Peculiar release kinetics of deuterium from tungsten revealed by an *on-line* and *in situ* laser induced desorption technique

M. Minissale[a,b], E. Hodille[a], T. Angot[a], C. Grisolia[c], L. Gallais[b], R. Bisson[a]

[a] *Aix-Marseille Université, CNRS, PIIM, Marseille, France*
[b] *Aix Marseille Université, CNRS,Centrale Marseille, Institut Fresnel UMR 7249, 13397 Marseille, France*
[c] *CEA, IRFM, 13108 Saint Paul lez Durance, France*

Abstract
Deuterium and tritium trapping at the divertor of tokamaks is one major concern in fusion devices such as ITER or DEMO because of tritium recycling issues as well as nuclear safety regulation related to tritium radioactivity. In this contribution, the fundamental mechanisms behind deuterium detrapping from tungsten has been studied in a new ultra-high-vacuum apparatus combining the advantage of *in situ* Temperature Programmed Desorption (TPD) and laser induced desorption methods.

Single crystal and recrystallized polycrystalline tungsten samples were implanted at 300 K with 500 eV deuterium ions (D_2^+). The kinetics of deuterium desorption (D_2 and HD) was studied using a new Laser-induced TPD technique (Laser-TPD). In Laser-TPD, the deuterium desorption rate is measured *on-line* and *in situ* during a well-controlled increase of the sample temperature upon laser heating. Combining continuous wave infrared laser heating with power densities up to 10 MW/m^2 and standard TPD filament heating, we made varied *in situ* the (Laser-)TPD heating rate from 0.1 to several hundreds of K/s. Desorption products were quantified *on-line* by using a differentially pumped mass spectrometer.

For heating rates below 10 K/s, a single desorption peak of deuterium is found for both tungsten single and poly-crystals. However, for higher heating rates in poly-crystals, the single desorption peak morphs in two desorption peaks, confirming the recent prediction of a dual trapping mechanism in recrystallized poly-crystalline tungsten [1]. One of the two desorption peaks presents a peculiar temperature shift with increasing the heating rate. The very large temperature shift of this deuterium release peak cannot be reproduced by neither a surface Polanyi-Wigner process, nor 1D bulk MRE models (MHIMS code) using the usual attempt frequency of 10^{12}-10^{13} s^{-1}. A Falconer-Madix analysis of the Laser-TPD series with varying heating rates allows to retrieving an effective attempt frequency several orders of magnitude smaller than usual ones.

The complete kinetic parameters set (activation energies and attempt frequencies) being determined for both trapping mechanism in poly-crystalline tungsten, we used them in the latest version of MHIMS, which includes temperature gradients [2], to forecast the tritium retention in an actively cooled ITER-like divertor in its D-T start-up phase i.e. without neutron damage.

References
[1] E. A. Hodille et al., Nucl. Fusion 57, 076019 (2017)
[2] E. A. Hodille et al., Phys. Scr. T170, 014033 (2017)