Experiment and modelling of hydrogen isotope exchange 
in beryllium layers as mean of T inventory control in ITER

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In the nuclear phase of ITER, wall conditioning will certainly contribute to the control of the tritium inventory - a major safety issue since the agreed safety limit inside the vessel must be kept under 640g during D:T operation [1] - by depleting tritium from the walls and in particular from that co-deposited with beryllium. High isotopic exchange efficiency in Glow Discharge Conditioning (GDC) or Ion Cyclotron Wall Conditioning (ICWC) plasmas have been reported [2,3]. However, the mechanisms at play in the interaction between hydrogen and beryllium layers are still poorly understood at a microscopic level, and there is in particular no specific theory or model in the literature to describe isotopic exchange. We present here a 1D Diffusion Trapping Model for Isotopic eXchange - DITMIX - developed in order to understand the interaction mechanisms between hydrogenic species and beryllium co-deposited layers. The model is based on existing approaches to simulate hydrogen transport in metals [4,5] and includes processes like hydrogen implantation, trapping in ion-induced trap sites, detrapping to a solute (mobile) state, diffusion in Be and recombination to molecular form at the surface. Simulated profiles of hydrogen atoms are in a good agreement with those measured by 15N-NRA on pre-characterized 600 nm thick Be:H layers, which were irradiated by D+ ions with well-defined fluxes and energies, for different durations and surface temperatures. However, the model predicts larger amounts of D atoms in the bulk of Be:H layers than those experimentally obtained from 4He-ERD measurements, casting some doubt on the processes involved.

Although DITMIX does not aim at an exact extrapolation of T removal in ITER, it yields important information on the efficiency of the foreseen conditioning techniques for T inventory control. Hence GDC applied in ITER during one day or more is just efficient enough to remove an amount of tritium comparable to the estimated retention in a nominal ITER D:T shot [6], even in combination with baking at 513 K. Pulsed ICWC at 343 K - the wall temperature during ITER operation – would be efficient for D+ fluxes to the wall as high as 1020–1021 m–2.s–1. If such fluxes, already measured on limiters of Tore Supra and TEXTOR [2], were on average attainable on the conformal first wall of ITER, ICWC operated between plasmas pulses would ensure efficient T inventory control in ITER.