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Studying the influence of redeposited tungsten and EUROFER97 layers on deuterium retention in plasma-facing materials

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Retention of hydrogen isotopes in plasma-facing materials is critical for the efficiency and safety of nuclear fusion reactors. While macroscopic retention in operational devices can be quantified using post-mortem analysis [1] or global gas balance [2], laboratory experiments are necessary to understand the microscopic mechanisms governing retention of hydrogen isotopes in first wall materials [3]. In realistic reactor conditions, where erosion, redeposition, implantation and outgassing occur simultaneously, it is furthermore important to investigate potential synergistic effects of these coupled processes under laboratory conditions.

In this study, we investigated deuterium (D) retention underneath redeposited material layers, to more closely mimic reactor conditions and gain more insight into realistic scenarios. Using Ion Beam Analysis (IBA) techniques, specifically Rutherford Backscattering Spectrometry (RBS) and Elastic Recoil Detection Analysis (ERDA), we quantified the amount of D retained in tungsten (W) and EUROFER97 during in-situ annealing. Via magnetron sputter deposition we grew approximately 200 nm thick W and EUROFER97 layers, which were exposed to 1 keV D2+ irradiation. The D-loaded samples were subsequently coated ex-situ with approximately 15 nm thick W or EUROFER97 layers. Furthermore, they were annealed to 500°C. Bare D-loaded layers without additional coating were also studied as reference samples. This allowed us to compare the outgassing characteristics of D-implanted bare materials to D-implanted coated layer systems, simulating possible redeposition effects in a reactor environment.

We observed that redeposited W can act as a diffusion barrier, preventing D from outgassing, a phenomenon not observed for redeposited EUROFER97. These findings highlight the critical role of redeposited layers on D retention in fusion devices. We will present our recent results and discuss their broader implications for fusion reactor operation.

[1] K. Heinola et al., J. Nucl. Mater. 463 (2015)
[2] S. Brezinsek et al., Nucl. Fusion 53 (2013)
[3] E. A. Hodille et al., Nucl. Fusion 57 (2017)