Evolution of extended defects in UO_2: synergetic effect of nuclear and electronic energy losses

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During the nuclear fission reaction, the UO_2 fuel is irradiated by various particles, including fission products (FPs). As they pass through the matrix, these particles lose energy through two types of interactions: on the one hand, ballistic energy losses, which result from elastic collisions with nuclei and cause the large majority of the atomic displacements; on the other hand, electronic energy losses, which result from inelastic collisions with electrons and induce ionizations and electronic excitations. These interactions have an impact on the creation and the evolution of point defects in UO_2. As a result, these microstructural modifications can also lead to the formation of extended defects such as interstitial dislocation loops [1].

Ion beams are a valuable tool for replicating FPs damage in the fuel and they allow to establish separate-effects damage kinetics. Previous studies have shown that electronic ionizations coupled with ballistic damage affect the evolution of defects in UO_2 [2,3]. However, these studies were performed at room temperature, where some defects may already be mobile [4-6] and thus may affect the kinetics of defect evolution [7]. Therefore, the question is: what is the impact of the coupled ballistic and electronic energy losses in UO_2 when the temperature influence is prevented?

To address this question, UO_2 thin foils were observed using *in situ* Transmission Electron Microscopy (TEM) during ion irradiations at the JANNuS-Orsay facility. Irradiations were performed using single beam 0.39 MeV Xe or 6 MeV Si ions to study the kinetics of ballistic or electronic damage, respectively. Then, the coupled effect was investigated using a simultaneous dual beam. All experiments were carried out at liquid nitrogen temperature to study microstructure evolution when defects migration is very low. The results show that electronic ionizations modify the evolution of dislocation loops. The addition of the electronic contribution accelerates the transformation of the loops into lines. The magnitude of this dislocation growth will be discussed in terms of the influence of temperature by comparing these results with those obtained at room temperature [3].

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