Focused Ion Beams from LMAIS for Surface Imaging, 3D Volume analysis, and SIMS

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The liquid metal alloy ion source (LMAIS) technology has been established for Focused Ion Beams (FIB) nanofabrication in recent years [1]. Its excellent beam current stability, patterning and imaging resolution [2] as well as fast adjustment of the sputtering yield with switching from one ion to the other within a few seconds allow a versatile use of this source technology.

Visualization of nanoscopic samples in 3D is of high interest in various domains, including nanotechnology, life and materials sciences, since it allows us to study in more details the surface and internal structure of the material compared to a simple 2D image. While a common method for 3D volume reconstruction consists of slice-wise imaging and milling of the sample involving stage tilt, the new GaBiLi source paves the way for a new approach to obtain 3D volume information. The GaBiLi source has the advantage of analyzing the sample by alternately imaging with Li+ primary ions at high spatial resolution in secondary electron (SE) mode and switching quickly to milling mode with Bi+ primary ions at a high sputtering rate. Using this Mill&Image workflow the ion beam is always perpendicular to the sample surface and no sample tilt is needed (Figure 1a). The set of SE images can be compiled into a 3D stack and cross-sectional views allow to visualize interior structures of the sample (Figure 1b).
An alternative approach for 3D reconstruction, limiting sputtering of the sample surface and fully considering the surface topography, has been developed recently. Therefore, series of ion microscopy images [3,4] are acquired around a region of interest (ROI). The images are implemented into a photogrammetry software used to obtain a full 3D surface model (Figure 2) allowing detailed observation at all possible angles and magnifications, and even further numerical analysis [4].

In this contribution, we will present the capabilities of the Raith VELION FIB-SEM system equipped with GaBiLi or AuGeSi sources for 3D imaging. We will explore the possibilities of correlating topographic 3D data with analytical surface information through Secondary Ion Mass Spectrometry (SIMS), providing a forward-looking perspective on the synergy between these capabilities.

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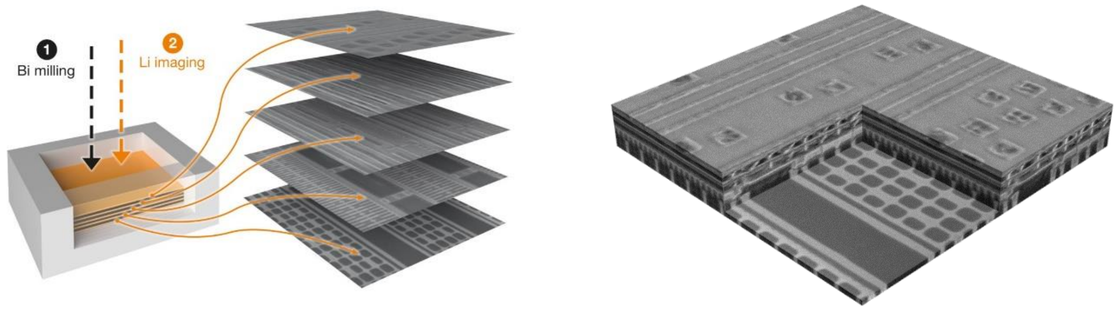

(a) (b)

Figure1: 3D volume reconstruction using SE images acquired with GaBiLi ion sources.

Reconstruction of a microchip. 35 keV Li^+ primary ions were used for high-resolution SE imaging (80 images in total) while 35 keV Bi^+ ions served as ionic species for efficient sputtering of the surface layer-by-layer (a). In this reconstruction, a cuboid (5µm x 5µm) was cut out to visualize the interior structure of the microchip (b).

Figure 2: Side view on a 3D SE surface reconstruction of a Bi_2Ca_2Co grain. A photogrammetric approach was used to reconstruct its surface using 48 SE images acquired around the ROI using a 70 keV Si^{2+} primary ion beam.