Abstract Submitted
for the MAR06 Meeting of
The American Physical Society

Mesoscale Theory of Grains and Cells: Crystal Plasticity and Coarsening[1] SURACHATE LIMKUMNERD, JAMES SETHNA, Laboratory of Atomic and Solid State Physics, Cornell University — Line-like topological defects inside metals are called dislocations. At high temperatures, polycrystalline grains form from the melt and coarsen with time: these dislocations can both climb and glide. At low temperatures under shear the dislocations (which allow only glide) form into cell structures. While both the microscopic laws of dislocation motion and the macroscopic laws of coarsening and plastic deformation are well studied, we have had no simple, continuum explanation for the evolution of dislocations into sharp walls. We present here a mesoscale theory of dislocation motion which provides a quantitative description of deformation and rotation, grounded in a microscopic order parameter field exhibiting the topologically conserved quantities. The topological current of the Nye dislocation density tensor is derived from a microscopic theory of glide driven by Peach-Koehler forces between dislocations using a simple closure approximation. The evolution law leads to singularity formation in finite time, both with and without dislocation climb. Implementation of finite difference simulations using the upwind scheme and the results in one and higher dimensions will be discussed.

[1]ITR/ASP ACI0085969 and DMR-0218475

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Date submitted: 29 Nov 2005 Electronic form version 1.4