High-resolution imaging, nanofabrication and nanoscale analytics with light and heavy ions from a single source

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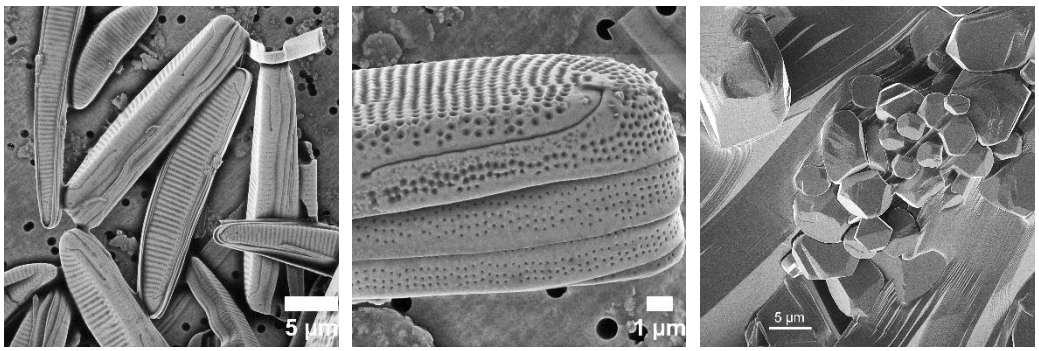
The Liquid Metal Alloy Ion Source (LMAIS) has been described as a high-impact technology offering new insights into the structure and function of nanomaterials [1]. Combining the high brightness of a Liquid Metal Ion Source (LMIS) with the capability of emitting light and heavy ions such as Silicon and Gold or Lithium and Bismuth simultaneously makes the LMAIS the ideal ion source for high-resolution imaging (Fig. 1), nanofabrication (Fig. 2), and nano analytics [2]. The ion species are emitted simultaneously from a single source and separated in a downstream Wien filter. This mature source technology allows for high-resolution Secondary Electron (SE) imaging with stunning surface detail by using light primary ions e.g. Li^+ as well as adjusting the required sputter yield and resolution for nanofabrication and sample modification by selecting the most suitable ion species from the LMAIS.
By adding a specifically designed compact magnetic sector mass spectrometer, the ion microscope is extended to be a high-resolution analytical instrument [3]. Secondary Ion Mass Spectrometry (SIMS) is a powerful and extremely sensitive surface analysis technique that can detect all elements from H to U and that provides trace element identification, isotope differentiation, elemental imaging at the nanoscale, shallow depth profiling and 3D analysis.
Our SIMS system takes advantage of the capability of selecting the optimum primary ion species for the analysis.
The SIMS system (Fig. 3) is based on:

(i) specifically designed secondary ion extraction and transfer optics for highest extraction efficiency and transmission, resulting in excellent sensitivity.
(ii) a compact floating double focusing magnetic sector mass spectrometer allowing operation in the DC mode at high transmission and hence avoiding secondary ion losses due to duty cycles like in TOF systems.
(iii) a focal plane detection system allowing the detection of all masses in parallel (up to 400 m/z).

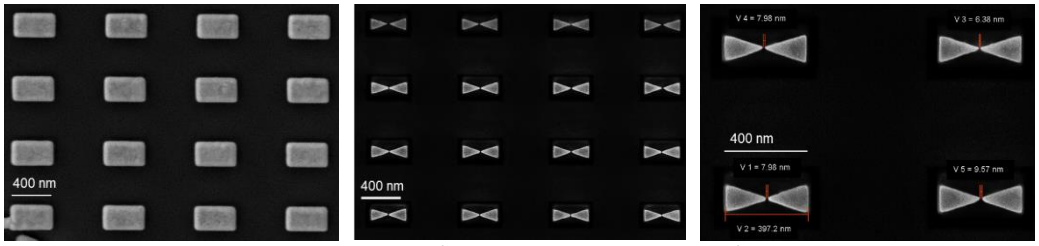
In this presentation we will show different use cases of our LMAIS based FIB platform in the field of ion imaging, nanofabrication, and nano analytics.

[1] L. Bischoff et al., Applied Physics Reviews 3, 021101 (2016)
[2] A. Nadzeyka et al., J. Vac. Sci. Technol. B 41(6) (2023)
[3] J-N. Audinot et al., Rep. Prog. Phys. 84 (2021)



(a) *(b)* *(c)*

Figure 1: Li^+ (SE) Images of (a, b) diatoms, (c) Bi2-Ca2-Co compound,



Large volume Bi^+ milling at high sputter yield

Li^+ fine shaping

Li^+ ion beam milling for gap optimization 9.6nm, 8.0nm, 6.4nm

Figure 2: 2-step nanofabrication workflow: Bismuth milling at high sputtering yield and Lithium fine shaping for <7nm gap size.

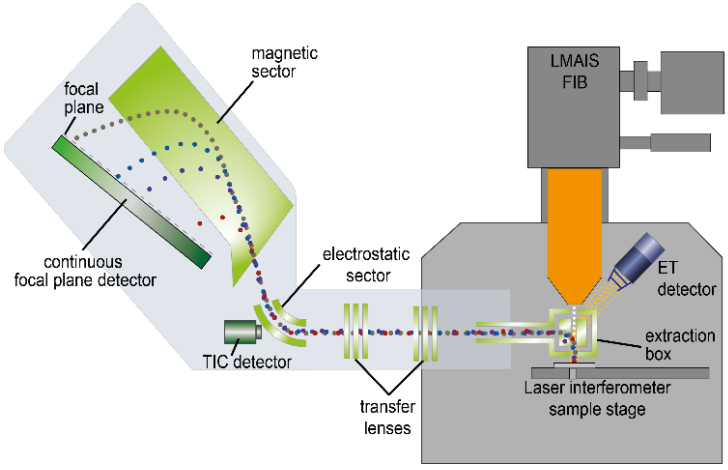


Figure 3: Schematic setup of the FIB-SIMS system