Song, Dingkun; Xiao, Xiazi; Xue, Jianming; Chu, Haijian; Duan, Huiling
Mechanical properties of irradiated multi-phase polycrystalline BCC materials. (English)
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Summary: Structure materials under severe irradiations in nuclear environments are known to degrade because of irradiation hardening and loss of ductility, resulting from irradiation-induced defects such as vacancies, interstitials and dislocation loops, etc. In this paper, we develop an elastic-viscoplastic model for irradiated multi-phase polycrystalline BCC materials in which the mechanical behaviors of individual grains and polycrystalline aggregates are both explored. At the microscopic grain scale, we use the internal variable model and propose a new tensorial damage descriptor to represent the geometry character of the defect loop, which facilitates the analysis of the defect loop evolutions and dislocation-defect interactions. At the macroscopic polycrystal scale, the self-consistent scheme is extended to consider the multiphase problem and used to bridge the individual grain behavior to polycrystal properties. Based on the proposed model, we found that the work-hardening coefficient decreases with the increase of irradiation-induced defect loops, and the orientation/loading dependence of mechanical properties is mainly attributed to the different Schmid factors. At the polycrystalline scale, numerical results for pure Fe match well with the irradiation experiment data. The model is further extended to predict the hardening effect of dispersoids in oxide-dispersed strengthened steels by the considering the Orowan bowing. The influences of grain size and irradiation are found to compete to dominate the strengthening behaviors of materials.

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74E15 Crystalline structure

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irradiation; self-consistent method; multi-phase polycrystal; dislocation density

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