Multiple ions from a single source for nanofabrication with top-down FIB on a lithography platform

T. Richter, A. Nadzeyka, P. Mazarov, L. Bruchhaus, F. Meyer
Raith GmbH, Konrad-Adenauer-Allee 8, 44263 Dortmund, Germany
torsten.richter@raith.de

Focused Ion Beams (FIB) are broadly used in nanoscale science related applications, and they are inherently applied for direct nano-patterning, nanofabrication, resist based processes [1] as well as ion microscopy [2]. FIB has become established as a direct, versatile, and precise fabrication method of smallest features at high fidelity. In combination with a lithography platform unlimited process pathways from single digit feature size to wafer scale nanofabrication become possible.

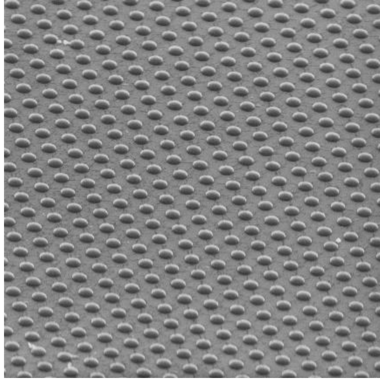
High demands are made on the focused ion beam in terms of beam stability, but also the sample stage requires a high degree of stability, stage accuracy and automation.

Liquid Metal Alloy Ion Source (LMAIS) is a versatile FIB source technology that is capable to deliver various ion species [3]. Light and heavy ions such as Silicon and Gold or Lithium and Bismuth are unified in a single source (AuGeSi or GaBiLi) [4]. Various ion species are emitted simultaneously from a single source and separated in a downstream Wien filter. This emerging source technology allows the optimization of lateral resolution with light ions as well as depth resolution, sputter yield or contamination by selecting most suitable ion species from the universal ion source.

Beyond nanofabrication, novel workflows for 3D ion microscopy become possible by leveraging LMAIS technology in combination with the excellent features of a lithography platform. In this way, the top-down FIB nanofabrication system becomes a powerful ion microscope for 3D tomography and sample reconstruction. Bismuth milling is used for accurate sample delayering at highest depth resolution, whereas light Lithium ions from the same source are applied to take high lateral resolution 2D images. Well known and established sample delayering strategies are applied to achieve best results.

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

[1] Lei Zhang et al Nanotechnology 31 325301 (2020)
[2] N. Klingner, G. Hlawacek, P. Mazarov, W. Pilz, F. Meyer, and L. Bischoff, Imaging and milling resolution of light ion beams from helium ion microscopy and FIBs driven by liquid metal alloy ion sources, Beilstein J. Nanotechnol. 11, 1742 (2020)
[3] L. Bischoff, P. Mazarov, L. Bruchhaus, J. Gierak, Liquid metal alloy ion sources - An alternative for focused ion beam technology, Appl. Phys. Rev. 3, 021101 (2016)
[4] W. Pilz, et al JVSTB 37, 021802 (2019)



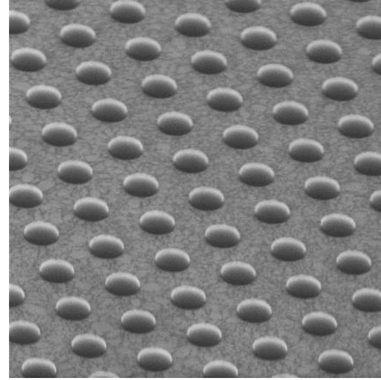
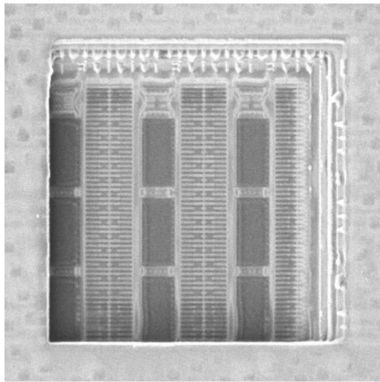


Figure 1: Li^+ lithography in SU8 resist (400nm) on Si substrate
Left: 50 µm field of view
Right: 20 µm field of view



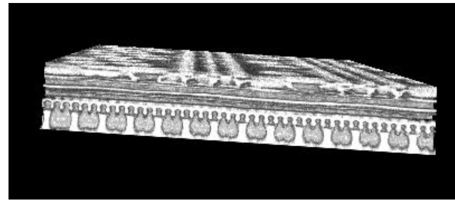


Figure 2: Bismuth ion beam milling strategies are effectively employed for uniform sample delayering while intermittent Lithium ion images are obtained.
Left: Delayered sample area (5µm x 5µm),
Right: 3D nano-reconstruction of the respective area