Investigation for deformation of ion-irradiated RPV steel using nanoindentation hardness test

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Abstract

To evaluate deformation depending on depth under ion irradiation, nanoindentation test was applied to heavy ion-irradiated SA508 CL.3 RPVSs. The specimens were irradiated with 8MeV Fe^{+4} ions to 0.15dpa and 1.5dpa at below 60℃. The derivative of the load-depth ratio, d(L/D)/dD, was estimated the depth dependent formation of plastic and elastic deformation in the irradiated specimens. In ion-irradiated SA508 CL.3 RPVS, the peak of deformation was observed at about 20nm from the surface, but the one of radiation damage was appeared at 1500nm from the surface when TRIM98 was simulated damage depth profile. In order to study the effect of deformation depth under ion irradiation rate, we evaluated nanoindentation hardness test. The hardness was larger for the irradiated than for the non-irradiated, and also larger for 1.5dpa than for 0.15dpa one.

Multiscale Modeling of Radiation Hardening in Pressure Vessel Steels

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Abstract

Radiation hardening is a multiscale phenomenon involving various processes, spanning a wide range of time and dimension. We present a multiscale model for estimating the amount of radiation hardening in pressure vessel steels under light water reactor environments. The model consists of largely two parts: molecular dynamics (MD) simulation and point defect cluster (PDC) model. MD simulations have been applied to investigate the formation of primary damage due to the displacement cascades. The evolution of microstructures has been described by interactions between point defects and their clusters, which are formulated by PDC model. Then, the hardening due to point defect clusters was calculated using a simple dislocation model. Key input into this multiscale model includes neutron spectrum at the inner surface of the reactor pressure vessel steels for the Younggwang nuclear power plant No. 5 (YG 5). The average energy of primary knock-on atoms (PKAs) produced from YG 5 irradiation condition was used as an initial value for the following MD calculation. The combination of MD simulation and PDC model calculation provides a convenient tool in estimating the amount of radiation hardening. The calculation results suggest that the yield strength is increasing with neutron dose, but not significant at this moment.