ISSN 1693-4687

High-Resolution Transmission Electron Microscope Analysis of Irradiation-Induced Structural Change in Magnesium Aluminate Spinel Compound

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ABSTRACT

The present talk will give an overview of our recent results on irradiation-induced structural change in magnesium aluminate spinel compound, which is known as a radiation tolerant oxide, especially to volumetric swelling. Magnesium aluminate spinel of MgO-nAl_2O_3 with n=1.1, was irradiated with swift heavy ions of 200 MeV Xe^{14+} (S_e=24 keV/nm) and 350 MeV Au^{28+} (S_e=34 keV/nm) at a Tandem ion-accelerator. Transmission electron microscopy techniques of high-resolution (HR) imaging, STEM dark-field imaging as well as high angular resolution electron channeling x-ray spectroscopy (HARECXS) were employed in quantitative analysis of irradiation-induced structural change. Dark spotty contrast appears at ion-tracks formed by swift-heavy irradiation in STEM dark-field imaging, indicating lower density inside the ion-tracks. Clear lattice fringes are observed in HR images even inside the ion tracks in both Xe^{14+} and Au^{28+} irradiated specimens. However, the fringe pattern inside the tracks is different from that appearing in the matrix, being indicative of formation of a defective NaCl structure. Molecular dynamics (MD) simulations have shown that the spinel structure becomes unstable by accumulation of displaced interstitials and a defective NaCl structure is formed after preferential evacuation of cations from the tetrahedral positions. Quantitative HARECXS analysis showed that cation disordering progresses successively with ion fluence. It was revealed that the disordered regions are extended over about 12 nm in diameter along the ion-tracks, which is much wider than the defective volume detected by HR images.