

Development of a compact electron ion coincidence analyzer using a miniature polar-angle-resolved time-of-flight ion mass spectrometer with four concentric anodes

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Introduction

When core electrons of surfaces are excited, ions are desorbed by the following three step processes: 1) a core-electron transition, 2) an Auger decay, 3) ion desorption due to hole-hole Coulomb repulsion and electron missing from valence orbitals (Auger stimulated ion desorption (ASID) mechanism). For study of ASID mechanism, the coincidence measurement of energy-selected electrons and mass-selected ions (electron-ion coincidence (EICO) spectroscopy) is a powerful technique, because core-excitation-final states or Auger-final-states leading to ion desorption is directly identified. The information on the coincidence ions, however, limited to the mass and the yield so far. In order to obtain information on kinetic energy and desorption polar angle of ions, we have developed a new compact EICO apparatus using a coaxially symmetric mirror electron energy analyzer and a polar-angle-resolved miniature time-of-flight ion mass spectrometer (TOF-MS) with four concentric anodes [1].

Results and conclusion

Figure 1 shows the miniature TOF-MS with four concentric anodes that we developed. The trajectories of ions with a kinetic energy of 3.5 eV were

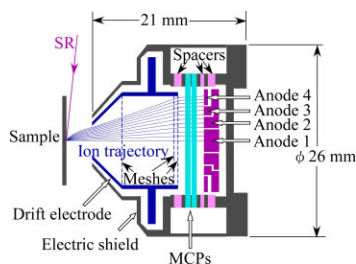


Figure 1. Cross section of a polar-angle-resolved miniature TOF-MS with four anodes.

simulated with SIMION 3D version 7.0

(<http://www.simion.com/>). It consists of a shield for the electric field, an ion drift electrode with three meshes, and MCPs with four concentric anodes. Figure 2 shows a TOF contour map of H⁺ for the miniature TOF-MS with four anodes as a function of desorption polar angle and kinetic energy of desorbed ions. For each ion that hits a particular anode after an electron is detected the ion's TOF can be determined. From the known drift bias voltages the desorption angle and the kinetic energy can be estimated.

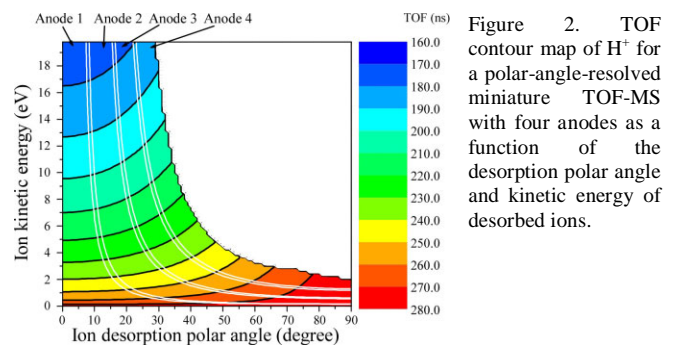


Figure 2. TOF contour map of H⁺ for a polar-angle-resolved miniature TOF-MS with four anodes as a function of the desorption polar angle and kinetic energy of desorbed ions.

Figure 3 shows Auger-electron H⁺ time-of-flight (TOF) difference spectra at the 4a₁ ← O 1s resonance of amorphous H₂O condensed on Si(100) at 100 K. The scales in kinetic energy of desorbed H⁺ are also shown. The kinetic energy of H⁺ offer significant information on the H⁺ desorption mechanism at the 4a₁ ← O 1s resonance, because the kinetic energy is the sum of the energy obtained on the potential curve of the (O 1s)⁻¹ (4a₁)¹ state and that obtained on the (valence)⁻² (4a₁)¹ state.

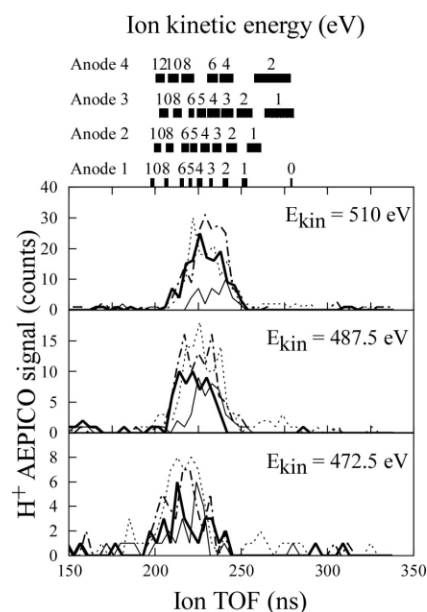


Figure 3. Auger electron photoion time-of-flight difference spectra with anodes 1 (thick solid lines), 2 (dash-dot lines), 3 (dotted lines), and 4 (thin solid lines) at the 4a₁ ← O 1s resonance of condensed H₂O.

References

- [1] E. Kobayashi et al., Rev. Sci. Instrum., 80, 043303 (2009).

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