Structural, Interfacial, and Energetic Evolutions for Defect-fluorite Gd2Zr2O7 Ceramics under He Irradiation

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$Gd_2Zr_2O_7$ is a promising ceramic waste form. We synthesized $Gd_2Zr_2O_7$ with grain sizes ranging from 55 to 634 nm. These samples were subjected to He ion irradiation (190 keV) up to a fluence of 5 x 10^{17} ions/cm^2. Both fresh and post-irradiation $Gd_2Zr_2O_7$ samples were characterized using grazing-incidence X-ray diffraction (GIXRD), scanning electron microscope (SEM) and atomic force microscope (AFM) as grain size and He radiation vary. We found that at the same ion fluence, $Gd_2Zr_2O_7$ structural degradation, including amorphization, cell volume expansion, lattice distortion, and He bubble formation, appears to be a function of grain size. The threshold He bubble concentration (at.%) of nanograin $Gd_2Zr_2O_7$ is much higher compared with that of the submicron $Gd_2Zr_2O_7$. Additionally, we also carried out high temperature oxide melt drop solution calorimetry to study the energetic landscape as function of $Gd_2Zr_2O_7$ as grain size and irradiation level vary. This study suggests that grain boundary plays a crucial role in (1) structural stabilization of $Gd_2Zr_2O_7$ ceramics, and inhibition of He bubble formation within the grains and at the grain-grain interfaces.