In-situ Investigation of Deuterium Retention in Tungsten with Ion Beam Analysis and Thermal Desorption Spectroscopy

P.S. Szabo¹, K. Kantreᵇ, M.V. Moroᵇ, C. Cupakᵃ, L. Zendejas Medinaᶜ, R. Stadlmayrᵃ, K. Schmidᵈ, D. Primetzhoferᵇ, F. Aumayrᵃ

¹ Institute of Applied Physics, TU Wien, Fusion@ÖAW, Wiedner Hauptstraße 8-10, 1040 Vienna, Austria
ᵇ Department of Physics and Astronomy, Uppsala University, Box 516, S-751 20 Uppsala, Sweden
ᶜ Department of Chemistry, Uppsala University, Box 538, S-751 21 Uppsala, Sweden
ᵈ Max-Planck-Institut für Plasmaphysik, EURATOM Association, Boltzmannstraße 2, 85748 Garching, Germany

szabo@iap.tuwien.ac.at

For the successful operation of a nuclear fusion reactor, a complete understanding of fuel retention in the reactor wall materials is necessary. Since W wall components are favored for utilization in current and future fusion experiments, the implantation and desorption of D in W targets has been studied extensively. D shows a low solubility and high mobility in W, leading it to diffuse far deeper into the material than the ion implantation range [1]. By using Thermal Desorption Spectroscopy (TDS) measurements, D implantation has been found to be strongly influenced by trapping in pre-existing or irradiation-induced defects [2]. This effect will cause higher concentrations close to the surface or blister formation due to D gas bubbles forming at grain boundaries [3].

The goal of our research is to perform TDS measurements while in parallel monitoring the total D content and its depth distribution with Ion Beam Analysis. All presented experiments were performed completely in-situ at the SIGMA experiment at Uppsala university [4], which is connected to a 5 MV Tandem accelerator [5]. 3 keV D ions were implanted in several bulk (0.5 mm thick W foil acquired from MaTecK) and sputter-deposited thin film targets with fluences between 10²¹ and 10²² m⁻². These samples were subsequently heated up to a temperature of 1400 K. D outgassing was measured with a residual gas analyzer, while Elastic Recoil Detection (ERD) with a 3.4 MeV He beam was used to continuously record D depth profiles during the heating process.

Results from these investigations show a continuous decrease of the D content in W above a temperature of 400 K showing no significant further threshold behavior. The development of the ERD signal is correlated to the measured desorption rate and in line with previously observed D outgassing characteristics. Differences in retention are observed for pre-annealed W samples (less D retention occurs at room temperature at identical fluences) and for thin film targets (D depletion is reached faster).