SIMULATING PLASMA-WALL INTERACTION IN FUSION REACTORS WITH BEAM-SURFACE EXPERIMENTS

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Abstract. Fusion fuel (deuterium and tritium) trapping at the divertor of tokamaks is one major concern in fusion devices such as ITER or DEMO because of fuel recycling issues as well as nuclear safety regulation related to tritium radioactivity. We developed an approach that couples dedicated experimental studies with modeling at relevant scales, from microscopic elementary steps to macroscopic observables, in order to build reliable and predictive fusion reactor wall models. This integrated approach is applied to ITER divertor material (tungsten) and advances in the development of wall models are presented.

The fundamental mechanisms behind deuterium trapping from pristine tungsten have been studied combining a multi-scale experimental and theoretical approach. Polycrystalline samples were implanted at 300 K with 500 eV D_2^+ ions. The experimental sample characterization included bulk microstructure (FIB-SEM), deuterium bulk profile (NRA), deuterium release kinetics (TPD) and surface chemical composition (AES). These experimental results are complemented by Density Functional Theory (DFT) inputs to initialize a Macroscopic Rate Equations (MRE) wall model describing all elementary steps of experiments: implantation of fuel, fuel diffusion in the bulk, fuel trapping on defects and release of trapped fuel during temperature variation of samples. We show that the DFT-based MRE model can account for all experimental observables only if two types of defects are taken into account, namely grain boundary sites and a defective tungsten oxide surface layer, see Hodille *et al.* 2017. These two type of defects can be highlighted thanks to their different fuel detrapping kinetics, as demonstrated by Laser Induced Desorption (LID) experiments using a high power infrared laser beam simulating transient thermal loads at power densities relevant for ITER.

References

Hodille, E.A., Ghiorghiu, F., Addab, Y., Založnik, A., Minissale, M., Piazza, Z., Martin, C., Angot, T., Gallais, L., Barthe, M.-F., Becquart, C.S., Markelj, S., Mougenot, J., Grisolia, C., Bisson, R. : 2017, *Nuclear Fusion*, **57**, 076019.