Contribution ID: **40** Type: **not specified**

Spectroscopic investigations on energy, angular and atomic level distribution functions of sputtered tungsten

Wednesday, 31 March 2021 10:45 (30 minutes)

The understanding of the ongoing processes during sputtering of plasma-facing components is of large importance in fusion research. For example, the angular and energy distribution of sputtered atoms strongly influence the transport into the plasma and, moreover, the redeposition of sputtered material on the inner vessel. Therefore, these distribution functions are also important input parameter for simulations. For high impact energies, the angular and energy distributions of sputtered atoms are well known and can be described by a cosine angular distribution and the so-called Thompson energy distribution [1]. However, the situation changes for low impact energies relevant in fusion research. Here, the data is only rare and deviations from the cosine angular and Thompson energy distribution 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 tungsten (W) atoms via a Doppler-shifted emission model. The experiments took place in the linear plasma device PSI-2, where W samples were exposed to low density ($n_e \approx 2 \times 10^{12}$ cm^{-3}) and temperature ($T_e \approx 3$ eV) argon plasmas. The ions hitting the sample were accelerated by 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 spectral resolution of $\lambda/\Delta\lambda \approx 7 \times 10^5$. In agreement with recent theoretical work [3], we found that the energy and angular distribution can be determined from the light emitted by sputtered atoms. The line shapes modeled by the usage of a cosine angular and a Thompson energy distribution show good agreement with the experimentally detected line shapes [4].
In addition to the energy and angular distribution of sputtered W the 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, ion beam experiments for different materials show a strong population of the ground state only [5]. On the other hand, for experiments in the Tokamak TEXTOR a nonphysical effective temperature was introduced to describe the level population distribution via a Boltzmann distribution within the ground term and the metastable $^7S_3$ level [6]. This resulted in a strong population also of other levels and not only of the ground state. The knowledge of the atomic level distribution is of importance for interpretation of spectroscopic data and further the determination of the net erosion via so-called S/XB values in fusion devices [7]. 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 of different transitions of W I. The W atoms were sputtered by mono-energetic Ar^+ ions at 80 eV and due to water-cooling the target was kept at room temperature. The experiments show a strong population only for the ground term $^5D_0$ of sputtered W atoms [8].
References:

[1] R. Behrisch and W. Eckstein, Sputtering by Particle Bombardment, ser. Topics in
Applied Physics. Berlin, Heidelberg: Springer Berlin Heidelberg, 110, 2007.
[2] A. Goehlich et al., Journal of Nuclear Materials, 266, 501-506, 1999.
[3] A. Sepetys et al., Plasma Phys. Control. Fusion, 61, 125017, 2019.
[4] S. Ertmer et al., Plasma Phys. Control. Fusion, 63, 015008, 2020.
[5] A. P. Yalin et al., Applied Optics, 44, 6496-6505, 2005.
[6] I. Beigman, et al., Plasma Phys. Control. Fusion, 49, 1833-1847, 2007.
[7] S. Brezinsek et al., Physica Scripta, T170, 014 052, 2017.
[8] S. Ertmer et al., 45th EPS Conference on Plasma Physics, 2018, pp. 1480.

Primary author: Mr ERTMER, Stephan (Forschungszentrum Jülich)

Co-authors: Dr MARCHUK, Oleksandr (Forschungszentrum Jülich); Dr DICKHEUER, Sven (Forschungszentrum Jülich); BREZINSEK, Sebastijan (Forschungszentrum Jülich); Dr KRETER, Arkadi (Forschungszentrum Jülich)

Presenter: Mr ERTMER, Stephan (Forschungszentrum Jülich)

Session Classification: EXP/2 A+M data