

Mapping the secondary neutral emission in Secondary Ion Mass Spectrometry

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Synopsis We temporally and spatially mapped the emission of SIMS neutrals by using an ultrafast NIR laser source. The mutual timing of the laser pulse and Bi_3^+ ion cluster, laser pulse chirp and pulse energy are examined with respect to the secondary neutral emission.

Secondary ion mass spectrometry [1] (SIMS) is a broadly adapted technique with applications ranging from semiconductor science and technology, through chemical analysis and forensics to bioanalysis. Primary ions (ion clusters) bombard the sample surface and secondary species is emitted from the uppermost atomic layers. Part of this species, that is in an ionized state (approx. ~1% of the total) is further analyzed by means of mass spectrometry. The remaining atoms/molecules remain neutral. The emission process is only understood in qualitative terms, with the process itself known as the collision cascade [1].

Here we focus on the emitted neutrals with the goal to temporally and possibly spatially characterize the emission by employing an ultrafast laser system in order to *postionize* [2] the neutrals.

The MS part of the setup employed the time-of-flight SIMS IV (ION-TOF GmbH, Germany). The sample surface was bombarded with 25 keV Bi_3^+ primary ions with the pulse duration of 1 μs and the repetition rate of 50 Hz. An ultrafast two-stage Cr:forsterite fs IR MOPA (Master Oscillator Power Amplifier, 100 fs, 1.2 mJ, 1240 nm) was used as the laser source for postionization. A typical peak focal intensity (for the transform limited pulse) was of the order of $5 \times 10^{14} \text{ W/cm}^2$. The laser beam from the amplifier passed through a $f=300\text{mm}$ (f30) lens and was subsequently focused into the target chamber of SIMS analyzer approximately 500 microns above the sample surface.

Native silver sample was chosen as a model system for the analysis. A comparative experiments has been performed by purging the analysis chamber with oxygen. The yield of selected fragments was examined with respect to the mutual timing of the laser pulse and Bi_3^+ ion cluster, laser pulse chirp and pulse energy. It

was explicitly shown that the yield is reduced over the analysis cycle (i.e. breaking the static limit) similarly to the secondary ions. Additionally, by changing the laser pulse energy and chirp, useful insights have been gained into the process of laser postionization.

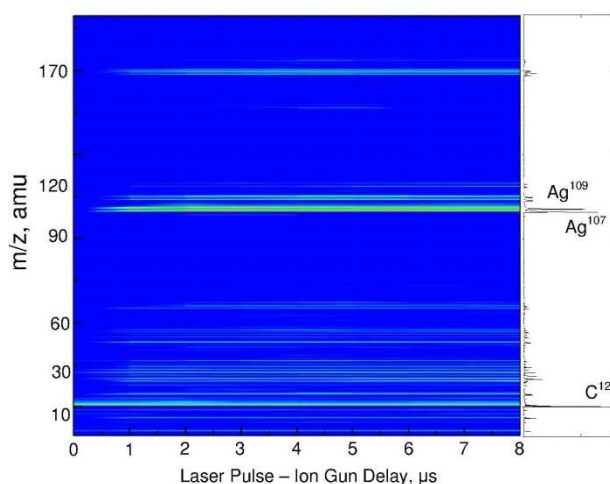


Figure 1. Silver mass spectra as a function of mutual delay btw. the laser pulse and Bi_3^+ ion cluster

Careful control of experimental degrees of freedom in a well designed (e.g. nanolayer) sample could in the future further elucidate the physical mechanism behind the collision cascade.

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References

- [1] J.C. Vickerman and D. Briggs 2001 *TOF-SIMS: Surface Analysis by Mass Spectrometry* (IM Publications, Charlton)
- [2] D. Willingham *et al.*, 2009 *Chem. Phys. Lett.* **468** 264

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