametric study, and it is demonstrated how a proper treatment of the back stress enables dislocation wall and cell structure type response in the adopted framework.

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