Ion-Irradiation-Induced Amorphization of Cadmium Niobate Pyrochlore

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Pyrochlores represent a large class of compounds with the general chemical formula $A_2B_20_7$. Recent investigations have focused on the effects of chemical composition and incident ion mass and energy on the irradiation-induced amorphization of several pyrochlore compositions. $Gd_2Ti_2O_7$ has been the subject of considerable study since it is one of the three main actinide-bearing phases of SYNROC, — a polyphase ceramic waste form proposed for the disposition of high-level nuclear waste. Replacement of the Gd with other lanthanide elements or Ca has been found to have a relatively minor effect on the kinetics of irradiation-induced amorphization; however, the substitution of Ti with Zr in increasing concentrations sharply increases the resistance to amorphization even at cryogenic temperatures. In the present work, we have grown large synthetic single crystals of $Cd_2Nb_2O_7$ and investigated the irradiation-induced transformation to the amorphous state. In-situ temperature-dependent ion-irradiation experiments were performed directly in a transmission electron microscope. Additionally, ion-implantation experiments (at ambient temperature) and RBS/channeling analysis were carried out using bulk single crystals. The in-situ TEM irradiation experiments were performed using Ne or Xe ions with energies of 280 and 1200 keV, respectively. For the bulk implantation experiments, the incident ion energies were 70 keV (Ne^+) and 320 keV (Xe^{2+}**).** The critical amorphization temperature for $Cd_2Nb_2O_7$was found to be ~580 K (280 keV Ne^+) or ~700 K (1200 keV Xe^{2+}) . The dose for in-situ amorphization at room temperature is 0.22 dpa for Xe^{2+}, but is 0.65 dpa for Ne^+ irradiation. The intensity in the RBS-channeling results reached the random value after an ion fluence that was ~40% lower than for the in-situ TEM experiments. Effects of the ion charge state and crystallographic orientation of the specimens were investigated. The results of the in-situ irradiation and bulk implantation experiments were analyzed in light of available models for the crystalline-to-amorphous transformation and were compared to previous ionirradiation experiments on other pyrochlore compositions.