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ODS STEELS: NANOSTRUCTURE EVOLUTION UNDER IRRADIATION

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Oxide dispersion strengthened steels providing exceptional high-temperature creep and irradiation resistance are presently being developed for fusion reactor. Excellent mechanical properties of ODS steels are directly related to the high density of homogeneously distributed, well-formed oxide particles (such as Y2O3, or Y-Ti-O). However, atom probe tomography (APT) study of ODS steels revealed that they contain much higher amount of nanoclusters enriched in Y, O, V and Ti than of the oxide particles. The effect of these clusters on the mechanical properties and irradiation resistance of ODS steels and, especially, on the evolution of their chemical composition under irradiation has not been investigated in detail yet. Previous studies of the effect of irradiation on ODS Eurofer steel revealed an exchange of chemical elements between oxide particles and nanoclusters. For example, neutron irradiation at 300 ℃ causes a significant change in nanocluster chemical composition: vanadium goes from clusters into the matrix, while yttrium and oxygen partially leave the oxide particles and enrich nanoclusters. A similar behavior in ODS Eurofer was observed in APT samples irradiated with low energy Fe ions up to 30 dpa at room temperature.

In this work, we carried out atom probe tomography (APT) and transmission electron microscopy (TEM) studies of three different ODS steels produced by mechanical alloying: ODS Eurofer, 13.5Cr ODS and 13.5Cr-0.3Ti ODS. These materials were investigated after irradiation with Fe (5.6 MeV) or Ti (4.8 MeV) ions up to 1015 ion/cm2 and part of them up to 3×1015 ion/cm2. In all cases, areas for TEM investigation were cut at a depth of ˜1.3 μm from the irradiated surface corresponding to the peak of the radiation damage dose. It was shown that after irradiation at RT and at 300 °C the number density of oxide particles in all the samples grew up. Meanwhile, the fraction of small particles in the size distribution has increased. APT revealed an essential increase in nanoclusters number and a change of their chemical composition at the same depth. The nanostructure was the most stable in 13.5Cr-0.3Ti ODS irradiated at 300 °C: the increase of the fraction of small oxides was minimal and no change of nanocluster chemical composition was detected.

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