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P2.202 Irradiation damage mechanism of tungsten studied by cold neutrons

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Tungsten is the leading choice as plasma-facing material in fusion reactors. Its brittleness can be alleviated by alloying with few-% rhenium. The earliest nuclear application of the W-Re system was as thermocouples in experimental breeder reactors. A drop in efficiency of the thermocouples was noticed and attributed to radiation-induced precipitation. Many studies followed with varied conclusions on W-Re phases. The chi-phase precipitates formed under neutron irradiation are extremely brittle and can initiate points of cracking.

Under fusion neutron irradiation, pure W will convert into W-3%Re within 5 years due to transmutation reactions. This would change the material properties. Fission reactor studies have shown significant irradiation hardening. Needle-like precipitates in small void-free areas are often seen in spite of radiation-induced diffusion having occurred. This is in contrast to the Re induced ductilization. Accelerator irradiations, with W ions have also resulted in precipitate formation at large damage dpa. Density functional theory calculations using first principle studies have pointed at the W-Re dumbbell three dimensional movement as being responsible for the Re precipitation far below the solubility limit.

In order to separate effects caused by transmutation (alloy formation) and by collisional damage, experiments with low-energy ("cold") neutrons can be useful and are often used to investigate i.e. biological samples due to their non-destructive probing nature. Cold neutrons don't incite displacement damage in tungsten, but only induce Re through transmutation. An irradiation using cold neutrons to induce Re precipitation without accompanying vacancy/interstitial creation leads to a deeper understanding of the W-Re system in a neutron environment. Isotopically pure 186W samples are exposed to cold neutrons in several locations at FRM-II, Garching. Subsequent atom probe tomography will evaluate the distribution of Re atoms and precipitates from transmutation. Sample preparation, activation, dose, recoil distribution simulations and pre-irradiation atom probe tomography study are discussed in this contribution.

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