Application of the RBD 9103 Picoammeter in ion beam experiments

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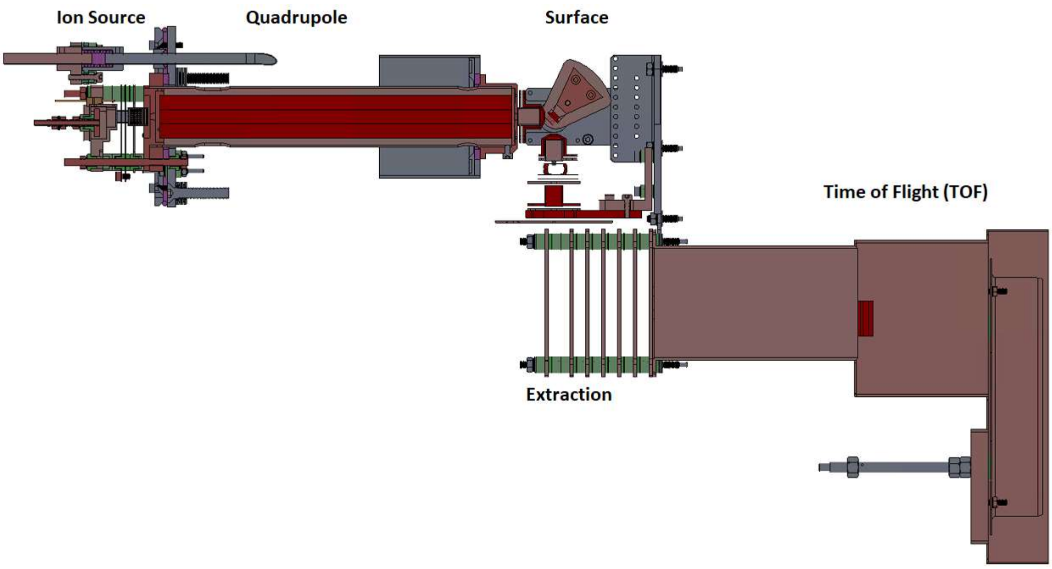
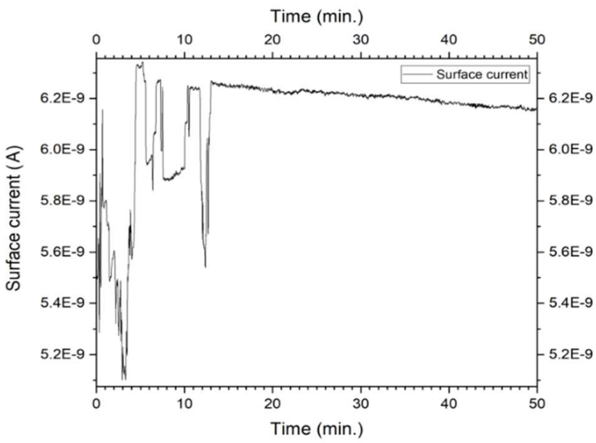
SurfTOF

The SurfTOF ion beam experiment investigates ion/surface reactions and consists of a tandem mass spectrometer (MS-MS) with a metal surface placed in between the two mass analyzers, as depicted in the figure beneath. The experiment is enclosed by an ultra-high vacuum setup, with differential pumping across the quadrupole region in order to maintain low pressures in the chamber containing the surface and avoid collisions of ions with residual gas. A beam of ions, mass selected by a quadrupole, is accelerated towards the surface and interacts with neutral adsorbed gas and the bulk material of the surface. Secondary ions formed on the surface are further focused by a lens stack towards a time-of-flight mass spectrometer. Furthermore, ejected neutrals can be post ionized by an electron impact ion source and follow the same flightpath as secondary ions. Mass spectra recorded with this setup give insight on various ion/surface reactions and processes, such as chemically assisted sputtering, physical sputtering and catalysis.



The graph on the right shows a typical trace of the surface current produced by accelerated Ar^{+} projectiles hitting the metal surface. In order to get detailed insight on the reactions taking place at the surface, time dependent variations of the surface current must be taken into account when recording TOF spectra. Therefore, surface current is monitored in the nA/pA regime with an RBD 9103 Picoammeter during each measurement.

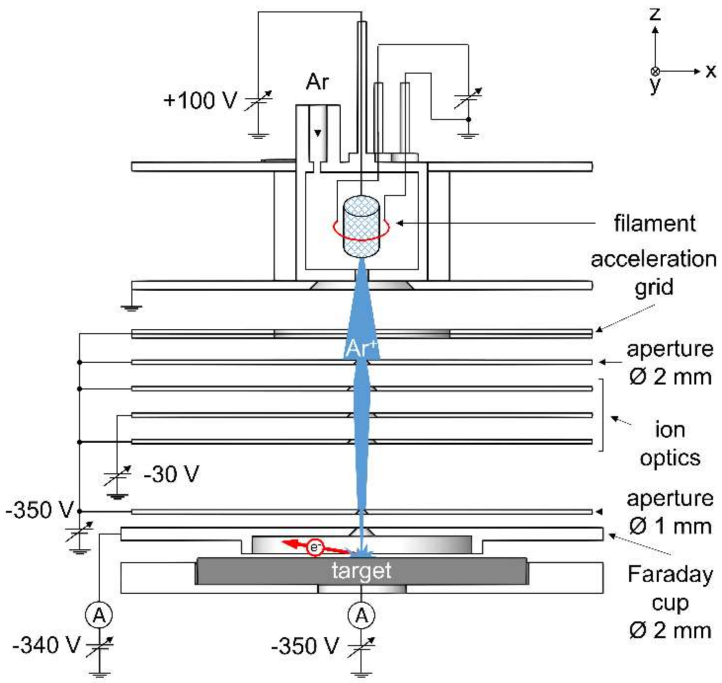


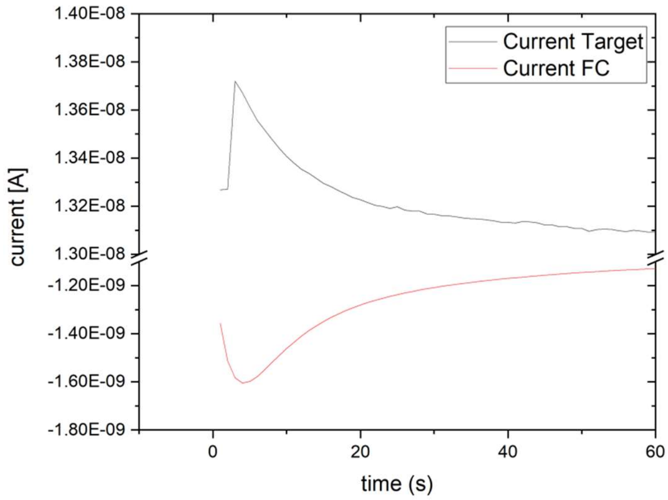
Further reading:

https://doi.org/10.1016/j.nme.2019.100722

MoSES

With the MoSES experimental setup, schematically shown on the right, spatially resolved secondary electron emission coefficients (SEEC) of various materials can be determined. Similar to the conditions in an industrial sputtering process, a focused ion beam is accelerated in vacuum onto a target surface with an energy of 420 eV. The current of the secondary electrons ejected from the surface is measured on a positively biased faraday cup and compared to the current of incoming ions on the target. To get spatially resolved SEEC, the target can be moved by two piezo stages in x- and y-direction in respect to the ion beam. The knowledge gained with the described setup is especially relevant to coating industry regarding cost optimization of sputtering processes, as secondary electron emission can be utilized to enhance sputtering rates.

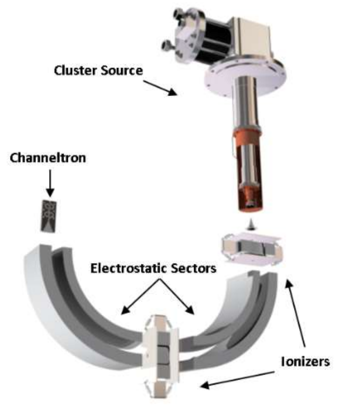


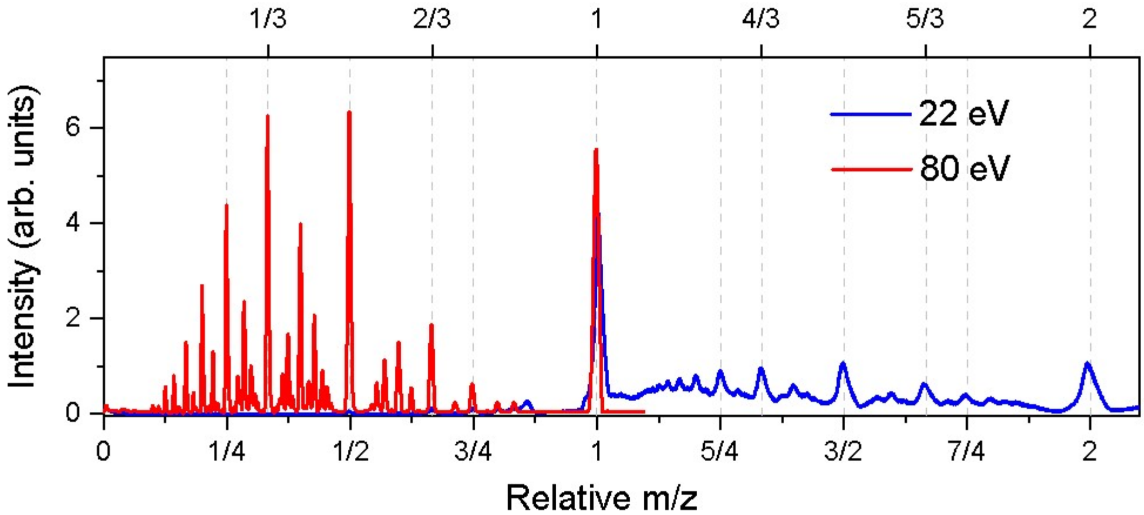


The trace of such a SEEC measurement using two RBD 9103 Picoammeters is shown in the graph on the left. Due to impurities and metal oxides on the target, the ion beam is used to remove the first layers by sputtering. During this process, the measured current is changing from the current emerging from the oxide layers to the current coming from the pure target. These traces are recorded for different positions of the target to investigate different grain orientations and tiny structures in materials like grain boundaries.

Snowball

The Snowball experiment, with the essential parts shown on the right, investigates fundamental properties of superfluid helium nanodroplets in ultra-high vacuum. A cluster beam of superfluid helium with uniform velocity, produced in a cluster source at temperatures below 10 Kelvin via supersonic expansion of high purity helium, is subjected to ion bombardment. The droplets in the beam are then selected for their mass-to-charge ratio via an electrostatic sector, consecutively ionized and deflected again in a second electrostatic sector. To detect these ionized droplets of superfluid helium, a channeltron electron multiplier is used. The collector anode of the channeltron can either be connected to a combination of a discriminator and frequency counter or directly to an RBD 9103 Picoammeter, floating on the voltage applied to the electron multiplier.





In the upper graph two measurements recorded at different electron energies with the Snowball experiment are displayed, which show that, contrary to what was accepted by the scientific community for many years, helium nanodroplets can hold a bevy of charges. This property makes them an ideal matrix for the production of ionic clusters for mass spectrometry and high yields of various nanoparticles which can be deposited on surfaces.

Further reading:

https://doi.org/10.1103/PhysRevLett.123.165301