7.1 Continuum Modeling of Plastic Flow Localization in Irradiated fcc Metals — G. Po and N. M. Ghoniem (University of California, Los Angeles)

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Under mechanical loading, neutron or ion irradiated metals may develop a mechanical instability characterized by the localization of plastic flow in narrow channels that are free of irradiation-induced defects. It is still unclear whether the resulting highly heterogeneous deformation plays a significant role in crack nucleation, fracture propagation and premature failure of structural components used in nuclear applications. Modeling of the phenomenon is an intrinsically multiscale problem since its onset and propagation depend of the interaction between the macroscopic elasto-plastic deformation process and the evolution of the underlying dislocation and defect microstructure. In this work, we develop a two-dimensional continuum model of plastic flow localization based on the continuum theory of dislocations. This framework allows a mechanism-based description of deformation in which plastic distortion is directly calculated from the evolution of dislocation density tensor fields on each slip system. The dislocation densities mutually interact through the self-consistent stress field derived from the deformation gradient and through back and flow stress corrections. The interaction between dislocation fields and irradiation-induced defects (mainly stacking fault tetrahedra (SFTs) in fcc metals) is two-fold. First, the flow stress depends locally on the SFT density. Second, based on existing Molecular Dynamics (MD) simulation results, dislocation fluxes are included as sink terms in the evolution equation of the SFT density. The model is implemented numerically using the Finite Element Method (FEM) and simulation results, showing plastic flow localization under simple loading conditions, are presented.