Towards SIMS on the Helium Ion Microscope: detection limits and experimental results on the ORION

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The ORION Helium Ion Microscope has become a well established tool for high resolution microscopy [1] and nanofabrication [2]. While secondary electrons are used for high resolution imaging, only limited compositional information can be obtained from backscattered He ions. In order to get chemical information with much higher sensitivity, we have previously investigated the feasibility of performing Secondary Ion Mass Spectrometry on the Helium Ion Microscope [3]. Our earlier studies concentrated first on potential useful yields, detection limits and achievable resolution and then on the practicality of secondary ion collection [4]. We have determined experimentally secondary ion yields under helium and neon bombardment for a range of semiconductor and metal samples. While basic yields are low due to the use of noble gas primary ions, they may be enhanced by several orders of magnitude for both negative and positive secondary ions by caesium and oxygen flooding respectively. Measurement of yields has allowed us to calculate detection limits for these samples under typical ORION imaging conditions (see figure 1). More recently a prototype extraction and detection system for secondary ions has been developed for the Helium Ion Microscope by the CRP - Gabriel Lippmann. We have investigated secondary ion emission for both semiconductor (Si, InP and GaAs) and metal (Cu, Ni) samples on the ORION. Both total secondary ion depth profiles and secondary ion images (see figure 2) have been obtained under helium and neon bombardment.

The obtained results are very encouraging and the prospects of performing SIMS on the ORION are very interesting. In this paper we will present an overview of our results to date and first experimental results of secondary ion detection on the Helium Ion Microscope.

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[1] L. Scipioni, C.A. Sanford, J. Notte, B. Thompson, and S. McVey, J. Vac. Sci. Technol. B **27**, 3250 (2009)
[2] D. Winston et al, Nano Letters **11** 4343 (2011)
[3] T. Wirtz, N. Vanhove, L. Pillatsch, D. Dowsett, S. Sijbrandij and J. Notte, Appl. Phys. Lett. **101** 041601 (2012)
[4] D. Dowsett, T.Wirtz, N. Vanhove, L. Pillatsch, S. Sijbrandij and J. Notte, J. Vac. Sci. Technol. B **30** 06F602 (2012)

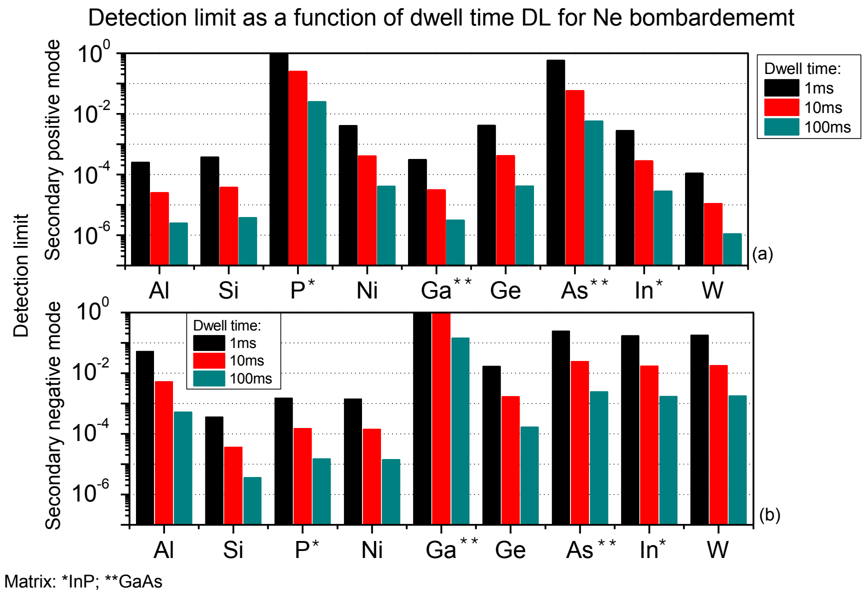

Figure 1: Detection limits for various semiconductor and metal samples under 10 pA neon bombardment a) secondary positive mode with oxygen flooding b) secondary negative mode with caesium flooding.

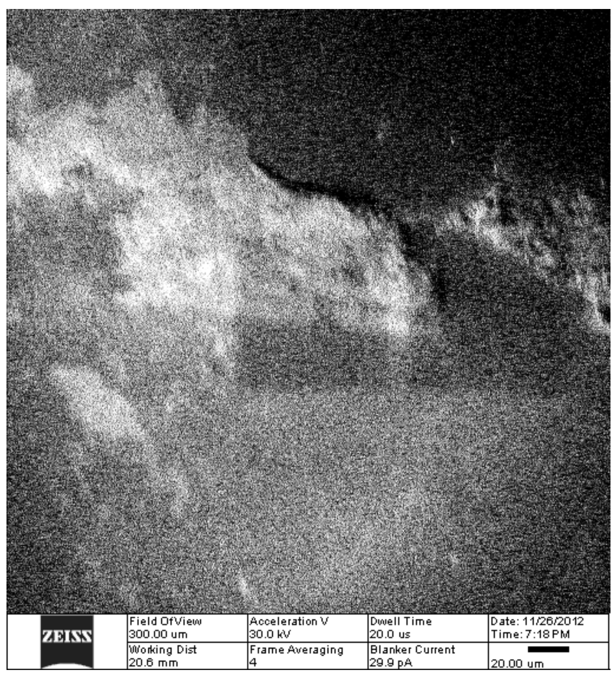

Figure 2: First total secondary ion image of the native oxide of nickel from prototype extraction system. Primary He current 30 pA, field of view 300 µm. NB ORION column optimised for maximum primary ion current rather than best probe size.