Modeling microstructure development using strain gradient plasticity

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Size-effects in metals have received significant attention in the past decades. The general trend within the plastic deformation regime, that increased resistance is observed for decreasing physical dimensions, has been confirmed for many different micron scale experiments. Strain gradient plasticity models, as well as discrete dislocation models, have been developed that succesfully model this effect in indentation, bending, torsion and many more problems.

Strain gradient plasticity models, being continuum models, tend to predict smooth deformation fields. Experiments, however, show that plastic deformation is associated with the development of complex microstructures. One example of such experiments are recent High-Resolution Electron Back Scatter Diffraction (HR-EBSD) methods that have shown microstructures with cell and wall formation developing due to plastic deformation. Thus, at best, smooth continuum models, may be interpreted as homogenized models of the real mechanics.

In this work we investigate the ablility to model wall formation by using back-stress based strain gradient plasticity models. Both thermodynamically consistent models based on a rigouros free energy functional as well as purely phenomenological methods are discussed.