MI 4: Helium and Neon Ion Microscopy for the Analysis and Structuring on the Nanoscale

Time: Wednesday 15:00–15:45 Location: H5

MI 4.1 Wed 15:00 H5

Nanometer scale elemental analysis in the helium ion microscope using time of flight spectrometry — •Nico Klingner[1], René Heller[1], Gregor Hlawacek[1], Johannes von Borany[1], John Notte[2], Jason Huang[2], and Stefan Fascko[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Ion Microscopy Innovation Center at Carl Zeiss Microscopy LLC, Peabody, USA

Helium ion microscopes (HIM) have become powerful imaging devices within the last decade. Their enormous lateral resolution of below 0.3 nm and the highest field of depth make them a unique tool in surface imaging. Up to now there are only limited possibilities for elemental analysis. Therefore we successfully implemented time of flight backscattering spectrometry (ToF-BS) into the HIM. Its integration introduces the ability to perform laterally resolved elemental analysis as well as elemental depth profiling on the nm scale. A lateral resolution of $\leq$ 54 nm and a time resolution of $\Delta t \leq 17$ ns ($\Delta t/t = 5.4\%$) are achieved. In addition laterally resolved time of flight secondary ion mass spectrometry (ToF-SIMS) can be performed with the same setup. Time of flight is implemented by pulsing the primary ion beam. This is achieved in a cost effective and minimal invasive way that does not influence the high resolution capabilities of the microscope when operating in standard secondary electron imaging mode. This technique can thus be easily adapted to existing devices. The particular implementation of ToF-BS and ToF-SIMS techniques are described, results are presented and advantages, challenges and limitations of this new techniques are discussed.

MI 4.2 Wed 15:15 H5

A Secondary Ion Mass Spectrometry (SIMS) add-on for Helium and Neon Ion Microscopy — David Dowsett, •Florian Vollnhals, Jean-Nicolas Audinot, and Tom Wirtz — Advanced Instrumentation for Ion Nano-Analytics (AINA), MRT Department, Luxembourg Institute of Science and Technology (LIST), 41 rue du Brill, L-4422 Belvaux, Luxembourg

Helium Ion Microscopy (HIM) was introduced a few years ago as an imaging tool with a lateral resolution below 1 nm. The addition of Neon as a working gas in the Orion NanoFab (Zeiss) has opened up new possibilities in high resolution nano-machining and FIB.

In contrast to electron microscopy, there are currently no analytical tools available on the HIM. Energy Dispersive X-Ray Spectroscopy (EDX), the most common technique in electron microscopy, is not applicable using ion radiation. In order to add analytical functionality, we combine the HIM with Secondary Ion Mass Spectrometry (SIMS). The sample is sputtered by the focused He or Ne primary ion beam while the secondary ion emission is recorded by a purpose developed spectrometer. This combination takes advantage of both the small probe size of the He/Ne beam as well as the sensitivity of SIMS analysis.

We will present our progress in instrumental and method development as well as data obtained on the prototype system [1]. He and Ne ion beams will be shown to be viable primary species for successful SIMS, approaching the physical resolution limits of <20 nm [2].

[1] D. Dowsett et al., J. Vac. Sci. Technol. B 30 (2012), 06F602
[2] T. Wirtz et al., Nanotechnology 26 (2015), 434001

MI 4.3 Wed 15:30 H5

Writing nanoscale magnets with neon using a gas field ion source microscope — •Gregor Hlawacek[1], Anna Semisalova[1], Falk Röder[2], Sebastian Wintz[1], René Hübner[1], Lothar Bischoff[1], Hannes Lichte[2], Kay Potzger[1], Jürgen Lindner[1], Jürgen Fassbender[1], and Rantej Bali[1] — [1]Ion Beam Physics and Materials Research, Helmholz—Zentrum Dresden – Rossendorf, Bautzner Landstr. 400, 01328 Dresden, Germany — [2]Triebenberg Labor, Institut für Strukturphysik, Technische Universität Dresden, 01062 Dresden, Germany

Gas field ion source (GFIS) based microscopy—historically called Helium Ion Microscopy (HIM)—provides the unique ability to structure material on the nano-scale using an ion beam with a diameter of less than 5 Å. Usually high fluences of the relatively light noble gases are needed to change the shape, or induce property changes in the target structure. Here, we present a method that allows to create arbitrary shaped magnets in a $Fe_{60}Al_{40}$ alloy using fluences of only a few neon ions per square nanometer. Using neon chemical disorder can be introduced into the paramagnetic B2 phase of the alloy. The increase in Fe–Fe nearest neighbors results in a switch to ferromagnetism in the irradiated area. We will discuss the achievable minimal size (<50 nm) and the in–depth thickness of the magnets (15 nm–60 nm). X-rays, TEM and MFM have been used for characterization.

[1] G. Hlawacek et al., J. Vac. Sci. Technol. B, 32(2):020801, 2014. [2] F. Röder et al., Sci. Rep., 5:16786, 2015. [3] R. Bali et al. Nano Lett., 14(2):435, 2014.