Contribution ID: **77** Type: **Oral**

Energy, angular and atomic level distribution functions of sputtered tungsten based on spectroscopic investigations

Thursday, 30 November 2023 10:45 (30 minutes)

Sputtering is one of the fundamental processes at plasma-facing components in fusion experiments as the lifetime of the components strongly depends on the sputtering rates. Therefore, it is of paramount importance to understand the processes underlying the sputtering, including the energy, angular and atomic level distribution functions of the sputtered tungsten (W). These distribution functions are further essential input parameter for erosion codes.
One aspect of the presented research deals with the investigation of the initial atomic level distribution of sputtered W. This distribution needs to be taken into account for the interpretation of spectroscopic data and further the determination of the net erosion via so-called S/XB values in fusion devices [1]. However, this initial atomic level population within the fivefold ground term $^5D_{0-4}$ and the metastable $^7S_3$ level of sputtered W remains an open question. On the one hand, experiments in the tokamak TEXTOR suggest a nonphysical effective temperature to describe the atomic level population distribution via a Boltzmann distribution [2]. This results in a strong population also of other levels and not only of the ground state. On the other hand, ion beam experiments for different materials show a strong population of the ground state only [3]. Using a new approach, we studied this open question in the low density and temperature plasma of the linear plasma device PSI-2. Via an imaging spectrometer with a high spatial resolution (50 μm/pixel) the temporal line intensity development as a function of distance to the target was studied for different transitions of W I. In the experiments, the W atoms were sputtered by mono-energetic Ar^+ ions at 80 eV. The target was cooled using water-cooling and different target temperatures were investigated.
A second aspect of the presented research deals with investigating the energy and angular distribution functions. These strongly influence the transport into the plasma and, moreover, the re-deposition of sputtered material on the inner vessel. Via ion beam experiments, these distribution functions are well accessible for high impact energies and can be described by a cosine angular distribution and the so-called Thompson energy distribution [4]. However, for the impact energies relevant in fusion research, of up to several hundred electron volts, the data is only rare and deviations from the distribution functions are reported [2]. To investigate these deviations and close the remaining gap of information, we carried out experiments and subsequently modeled the line shape emitted by sputtered W atoms via a Doppler-shifted emission model. The experiments were carried out in the linear plasma device PSI-2, where W samples were exposed to low density (n_e 2×10^{12}cm^{-3}) and temperature (T_e 3eV) argon plasmas. The ions hitting the sample were accelerated due to biasing the sample to mono-energetic impact energies in the order of 100 eV. The light emitted by the sputtered atoms was detected via a high-resolution spectrometer with a resolving power of $\lambda/\Delta\lambda \approx 7 \times 10^5$.
Until now, the finite size of the targets has not been taken into account in the analysis of the observed spectral lines during sputtering. The standard emission model used so far, which assumes an infinite target or point source, fails for observations with two lines of sight. This gap could be removed due to the new finite-size model.

[1] S. Brezinsek et al., Physica Scripta, T170, 014 052, 2017.
[2] I. Beigman, et al., Plasma Phys. Control. Fusion, 49, 1833-1847, 2007.
[3] A. P. Yalin et al., Applied Optics, 44, 6496-6505, 2005.
[4] R. Behrisch and W. Eckstein, Sputtering by Particle Bombardment, ser. Topics in Applied Physics. Berlin, Heidelberg: Springer Berlin Heidelberg, 110, 2007.
[5] A. Goehlich et al., Journal of Nuclear Materials, 266, 501-506, 1999.

Primary author: ERTMER, Stephan

Co-authors: KRETER, Arkadi (Forschungszentrum Juelich); SACKERS, Marc; MARCHUK, Oleksandr (Forschungszentrum Juelich); BREZINSEK, Sebastijan (Forschungszentrum Jülich)

Presenter: ERTMER, Stephan

Session Classification: EXP/2 A+M data