Ion beam analysis in a Helium Ion Microscope – elemental mapping on the nm scale

N. Klingner[1], **R. Heller**[1], G. Hlawacek[1], P. Gnauck[2], S. Facsko[1] and J.v. Borany[1]

r.heller@hzdr.de

[1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research,
Bautzner Landstr. 400, 01328 Dresden, Germany
[2]Carl-Zeiss-Microscopy GmbH, D-73447 Oberkochen, Germany

In recent years Helium Ion Microscopes (HIM) rapidly have become commonly used high resolution imaging devices in laboratories all over the world. Beside a sub nanometer resolution and a high depth of field the latest generation of HIM devices (Zeiss Orion NanoFab) can be operated with both helium and neon ions as well and thus offer various opportunities for local surface modifications [1].

While the image generation in a HIM is realized by evaluating the amount of secondary electrons (SE), the energy of backscattered He or Ne projectiles was rarely taken into consideration so far. However, this energy contains information on the elemental composition of the surface and the sub-surface region and it thus provides an additional mechanism for contrast generation. Early attempts to measure BS energy spectra were carried out by Sijbrandij et al. [2] and gave evidence for the general feasibility but also revealed that a quantitative element analysis of thin layers would require the development of more sophisticated detection concepts.

In this contribution we present an experimental approach and the corresponding results of backscattering spectrometry (BS) in a HIM with a lateral resolution < 55 nm and an energy resolution < 3 keV (example seen in fig. 1). We show that pulsing the primary ion beam and measuring the Time-of-Flight (ToF) of the backscattered He/Ne enables BS spectrometry in a HIM without disturbing its excellent imaging capabilities [3]. Since our approach enables us also to perform Secondary Ion Mass Spectrometry (SIMS) by biasing the sample to a positive or negative potential, elemental contrast in chemical analysis is further increased.

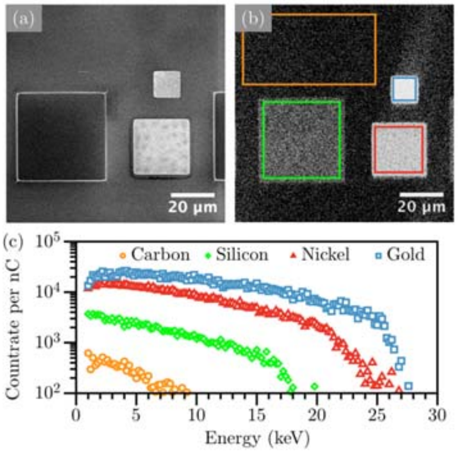

Figure 1: Images of a carbon sample covered with rectangular patterns of Si, Ni and Au acquired in standard SE mode (a) and in ToF-BS mode (b). The color scale in (b) corresponds to the time of flight of the BS particles. In contrast to SE imaging this technique reveals well-defined elemental contrast. ToF-BS spectra obtained from different regions in (b) - marked by rectangles - are plotted in (c). The color of the spectra equals the color of the rectangles in (b). The ToF-BS spectra allow clearly to distinguish between different elements.

Both techniques - SIMS and BS - in conjunction with the high-resolution imaging by SEs reveal a “complete” picture of the sample in terms of topography and chemistry. Additionally, the evaluation of BS spectra opens access to investigate the sub-surface chemistry by measuring elemental depth profiles.

[1] G. Hlawacek, V. Veligura, R. van Gastel and B. Poelsema, J. Vac. Sci. Technol. B **32** (2014) 020801

[2] S. Sijbrandij, B. Thompson, J. Notte, B. W. Ward and N. P. Economou, J. Vac. Sci. Technol. B **26** (2008) pp 2103-2106

[3] N. Klingner, R. Heller, G. Hlawacek, J. von Borany, J. Notte, J. Huang and S. Facsko, Ultramicroscopy **162** (2016) pp 91-97