Comments on analysis of thermal desorption spectrum of hydrogen isotopes from neutron-irradiated tungsten

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Formation of defects in tungsten by neutron irradiation results in significant increase in hydrogen isotope retention due to trapping effects of the radiation-induced defects [1,2]. The trap density and binding energy are important parameters determining fuel inventory in irradiated tungsten. A common way to evaluate these parameters is to measure thermal desorption spectrum after exposing an irradiated sample to deuterium plasma or gas and then perform curve fitting using a diffusion analysis code with assumed values of trap density and binding energy.

For accurate analysis of thermal desorption spectrum, we need the information on depth profile of deuterium and the fraction of occupied traps to all neutron-induced traps before starting desorption measurements. However, it is difficult to evaluate the depth profile of deuterium before starting desorption measurements because the penetration depth of deuterium in neutron-irradiated tungsten can be larger than range of probe beams for nuclear reaction analysis (NRA). It is also hard to determine the fraction of occupied traps because the direct measurement of amount of radiation-induced traps is practically impossible. For these reasons, the fraction of occupied traps is assumed to be unity in most cases, but this assumption can cause serious error under certain conditions.

In the presentation, we will discuss how sensitively the value of binding energy evaluated by the analysis of desorption spectrum is affected by the variations in assumed “initial depth profile” and “fraction of occupied traps”. Simulation methods [3] and the experimental procedures to minimize the uncertainty will be proposed.

[1] Y. Hatano et al., Nucl. Fusion, 53(2013)073006 (doi: 10.1088/0029-5515/53/7/073006).
[2] Y. Hatano et al., J. Nucl. Mater., 438(2013)S114-S119 (doi: 10.1016/j.jnucmat.2013.01.018).
[3] M. Oya et al., Nucl. Mater. Energy, in press (doi: 10.1016/j.nme.2021.100980).