Modelling of Deposition at the Bottom of Gaps in TEXTOR Experiments

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Fuel retention in fusion devices with carbon based armour materials is to a large extent governed by the co-deposition process. Formation of fuel-rich carbon layers takes place preferentially in remote areas hidden from direct plasma impact. As such, gaps of castellated plasma-facing surfaces act as potential trapping sites for tritium, thus representing a critical issue for continuous and safe operation of next step fusion devices.

A dedicated experiment in TEXTOR using a test limiter with gap-like structures [1] revealed that thick carbon layers are formed not only near the entrance but to a certain extent also at the bottom in gaps. In this case, cleaning of gaps becomes a challenging task. In the experiment it was not clear whether observed deposition on the bottom results from normal discharges or from off-normal events like losses of the plasma position control. Modelling performed with the 3D-GAPS code [2] for normal TEXTOR discharges was not able to reproduce the significant level of deposition in those most plasma remote areas without imposing extreme assumptions on particle transport in gaps.

In order to clarify the deposition in gaps, a dedicated experiment is planned in TEXTOR with injection of quantified amounts of $^{13}CH_4$ molecules in the vicinity of a gap and shot-resolved in-situ measurements of deposition at the gap bottom with sensitive Quartz Microbalance (QMB) diagnostics. Predictive modelling with coupled ERO [3] and 3D-GAPS simulations is applied to estimate the amount of injected carbon capable of reaching the bottom of the gap. ERO calculates the transport of injected $^{13}CH_4$ molecules in plasma and provides fluxes of particles entering the gap. The gap is located approximately 23 mm away from the injection hole and the gap bottom is about 9 mm recessed from the plasma exposed surface. ERO simulations for a representative TEXTOR discharge show that up to 0.7% of injected particles can reach the gap aperture. The 3D-GAPS code is used to follow the transport of these particles down to the QMB surface. Under a very conservative assumption of no reflection and without re-erosion taken into account, only small fraction of particles entering the gap can be deposited at the bottom resulting in carbon deposition efficiency on QMB of the order of 0.01%. With such efficiency, an injection rate of 5×10^{19} molecules per discharge will be sufficient to reach a detectable level of deposition on QMB. Application of an improved particle reflection model with reflection coefficients according to Molecular Dynamics data leads to two times smaller deposition efficiency still affordable from the point of view of QMB sensitivity. Detailed results of refined predictive modelling will be presented in this contribution.

[1] A. Litnovsky et al, J. Nucl. Mater. 390-391 (2009) 556
[2] D. Matveev et al, Plasma Phys. Control. Fusion 52 (2010) 075007
[3] A. Kirschner, V. Philipps, J. Winter, and U. Kögler, Nucl. Fusion 40 (2000) 989

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