A Mesoscopic Investigation of the Mechanical Response of Iron with Irradiated Microstructure

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Abstract

Irradiation of crystalline solids results in the production of point defects, the evolution of which leads to the formation of microstructure features such as dislocation loops and voids. The presence of these features impact the deformation response of the irradiated materials via interaction with dislocations. At the macroscale, such interactions result in hardening and loss of ductility by strain localization. Discrete Dislocation Dynamics (DDD) simulations provide a viable approach for the simulation of interactions of irradiation-induced microstructure and dislocations, and for the assessment of the mechanical property changes due to irradiation. In this work, we use DDD simulations to investigate the stress-strain response of Fe and Fe-Cr-Al alloys. We study the response of iron before irradiation to provide reference stress-strain behavior. We then apply DDD to investigate the response of irradiated Fe and Fe-Cr-Al alloy to investigate the impact of irradiation microstructure and composition evolution on the deformation response. In DDD simulations, realistic defect densities and the orientation of the loops have been incorporated using experimental data from literature. Uniaxial stress-strain response of the virgin material and irradiated material has been determined and compared.