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A new Ion Microscope for high-resolution imaging and SIMS nano-analytics

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Powerful material characterization techniques excelling in terms of lateral resolution and sensitivity are needed to study nanoscopic materials and their transformation processes in 3 dimensions at the relevant spatial scales. State-of-the-art Focused Ion Beam (FIB) technologies allow not only to visualize nanoscopic 3D structures, but also analytical surface measurements with Secondary Ion Mass Spectrometry (SIMS). SIMS is a powerful surface analysis technique which uses energetic primary ions to sputter the surface of a sample and to generate secondary ions separated by a mass analyzer to record chemical information. Advantages of SIMS are the high sensitivity, the high dynamic range, the ability to differentiate between isotopes and the access to the complete periodic table. Typical SIMS analysis modes are mass spectrum recording, depth profiling, 2D, and 3D imaging. In the past, the correlation of high-resolution ion microscopy with in-situ SIMS has allowed to acquire complementary topographic and chemical information for a deeper understanding of samples in various domains, including material sciences, geology, and biology [1].

The IONMASTER magSIMS is a novel system devoted to correlative high-resolution 2D/3D imaging and SIMS nano-analysis. The system is a unique combination of a Liquid Metal Alloy Ion Source (LMAIS) [2] and a dedicated magnetic sector SIMS unit. Within the LMAIS various ion species are emitted simultaneously from a single ion source (GaBiLi [3] and AuGeSi sources available) and are separated in a downstream Wien filter within the FIB column. This allows to choose the most suitable primary ion species depending on the application and also to toggle within a few seconds between the ion species. This has for instance the advantage to use heavy (e.g., Bi+ or Au+) primary ions to delayer the sample stepwise and to use lighter primary ions (e.g., Li+ or Si2+) to image the sample at high spatial resolution. These image planes can be stacked and used to create a 3D volumetric reconstruction of the sample [4]. The SIMS unit is equipped with an insertable/retractable extraction optics to transfer the generated secondary ions through the magnet based mass analyzer onto a focal plane detector. The latter allows parallel acquisition of full mass spectra for each scanned pixel within the chosen field of view [5] which gives the user a multitude of possibilities to post-process and correlate the SIMS image data.

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Further key strengths of this FIB-SIMS platform are the possibility to use application specific primary ion beams, i.e. the ability to switch quickly between reactive primary ion species to maximize either positive (e.g., Au+ or Bi+ single primary ions and clusters) or negative ionization (e.g., Li+ primary ions) of the sputtered particles. The small beam diameter of the lightest primary ions (Li+ and Si2+) allows to perform high spatial resolution imaging in SIMS (< 20 nm) . The low penetration depth of heavy Bi+ and Au+ (and clusters) primary ions into the material enables excellent depth resolution. Moreover, the combination of a LMAIS FIB, a Laser Interferometer Stage with CAD based navigation, and a magnetic-sector SIMS offers a high potential for automatized workflows.

In this contribution, we will present the key features and the working principle of the IONMASTER magSIMS system equipped with a LMAIS. We will show results on correlative 2D and 3D imaging focused on applications including CIGS solar cells (Figure 1), geological and microelectronics samples investigated on the recently developed nano-analysis system. Thus, we will demonstrate that the new IONMASTER magSIMS paves the way for nano-analytics beyond the conventional methodology for sample analysis by combining the LMAIS technology with a stable stage and a SIMS unit for highest spatial resolution imaging.

Graphic:

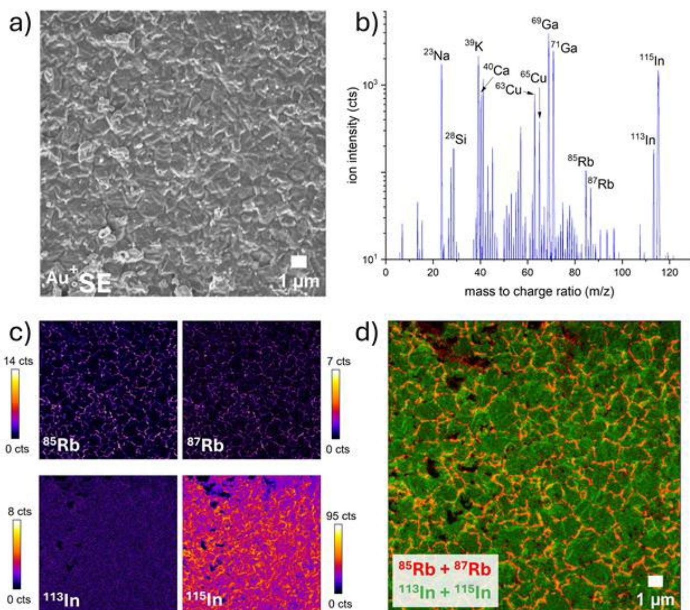

Figure 1: a) Secondary Electron (SE) image generated using a 35 keV Au^+ primary ion beam acquired on the IONMASTER magSIMS on a RbF-treated CIGS solar cell sample. b) Mass spectrum acquired in positive SIMS mode. c) SIMS image maps showing the distribution of ^{85}Rb, ^{87}Rb, ^{113}In, and ^{115}In of the same zone as a). d) Red-green map of the sum of the ^{85}Rb and ^{87}Rb (red) as well as ^{113}In and ^{115}In (green) isotopes showing that Rb segregated at the grain boundaries of the CIGS surface.

Keywords:

FIB, SIMS, Imaging, LMAIS, Applications

Reference:

1. J.-N. Audinot et al., ROPP 84 (2021), p. 105901.
2. L. Bischoff et al., Appl. Phys. Rev. 3 (2016), 021101.
3. L. Bischoff, S. Akhmadaliev, DE102007027097B4.
4. A. Nadzeyka et al., JVST B 41 (2023), 062802.
5. O. De Castro et al., Anal. Chem. 93 (2021), p. 14417–14424.