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Fuel retention properties in first wall material: the influence of microstructure, displacement damage and helium

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In future thermonuclear devices such as DEMO displacement damage by 14 MeV fusion neutrons will be created in the plasma-facing materials while they are exposed to high fluxes of ions and neutrals of hydrogen isotopes (HIs) at elevated temperatures. It was shown in several studies in the past twenty years that HI retention and transport will be dominated by trapping at the defects created by the neutron irradiation [1]. Moreover, the synergism between displacement damage creation and presence of HIs needs to be taken into account for realistic predicting of fuel retention and transport in future fusion devices.
I will give an overview on the knowledge gained so far for tungsten (W), being the main plasma facing material in future fusion devices. As presently there is no existing 14 MeV neutron source, most studies were performed by using MeV heavy ions to create displacement damage in W. In order to be able to describe the interaction between HI and defects as well as the creation and evolution of defects and their dependence on temperature and HI flux one needs to isolate and understand the individual processes. An overview of the relevant set of experiments will be given where individual aspects were addressed. For instance, the creation and evolution of defects with temperature was studied where D retention and desorption kinetics were obtained by measuring D depth profiles and D thermal desorption spectra, showing that created defects act as traps for D and the defect densities increase with damage dose [2] and decrease with temperature [e.g. 3, 4]. The synergism between defects and HI was studied by simultaneously irradiating polycrystalline W MeV W ions and exposed to low-energy D at different temperatures ranging from 450 K to 1100 K [3,4], showing increased D retention when defects were created with the presence of deuterium. The effect of microstructure [5] and helium on the surface and in the bulk [6] on HI retention will be addressed and discussed. Recent attempts to study the location of trapped D in displacement-damaged W will be presented [7].

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