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Transmission Electron Microscopy Study on Ion Tracks in Ceria

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High density electronic excitation caused by fission fragments (FFs) in nuclear fuels and transmission targets is known to induce of ion tracks along the penetration path of FFs. Understanding of the structure of ion tracks together with the overlapping effects is one of the essentials for the development and assessment of the fuel/target materials under the extreme radiation condition. This paper reports the structure and accumulation process of ion tracks in ceria through a variety of transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM) techniques.

Ion tracks in CeO2 have been shown to retain the fluorite structure. Bright-field TEM and high-angle annular dark-field (HAADF) and annular bright-field (ABF) STEM techniques showed that the core region of ion tracks is 3-4 nm in diameter [1,2], and that the atomic density inside the ion tracks is decreased for about 10% [3]. Furthermore, ABF-STEM observation detected the preferential disorder of O-anion sublattice at the core region of the ion track [3]. On the other hand, analysis of the accumulation of ion tracks suggested the existence of an influence region, in which the formation and recovery of ion tracks are balanced [1]. The significantly large size of influence region (17 nm in diameter) than observable size is discussed that the core damage region detected by TEM and STEM is a vacancy-rich region formed after the recovery process of thermal spike [4]. Interstitial ions are considered to be generated during the recovery process within a rather wide region, to result in the development of dislocation structure at high fluence irradiation condition. It is also presented in this paper that the size of Fresnel contrast of ion tracks with bright-field TEM strongly depends on the defocused condition.

[1] K. Yasuda, et al., Nucl. Instr. Meth. B 314 (2013) 185

[2] K. Yasuda, et al., Proc. on 11th Int. Topical Meetings on Nuclear Applications of Accelerators (2013) 7.

[3] S. Takaki et al., Nucl. Instr. Meth. B, 326(2014) 140.

[4] S. Takaki et al., Prog. Nucl. Energy (2014) in press.

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