Emission of multiple ion species from a single ion source: Top-down FIB with LMAIS on a Lithography Platform

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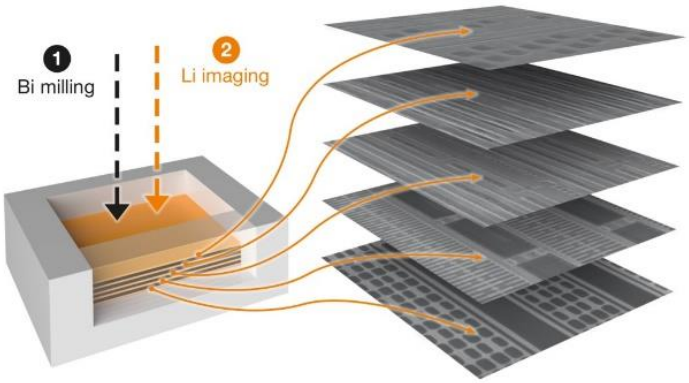
Focused Ion Beams (FIB) technologies are broadly used in nanoscale science related applications, and they are inherently applied for direct nano-patterning, resist based processes [1] as well as ion microscopy [2]. FIB patterning has become a direct, versatile, and precise fabrication method of smallest features at high reproducibility. Therefore, high demands are made on the FIB in terms of beam stability, but also the sample stage requires a high degree of stability, accuracy and automation for nanoscale patterning and imaging.

The Liquid Metal Alloy Ion Source (LMAIS) is a versatile FIB source technology able to emit various ion species [3] at high stability. Light and heavy ions such as Silicon and Gold or Lithium and Bismuth are emitted simultaneously from a single ion source (AuGeSi or GaBiLi) [4] and separated using a downstream Wien filter. This source technology allows the optimization of lateral resolution as well as depth resolution, sputter yield or avoiding sample contamination by selecting the most suitable ion species. Combining the LMAIS with a high-precision laser interferometer stage, the Raith VELION FIB-SEM offers new process pathways reaching from nm-sized feature to wafer-scale patterning.

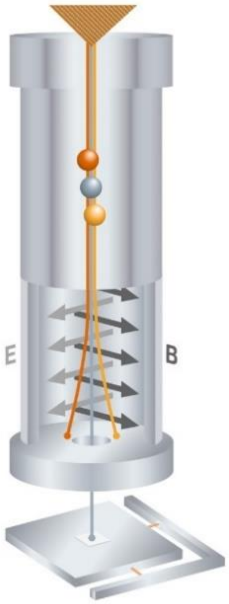
Besides nanofabrication, novel 3D ion microscopy imaging workflows have become possible thanks to the top-down FIB geometry on the VELION, becoming thus a powerful ion microscope for sample 3D reconstruction. Milling with bismuth allows a fast and homogeneous surface sputtering at highest depth resolution, while switching to Lithium ions enables 2D imaging at high lateral resolution (down to 1.5 nm).

In this contribution, we present the latest advances in LMAIS source technology along with related applications such as resist based ion beam lithography and introduce 3D ion microscopy using both light and heavy ions from LMAIS.

[1] Lei Zhang et al., Nanotechnology 31 325301 (2020)
[2] N. Klingner et al., Beilstein J. Nanotechnology. 11, 1742 (2020)
[3] L. Bischoff et al., Appl. Phys. Rev. 3, 021101 (2016)
[4] W. Pilz et al., JVSTB 37, 021802 (2019)



Left: Bismuth ions and Lithium ions are applied alternately for 3D ion microscopy. Bi beam milling is used to ensure smooth and fast sputtering of the sample surface. High-resolution images acquired with Li primary ions between the milling steps can be combined to obtain a 3D reconstruction of the sample.



Right: Setup of a top-down FIB equipped with a LMAIS source and a downstream Wien Filter for reliable and fast ion switching combined with a high-precision laser interferometer stage.