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Neutron irradiation micro-structural effects in standard and B-alloyed EUROFER97 steel

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The low activation ferritic/martensitic steel EUROFER97 (9 Cr, 0.12 C, 1.08 W, 0.12 Ta, 0.48 Mn, 0.2 Ta Fe bal wt%) is currently considered as the reference structural material for the fabrication of the first-wall, directly facing the burning plasma, in future fusion reactors. Small-angle neutron scattering (SANS) has been utilized to characterize the micro-structural effects of neutron irradiation in this steel, both in its standard composition and doped with B contents up to 5600 appm; such B contents are introduced by mechanical alloying to artificially increase the content of helium, produced by transmutation, to levels representative of the fusion reactor. The SANS measurements have been carried out at ILL-Grenoble and at FRM II-Garching, always utilizing an external magnetic field of at least 1 T and un-irradiated EUROFER97 reference samples. In standard EUROFER97 samples irradiated at HFR Petten, at 250℃ and 300℃ for doses up to 16 dpa (displacement per atom) an increase of the SANS cross-sections with the dose is observed, tentatively attributed to the evolution of micro-voids distributions, with volume fractions in the order of 10-3 and average radii of a few Å. In B-alloyed EUROFER97, HFR neutron irradiated to 16 dpa at various temperatures, a huge increase of the SANS cross-section and a strong decrease of the magnetic SANS component are observed, both enhanced increasing the irradiation temperature: these effects are attributed to the increased production of helium bubbles and to the occurrence of empty halos in the martensitic matrix, following the dissolution of the large B carbides. All these results will be discussed with reference to TEM observation of the same samples investigated by SANS.

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