Towards Secondary Ion Mass Spectrometry on the Helium Ion Microscope

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The ORION Helium Ion Microscope (HIM) has become a well-established tool for high-resolution microscopy over the last years [1]. The ORION instrument is based on the atomic-sized ALIS gas field ion source, which has a brightness of $4 \cdot 10^9$ A/(cm$^2 \cdot$sr) and which leads to a probe size down to < 0.5 nm. The source can operate with helium and neon ions [2]. While secondary electrons are used for high-resolution high-contrast imaging, the detection of backscattered helium atoms can provide some composition information about the specimen.

In order to get chemical information with much higher sensitivity on the Helium Ion Microscope, we have investigated the feasibility of performing Secondary Ion Mass Spectrometry (SIMS). SIMS is an extremely powerful technique for analyzing surfaces owing in particular to its excellent sensitivity, high dynamic range, very high mass resolution and ability to differentiate between isotopes.

We have experimentally determined on a test set-up the secondary ion yields for different elements sputtered from different materials exposed to helium and neon ion beams. While the basic yields were found to be rather low compared to the ones found in conventional SIMS due to the use of rare gas elements for sputtering, as expected, these yields could be increased by several orders of magnitude by using reactive gas flooding during analysis (oxygen flooding for positive secondary ions [3], cesium flooding for negative secondary ions [4]). In addition, the experimentally determined sputtering yields coupled with modeled characteristics of the collision cascades triggered by He^+ and Ne^+ impacts allowed us to estimate the achievable lateral resolutions by taking into account the competition between sputtering and imaging.

The obtained results are very encouraging and the prospects of performing SIMS on the ORION are very interesting. In addition to having high-resolution microscopy and high-sensitivity chemical mapping on a single instrument, this information can be combined to reach a new level of correlative microscopy. This paper will present an overview of our experimental and simulation results and it will discuss the prospects of SIMS on the Helium Ion Microscope in terms of detection limits and lateral resolutions. Our experimental results show in particular that detection limits down to the ppm level are possible.

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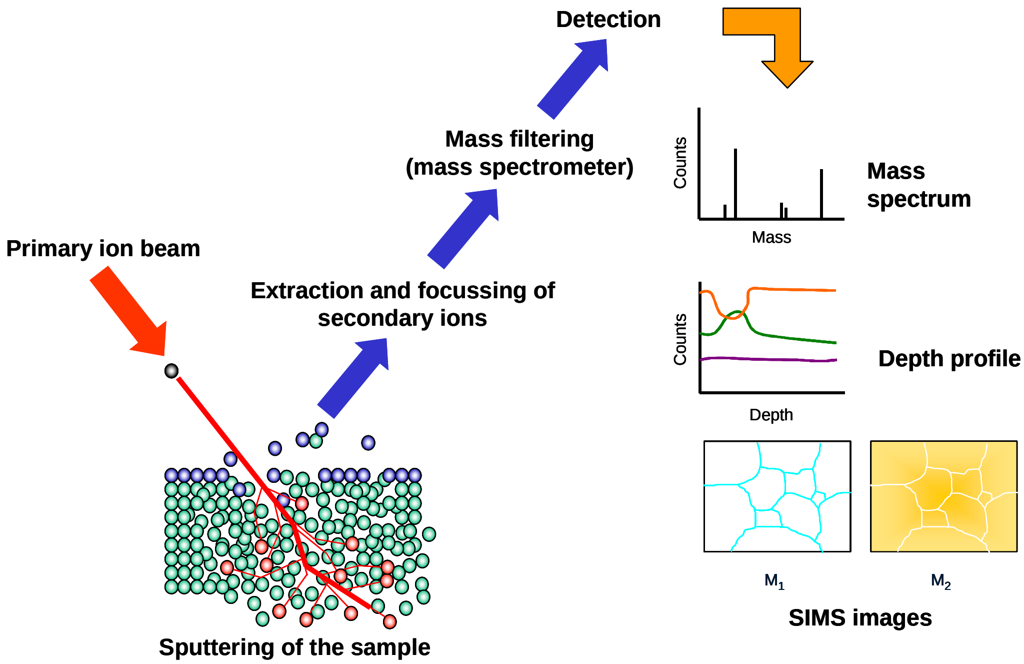

Figure 1: Schematic of Secondary Ion Mass Spectrometry and its main applications.

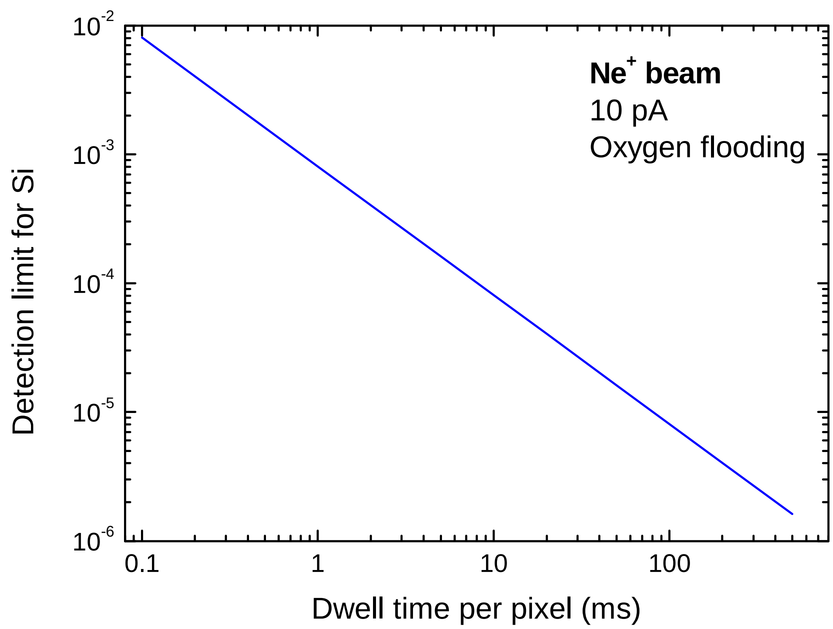

Figure 2 : Detection limits obtained for Si with a 10 pA Ne^+ beam and oxygen flooding in the positive secondary ion mode.