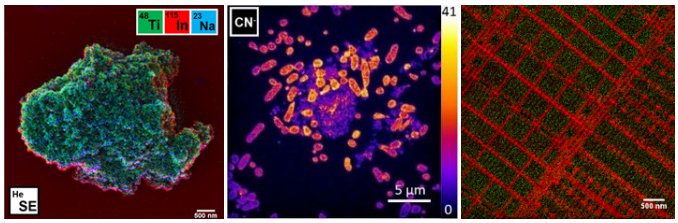
Instruments for correlative microscopy

SIMS system for the Helium Ion Microscope

Secondary Ion Mass Spectrometry (SIMS) is an extremely powerful technique for analyzing surfaces owing in particular to its excellent sensitivity, high dynamic range, very high mass resolution and ability to differentiate between isotopes. During the past several years, we have been performing a multidisciplinary R&D effort combining fundamental research on particle matter interactions, instrument development and application development to develop the HIM-SIMS, which is a unique tool for high-resolution high-sensitivity correlative microscopy.

Considering that the highest-resolution ion beam (sub nm spot sizes!) is obtained by the so-called Gas Field Ion Source (GFIS) technology, and taking into account that He+ and Ne+ are the ions most efficiently created by the GFIS process, the team investigated in detail the interaction between energetic He+ and Ne+ ions and surfaces (both soft and hard matter). This newly gained fundamental knowledge on e.g. sputtering and ionization mechanisms allowed the team to develop strategies to optimize the ion emission from samples exposed to GFIS beams. Encouraged by these new findings, we developed in a second step a compact but high-performance SIMS spectrometer consisting of high-efficiency secondary ion extraction optics, post-accelerating transfer optics and a double focussing magnetic sector mass spectrometer allowing parallel detection of all elements and isotopes. This SIMS system has been successfully installed and tested on the Zeiss ORION Helium Ion Microscope (HIM), which uses the GFIS as key enabler and which has emerged during the last few years as an ideal tool for nano-imaging and nano-fabrication.

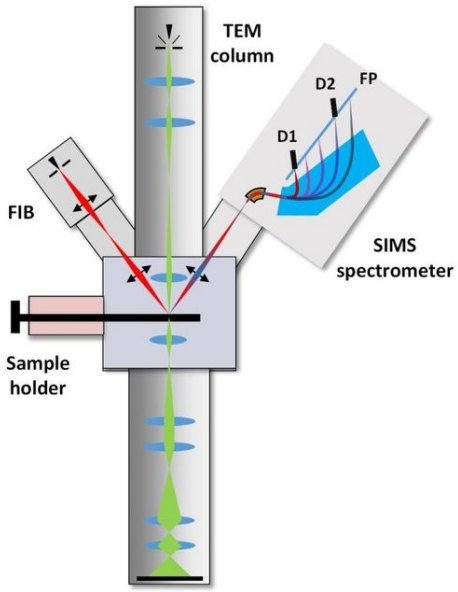
During a beta-tester phase, the team has installed 5 SIMS systems all over the world. These instruments have led to excellent results , ranging from a world record resolution in SIMS of 10 nm to applications in various R&D areas (e.g. toxicological studies on nanoparticles, photovoltaics, etc), so that the HIM-SIMS has become a commercial product in 2018 and is now manufactured and commercialised via Luxembourg Ion Optical Nano-Systems , a Luxembourg based spin-off company from LIST.

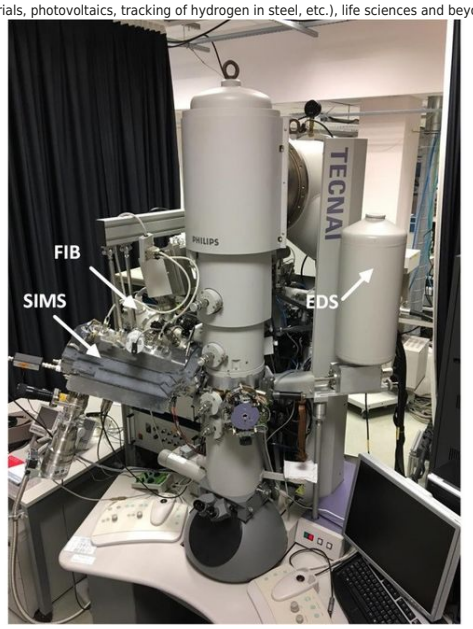


Contact: Tom WIRTZ & Jean-Nicolas AUDINOT

Integrated TEM-SIMS instrument

Transmission Electron Microscopy (TEM) is a well-known technique for high-resolution structural imaging down to atomic scale. However, the conventional analytical techniques associated with TEM such as Energy-Dispersive X-Ray Spectroscopy (EDX) or Electron Energy-Loss Spectroscopy is inadequate for the analyses of trace elements (< 0.1 at. %) or isotopes. Analysis of light elements is particularly challenging by EDX. SIMS has the advantage of high-sensitivity down to the ppm level and all the elements in the periodic table can be analyzed, including isotopes. However, the lateral resolution in SIMS imaging is fundamentally limited to ~10 nm, which is more than two orders-of-magnitude poorer than TEM. To combine the benefits of TEM and SIMS in a single instrument, we developed an in-situ TEM-SIMS instrument. The concept was realized by modifying the octagon of a FEI Tecnai F20 TEM (80-200 kV) to accommodate a FIB and a SIMS around the TEM objective lens pole-pieces area. The FIB is a commercial FEI Magnum with Ga+ source operating at 30 kV. A special high-voltage TEM sample holder which can be biased to ±4.5 kV was developed for enhancing secondary ion collection efficiency. The secondary ion extraction optics and a compact mass spectrometer was completely designed and developed in house. The performance of the in-situ TEM-SIMS instrument and the benefits of correlative microscopy have been demonstrated. Ongoing research focuses on the development of analytical strategies and optimization methods for the characterization of various types of samples taken from a range of applications in materials science (e.g. battery research, energy materials, photovoltaics, tracking of hydrogen in steel, etc.), life sciences and beyond.





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Technologies liées

- Instrumentation for nano-analytics
- Correlative methodologies and workflows in materials science and life sciences
- Data treatment and visualization for correlative microscopy
- Particle – matter interactions for ion microscopy

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