A MODEL OF CREEP AND GROWTH AT THE MESOSCALE

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We develop a framework to investigate irradiation growth and creep of Zirconium and alloys. Simulations are carried out in finite domains, where the climb motion of discrete dislocations is coupled to a cluster dynamics model including both mobile and immobile irradiation clusters. The model is first formulated in a continuum finite-deformation setting. All governing equations and boundary conditions are obtained from a unified irreversible thermodynamics principle. The resulting model couples a mechanical boundary value problem (BVP), diffusion BVPs for mobile species, spatially-dependent ODEs for immobile species, and the climb and glide motion of the discrete dislocations within the crystal. The framework is then linearized for implementation in three-dimensional (3D) discrete dislocation dynamics (DDD) simulations for arbitrary anisotropic crystals. A solution scheme is developed based on the superposition principle, which is imposed weakly on the dislocation network to obtain a Galerkin solution for the nodal climb velocities. The framework includes diffusional (Nabarro-Herring) creep deformation as well as dislocation-mediated irradiation creep and growth. The model is compared to irradiation growth and creep experiments performed on Zircaloy.