Dual Beam Helios Nanolab 600 and 650

In the Clean Room facilities of the INA-LMA, several lithography facilities permit to pattern structures at the micro- and nano-meter scale and to create devices. In particular, the two dual beam instruments (Helios 600 and Helios 650) assigned to the nanolithography and lamellae preparation areas are located on two concrete platforms inside the 125 m^2 10,000-class Clean Room.

The Dual Beam Helios 600 model consists of a 30 kV field-emission scanning electron column and a 30 kV Ga focused ion beam placed at 52º one from each other. The ion column is able to work properly at low voltage (5 kV and lower), allowing the preparation of lamellae with low ion damage. In this equipment, there are five gas injectors which allow the growth of nano-deposits with high resolution, such as W-based superconducting nano-deposits with lateral size of 40 nm and Co-based ferromagnetic nano-deposits with a lateral size of 30 nm. These ultranarrow dimensions are at the forefront of research in these topics. In addition, electrical microprobes (Kleindiek®) could be placed inside the chamber for *in-situ* electronic transport measurements; electron beam lithography is also possible thanks to a Raith® software/hardware.

The Dual Beam Helios 650 model is an improved version of the Helios 600 one. Thus, the SEM column has resolution of 0.9 nm and it bears a monochromator and beam deceleration. The FIB column is differentially vacuum-pumped at the lowest part, allowing a well-defined beam profile impacting on the sample surface. Results with such a column indicate that ultranarrow nano-deposits can be grown. This Focused Ion Beam (FIB) column is nicely suited for lamellae preparation too, in combination with the Omniprobe nanomanipulator. The equipment has got 5 gas injectors and electrical microprobes (Kleindiek®).

Both instruments are working properly for the requested main tasks, i.e., lamellae preparation, cross-section imaging, nanolithography based on ion patterning, ion/electron nanodeposition, electronic transport measurements and electron beam lithography (Raith® software/hardware).

The expertise of our scientific and technical staff is also offered to researchers from public and private research centers and also to professionals from industrial sectors that require the use of this instrument.

What can be done with these instruments?

Image (resolution 1.4 nm)/ **Analysis**:

By using the different detectors available within these instruments, the following information can be obtained:

- Image with secondary electrons and topography by means of an ETD/TLD (Everhart-Thornley Detector */ Through Lens Detector)*.
- Image (back scattered electrons) and composition by using a BSED (Back Scattering Electron Detector).
- Images of secondary ions sensitive to crystallographic direction by using CDEM/ICE (Channel Detection Electron Multiplier / Ion Conversion and Electron) detectors.
- Elementary Chemical Analysis by EDX (Energy-Dispersive X-ray micro-analysis).
- STEM (scanning-transmission) images.

Nanofabrication (lateral dimension between 50 nm and tens of microns):

- Direct FIB: focused ion beam; etching of a predesigned motif over the sample.
- Direct FEBID/FIBID: focused electron/ion beam induced deposition.

PRECURSOR GASES

$(CH_3)_3(CpCH_3)Pt$, $Co_2(CO)_8$, $W(CO)_6$, TEOS + H_2O → SiO_2, Selective Carbon Mill ($MgSO_4 \cdot 7H_20$), I_2, XeF_2

- Indirect: e-beam lithography (Raith®).

Micromanipulation

- Lamellae preparation for TEM observation– Omniprobe®.
- Micro-tweezers (Kleindiek®).

***In-situ* electrical measurements**

- 4 Microprobes Kleindiek®.

Sample requirements

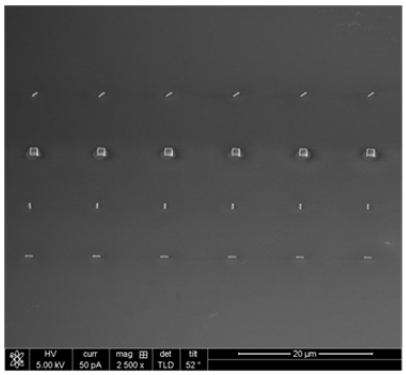
- Non-conductive samples must be coated with a conductive material (by sputtering or evaporation, which can also be done in our Centre).
- Conductive and non-conductive samples as bulk, films, powder (compacted), etc. can be studied.
- Samples should be compatible with high vacuum conditions.
- Dimensions of the samples: less than 1 mm to 100 mm (sample height < 10 mm).

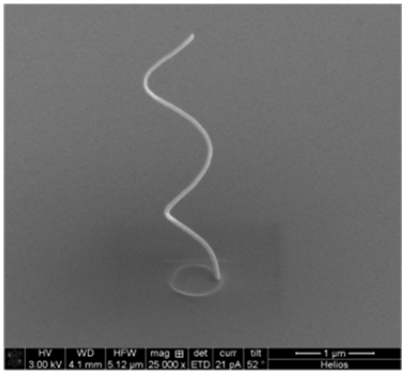
Technical Specifications

Electron beam resolution	0.9 nm at 5 kV
Ion beam resolution	4.0 nm at 30 kV
Landing voltage range	E-beam: 20 V - 30 kV I-beam: 500 V - 30 kV
Probe current	E-beam: 0.8 pA up to 26 nA I-beam: 0.1 pA - 65 nA (15 position aperture strip)
High Precision 5-axes motorized stage	XY: 150 mm, piezo-driven Z: 10 mm motorized T: - 10° to + 60° R: n x 360° (endless), piezo-driven Tilt accuracy (between 50° to 54°): 0.1° X,Y repeatability: 1.0 µm Compucentric rotation and tilt
Chamber vacuum	< 2.6*10-6 mbar (after 24 h pumping)
Sample size	Maximum size: 150 mm diameter with full rotation (larger samples possible with limited rotation) Weight: max. 500 g (including the sample holder)

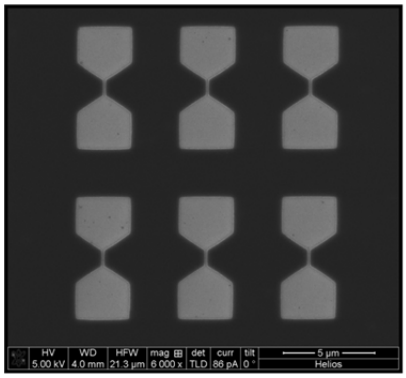
Images

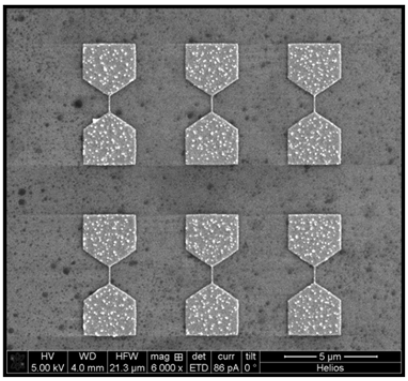
Growth of nano-deposits with high resolution:



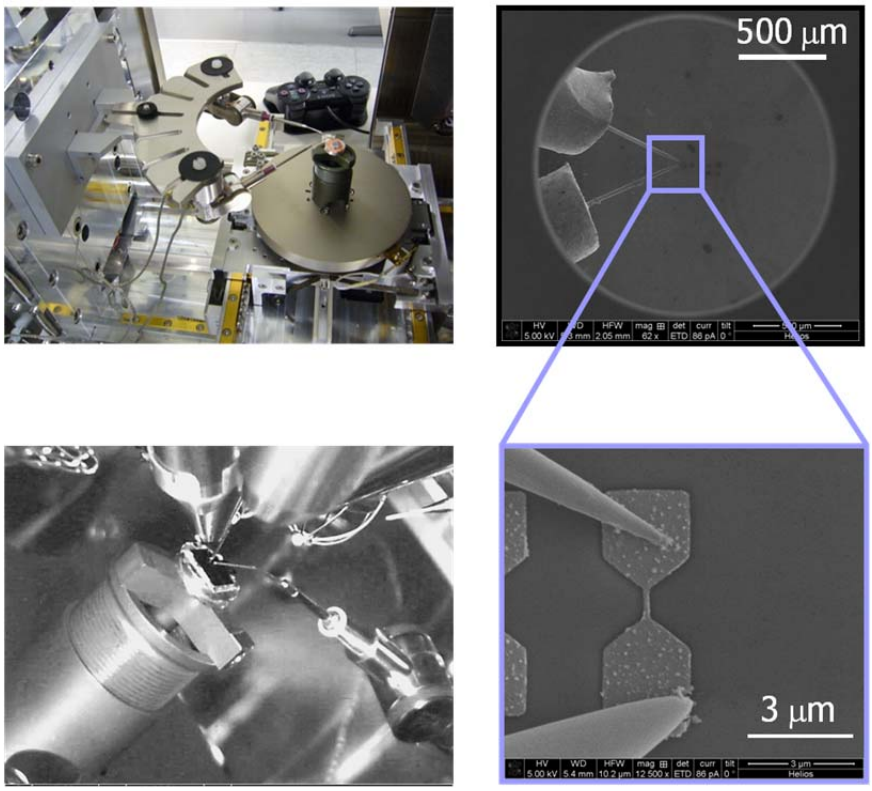


EBL: electron beam lithography (Raith® software/hardware)





Electrical microprobes (Kleindiek®)



Lamellae preparation (Omniprobe® micromanipulator)