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In-situ Observation of Irradiation-induced α-U Phase Reversion in U-Mo

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ABSTRACT

It has been well studied that room-temperature-stable U-Mo alloy, a mixture of α-U and ordered U_2Mo, can transform to a single-phase metastable γ-U phase under neutron irradiation in reactors, even when the temperature is less than 150°C. But little was known whether the phase transformation process may directly relate to irradiation-induced recrystallization, the major mechanism causing accelerated U-Mo alloy swelling at high burnup. In order to investigate the impact of irradiation-induced phase transformation on U-Mo fuel recrystallization, in-situ irradiation experiments on decomposed γ-U phase were carried out. In this study, 1 MeV Kr ions were used to irradiate TEM (Transmission Electron Microscopy) thin foils lifted out from atomized U-7Mo fuel particles at both room temperature and 200°C. TEM micrographs were taken during irradiation to track the phase transformation process. Initially, large amount of α-U precipitates were observed near grain boundaries. Starting from the dose of 1×10^{15} ions/cm^2, the precipitates shrunk, and the associated electron diffractions showed only the major diffraction spots from γ-U phase. Bright-field (BF) TEM micrographs taken on the same location at different doses reveal that high-density dislocations were generated in the region where α-U precipitates shrunk, which can serve as the nucleation sites of recrystallization. From the observation, it is reasonable to speculate that stresses generated during irradiation-induced phase transformation initiated recrystallization in U-Mo alloy. This new perspective of the cause of recrystallization in U-Mo will benefit not only the design of fuel fabrication process but also the development of theoretic models to describe the recrystallization process.