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Ion-solid interaction for light ions in plasma-facing materials: Experimental corrections and their effects on simulation-based sputter yields

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Sputtering, defect formation, and particle implantation due to plasma-wall interactions (PWI) are key processes that must be understood for operation of future fusion reactors with minimum maintenance [1]. In these processes, fundamental quantities in ion-solid interactions such as the specific energy deposition of plasma species in wall materials or the interaction potentials between ions and wall species play significant roles. Despite being important input variables for modelling erosion and implantation, such quantities are often insufficiently known: For example, there are no available experimental datasets for interatomic potentials for slow light ions in tungsten (W). In addition, the influence of these quantities on plasma-wall related parameters such as sputtering yields remains to be investigated.

This contribution summarizes recent experimental studies of these fundamental quantities. In particular, electronic energy losses and short-range repulsive potentials of impacting light plasma species (H, D, and He) in candidates for plasma-facing materials of next-generation fusion devices (W, Fe, and EUROFER97) are evaluated experimentally. For that, ions with a wide range of energies (sub-keV to multiple MeV) [2] and different targets (bulk samples, pre-irradiated and damaged materials, and deposited thin films) are used. The experimental results [3,4] are compared to currently available semi-empirical and theoretical models, and quantitative corrections are extracted. From our results, discrepancies up to 60% were identified in comparison to commonly used semi-empirical models.

The sensitivity of statistical quantities such as sputtering yields on the magnitude of the aforementioned parameters is furthermore tested with simulation codes based on the binary collision approximation. The simulated values are compared to experimentally obtained ones using a high sensitivity quartz crystal microbalance and discrepancies are discussed. Our recent results thus not only provide necessary datasets for these fundamental quantities but also directly enhance the understanding on how these values influence ion-solid interaction relevant for future fusion reactors.

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