Ionization efficiency of material sputtered under swift heavy ion bombardment

L. Breuer[1], F. Meinerzhagen[1], M. Bender[2], D. Severin[2], and A. Wucher[1#]

[1]Universität Duisburg-Essen, 47057 Duisburg, Germany
[2]GSI, Darmstadt, Germany

In 2014 a new time-of-flight (TOF) spectrometer was built up at the M-branch of GSI to investigate sputtering phenomena induced by swift heavy ions in the electronic stopping regime. The emphasis of this experiment is put on the ionization efficiency of the sputtered material by comparing the yields of emitted secondary ions and their neutral counterparts.

Experimental setup

A TOF spectrometer is used for the mass selective analysis of sputtered particles (see [1] for construction). Secondary ions emitted from the surface are accelerated to the entrance of the spectrometer by a pulsed electrical extraction field. The ions then travel through a field free drift zone and - depending on their mass/charge ratio- arrive at different flight times at a multichannel plate detector (SIMS). For the detection of sputtered neutral species, the system is equipped with a pulsed VUV laser for post-ionization of atoms and molecules (SNMS) above the surface via single photon ionization at a wavelength of 157 nm (corresponding photon energy:7.9 eV). The setup also includes a 5 keV Ar^+ ion beam directed to the sample area, which allows a comparison to nuclear sputtering and can be used for alignment purposes of the spectrometer.

Common TOF mass spectrometry measurements use short primary ion pulses (≈ 100 ns to several µs) at high (kHz) repetition rates. The UNILAC, however, permits only repetition rates of 1 to 50 Hz at pulse lengths of around 1 ms. In order to accommodate for that difference and make efficient use of beam time, we developed a measurement protocol which enables us to acquire secondary ion and neutral spectra obtained under MeV/u, and keV primary beams as well as without ion bombardment in an interleaved manner throughout a single accelerator pulse cycle. In addition, the keV ion beam can be intermittently switched to dc mode between subsequent accelerator pulses in order to ensure reproducible surface conditions by dynamical sputter-cleaning, which is, for instance, important for the analysis of clean metal surfaces.

First results

With this new setup, secondary ions and neutrals emitted under MeV/u electronic sputtering conditions are analyzed by a TOF spectrometer for the first time. As an example, figure 1 shows spectra of Mo^+ ions and Mo^0 atoms measured for a dynamically sputter-cleaned molybdenum surface under bombardment with 5 keV Ar^+ and 4.8 MeV/u Au^{26+} ions, respectively. From these data, the ionization probability of Mo atoms emitted under electronic sputtering conditions is determined $\alpha_{Mo}^{+} = (4.0 \pm 0.9) \cdot 10^{-5}$ [2].

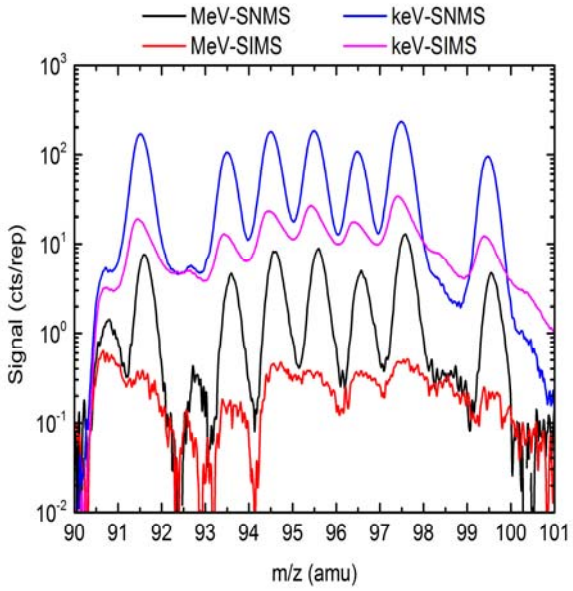

Figure 1: Spectra of Mo^+ ions (SIMS) and Mo^0 atoms (SNMS) measured for a dynamically sputter cleaned molybdenum surface under bombardment with 5 keV Ar^+ and 4.8 MeV/u Au^{26+} ions.

References

[1] Dissertation Michael Wahl, Universität Kaiserslautern, 1995
[2] Dissertation Lars Breuer, Universität Duisburg-Essen, 2015

* andreas.wucher@uni-due.de

DOI:10.15120/GR-2015-1-APPA-MML-MR-02