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Modelling of Prompt Deposition of Tungsten under Fusion Relevant Conditions

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Tungsten is a promising first wall material in fusion devices. Though, due to its high atomic number, tungsten concentration levels in the plasma core have to be kept small. However, in addition to low sputtering yields the high atomic number has the beneficial effect of prompt deposition, i.e. depending on the plasma parameters large amounts of sputtered tungsten can be deposited during the first gyration.
The deposition of sputtered tungsten is simulated with the 3D Monte Carlo impurity transport and plasma-wall interaction code ERO. No specific device geometry is used but constant plasma parameters along the surface. Variations of plasma density, temperature, flow velocity and sheath potential along the magnetic field are considered according to the simple two point model and PIC-simulated sheath characteristics. Simulations have been done for a magnetic field of 3 T with an angle of 2 deg relative to the surface. With an electron temperature T_e = 20 eV and density n_e = 6E19 mˆ-3 at the sheath entrance, the modelled amount of tungsten prompt deposition is 95%. Reducing T_e at the sheath entrance to 5 eV lowers the modelled deposition fraction to 65%. In both cases tungsten ionisation occurs outside the sheath leading to mean deposition energies of about 3QT_e (with Q the mean charge of depositing tungsten ions), which are in accordance with the sheath potential drop.
Further parameter studies with T_e between 1 and 20 eV and n_e between 1E18 and 1E21 mˆ-3 have been performed. At very high n_e and T_e, the tungsten ion trajectories do not describe clear gyration motions anymore as the movement is dominated by the large electric field near the surface. Therefore, the term "prompt deposition"is used for atoms, which after their ionisation return to the surface within t < t_gyro. Whereas at the lowest T_e, n_e no prompt deposition occurs, all eroded tungsten is promptly deposited at the largest T_e, n_e. At high n_e in combination with low T_e deposited tungsten ions can reach energies much larger than expected from the sheath potential. The energy excess comes from very effective entrainment of the tungsten ions with the plasma via friction.
The possible runaway sputtering due to an avalanche effect of tungsten self-sputtering will be studied. Also, the influence of ELMs on the prompt and overall deposition and resulting sputtering will be addressed.

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