Microstructural stability of a 9Cr ferritic-martensitic steel irradiated to 7.44 dpa at ~490°C†

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Ferritic-martensitic (FM) steels are candidate materials for nuclear applications. Unlike the generally studied low-temperature irradiation embrittlement of FM steels, this work is to understand microstructural stability under irradiation at an intermediate temperature. A 9Cr ferritic-martensitic (FM) steel was irradiated to 7.44 displacements per atom (dpa) at ~490°C in the High Flux Isotope Reactor of Oak Ridge National Laboratory. Vickers hardness and tensile tests indicated more than 25% softening after the irradiation. Microstructural characterization using transmission electron microscopy and energy dispersive x-ray spectroscopy revealed primarily <100> type dislocation loops with a density on the order of 10^{21} m^{-3}, together with scant tiny (<4 nm) cavities. Primarily V-rich MX and Cr-rich $M_{23}C_6$ precipitates, with densities on the order of 10^{19} and 10^{18} m^{-3}, respectively, were observed in the irradiated sample, which exhibited some radiation-induced crystalline evolutions, such as local lattice reconfigurations in MX and partial amorphization in fine matrix $M_{23}C_6$. The effects of the intermediate irradiation temperature (~$0.34T_M$) and transmutations on the microstructural evolution and material softening are discussed.

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