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Experiments and modelling of in-situ uptake, transport and release studies of hydrogen isotopes in irradiated tungsten

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Implantation of energetic hydrogen, charge exchange neutrals and helium (He), as well as displacement damage creation by neutron irradiation will occur simultaneously during operation of a real fusion reactor. All this is leading to consequences on crystal structure, hydrogen isotope (HI) retention and transport which we do not understand sufficiently in order to predict tritium retention in future fusion devices. Basic processes that occur in the plasma-facing wall material, such as hydrogen transport in a material with lattice defects, the effect of interstitial impurity atoms (HI and He) on defect evolution, and the role of the surface on HI uptake and release need to be studied. For this purpose, well-defined experiments with in-situ measuring the D depth profile are proposed to study transport and permeation through tungsten.

I will present recent advances on the field of in-situ studies on the dynamics of hydrogen isotope retention and transport, isotope exchange and D outgassing in displacement damaged tungsten. I will give an overview of our in-situ studies that we have performed on tungsten by the use of a hydrogen atom beam source delivering atoms with kinetic energy of 0.3 eV [1,2]. By the help of rate equation models the experiments enabled us to determine the de-trapping energies, parameters for the surface processes and the energy barrier for inward diffusion [2,3,4]. I will discuss also how the microstructure and He can affect transport and retention. Plans for further studies performed within the project will be presented.

[1] S. Markelj et al., J. Nucl. Mater. 469, 133 (2016).
[2] A. Založnik et al., J. Nucl. Mater. 496, 1-8 (2017).
[3] E. A. Hodille et al., Nucl. Fusion 57 (2017) 056002.
[4] E. A. Hodille et al., Nucl. Fusion 60 (2020) 106011.

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