An analytical ion microscope for high-resolution imaging, nanoscale analytics and nanofabrication

Peter Gnauck[1], Torsten Richter[1], Alexander Ost[1]
[1]Raith GmbH, Dortmund, Germany

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, nanofabrication, and nano-analytics (Fig. 1) [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 exceptional surface details by using light primary ions 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.

With a top-down FIB geometry and capability of fast ion toggling a novel workflow for 3D sample reconstruction with sample tilt becomes possible: heavy ions have an excellent depth resolution for sample delayering. The selection of various beam paths or looping strategies as known from many applications in nanofabrication minimize selective sputtering and redeposition while digging into the sample.

Intermittent imaging with light ions prevents further sputtering and allows 2D sample imaging for mapping the region of interest layer by layer. Obtained ion images are then stacked for 3D sample reconstruction [2].

By adding a specifically designed compact magnetic sector mass spectrometer, the ion microscope becomes a high-resolution analytical instrument [3].
Secondary Ion Mass Spectrometry (SIMS) is a robust and highly sensitive surface analysis method capable of detecting all elements ranging from hydrogen to uranium. It offers trace element identification, differentiation of isotopes, elemental imaging at the nanoscale, shallow depth profiling, and three-dimensional analysis.

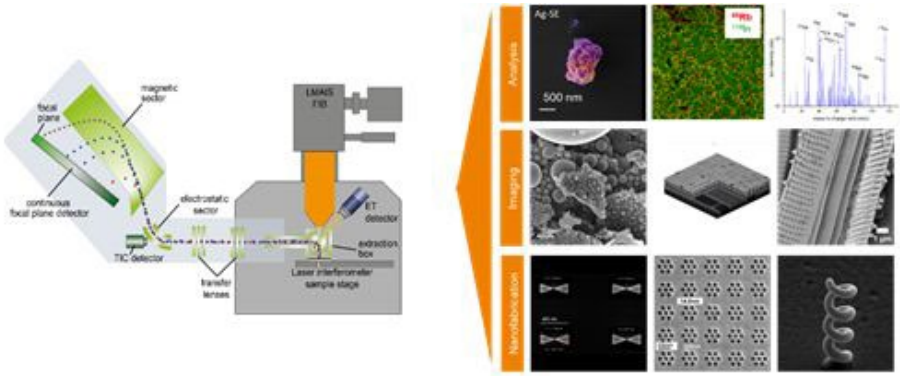
By selecting the most suitable ion species from the LMAIS the SIMS system takes advantage of the LMAIS technology by selecting the most suitable primary ion species for the analysis.

The SIMS system 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).

This contribution outlines the working principles and features of the focal plane magnetic SIMS detector combined with a LMAIS. By combining LMAIS technology with a stable stage and sensitive SIMS unit, this system offers a pathway for advanced nano-analytics, surpassing conventional methodologies for sample analysis.

Graphic:



Keywords:

FIB, SIMS, LMAIS, Microscopy, Ion

Reference:

[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)