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Recent irradiation experiments involving baseline and advanced tungsten materials performed at SCK CEN

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To reduce uncertainty on the scarce information available on neutron irradiation damage in tungsten and to support the development of advanced tungsten-based alloys, SCK-CEN has recently executed the neutron irradiation programme. The irradiation programme lasted for about 2 years and covered a large range of irradiation temperatures and doses. The primary types of post irradiation experiments (PIE) are mechanical testing and microstructural investigation. Next to the main irradiation programme, SCK-CEN has executed the irradiation programme for internal studies, where a number of samples for advanced characterization such as hardness testing and tritium permeation experiments. The irradiation was performed inside the fuel elements to ensure that the transmutation of tungsten into Re and Os would be minimized and achieve the rates comparable to DEMO/ITER conditions.
Six tungsten grades were selected for the irradiation programme due to specific relevance for the application in plasma-facing components of ITER and/or DEMO. These tungsten grades included: Plansee (Austria) ITER specification tungsten, ALMT (Japan) ITER specification tungsten, two products from KIT (Germany) produced by powder injection molding and strengthened by 1% TiC and 2% Y2O3 dispersed particles, and rolled tungsten strengthened by 0.5% ZrC from ISSP (China). The materials were irradiated face-to-face at three temperatures equal to 600 ℃, 1000 ℃, and 1200℃ to the dose of ~1 dpa. The Vickers hardness tests under 200 gf (HV0.2) were performed at room temperature. The Vickers hardness increases as the irradiation temperature increases from 600 to 1000 ℃ for all materials, except for the ZrC-reinforced tungsten, for which the increase of hardness does not depend on irradiation temperature. The irradiation-induced hardness decreases after irradiation at 1200 ℃. This is a result of defect annealing enhanced by thermally activated diffusion. However, even at 1200 ℃, the impact of neutron irradiation on the hardness increase remains significant; the hardness increases by ~30 to 60% compared to the non-irradiated value. In the case of TiC-strengthened material, the irradiation hardening progressively raises with irradiation temperature, which cannot be explained by the accumulation of neutron irradiation defects solely.
The samples irradiated in the above specified programme and in an extra campaign (irradiated to lower dpa) are now available for the advanced post irradiation characterization. The sample irradiated in extra campaign up to 0.2 dpa exhibit the activity of less than 2 mSv/hour on contact – i.e. can be handled in fume hood. These samples could be used for this CRPs to perform dedicated experiments to investigate permeation and retention of hydrogen isotopes.

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