Zeiss Orion NanoLab - He microscope and ion beam

Link to Zeiss Scientist video presentation

Functionalities:

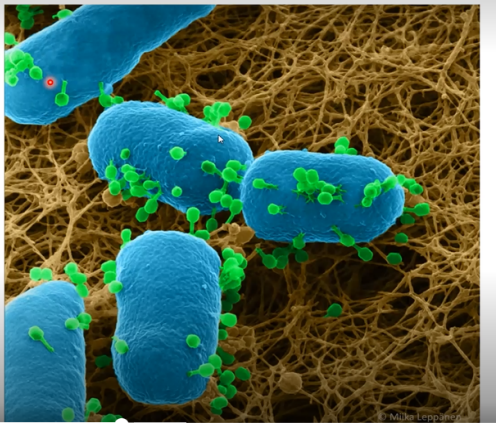
- This is Helium only microscope and ion beam (nanofabrication) system.
- It can pattern structures with sub 10 nm resolution just with the He source.
- It can also be used as a He microscope with a resolution of 0.5nm (1nm if the room doesn't meet the installation requirements). This He microscope is great for bio materials (maybe there will be interests from Bindley) and non-conductive samples.
- The system from IBM has all the piping to work with Neon, it just needs the canister and apertures to be upgraded. There is an option, which was not quoted in the documents we received, to upgrade this tool to add a Neon canister for larger patterning (2nm resolution). However the lifetime of the trimer (tip producing the beam) is shorten by Ne, and it requires often maintenance.
- The system also comes with a FIBIX system, similar to Reith, which is designed to create complex patterns with the Zeiss Nanolab.
- System doesnt have a Gas Injection Sytem (GIS), however third party options are available
- Plasma cleaner for C contamination

Applications:

Phage Bacteria Imaging with Helium Ion Microscopy

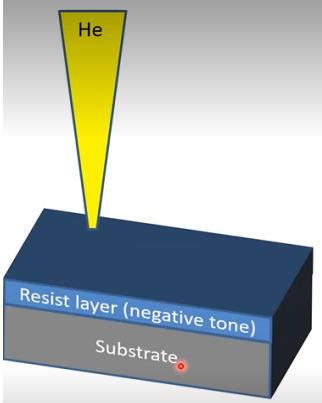
Background:

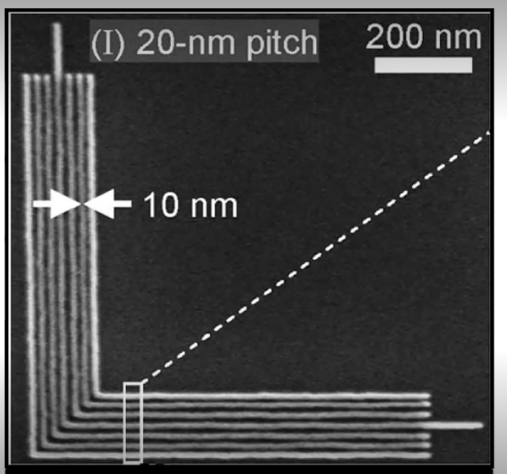
Result: HIM Images of T4-Phages attacking E-coli bacteria on an agar substrate. Some phages have attached themselves and already injected their genome so new phages can be created. FOV ~ 2.5 microns. Manually colorized.



Imaging Bacterial Colonies and Phage-Bacterium Interaction at Sub-Nanometer Resolution Using Helium Ion Microscopy. Miika Leppänen, Lotta-Riina Sundberg, Elina Laanto, Gabriel Magno de Freitas Almeida, Petri Papponen, and Ilari J. Maasilta Adv. Biosys. 2017, 1700070 DOI: 10.1002/adbi.201700070

NanoFabrication by Resist Lithography





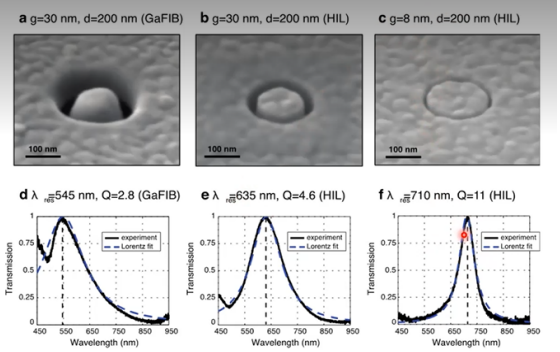
Scanning Helium Ion Beam Lithography with HSQ Resist – Winston, Cord, Ming, Bell, et al., JVSTB 27(6) 2009

Helium Ion Lithography: The helium beam exposed a 25 nm layer of HSQ resist to produce these fine structures after the resist was exposed.

Precision Sputtering of Plasmonic NanoResonators

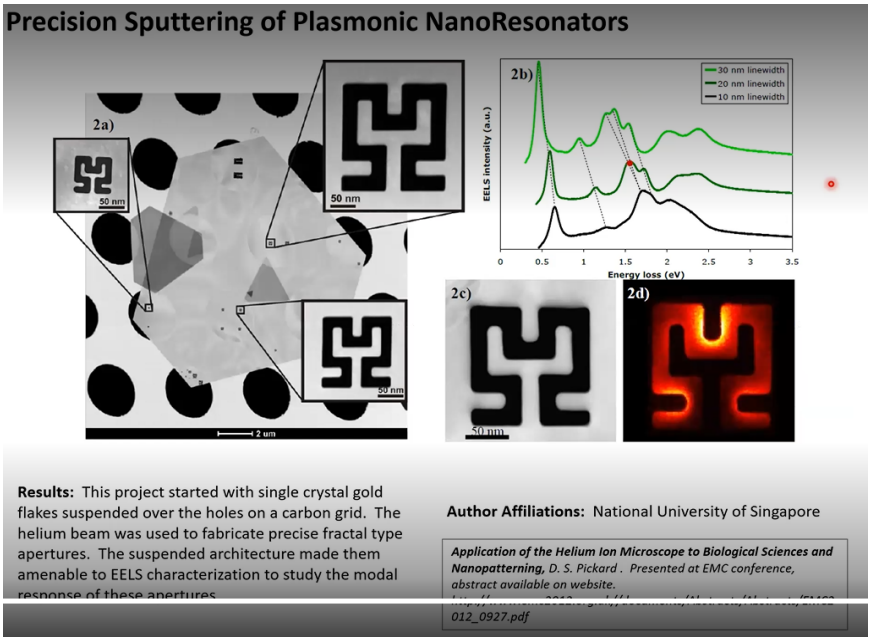
Background: Plasmonic devices are designed to have their charge distributions collectively resonate when excited by electromagnetic radiation. The resonant frequency is determined to a large extent on the geometry of the metal structure. Manufacturing these at the nanometer scale is chiefly limited by the available FIB technologies.

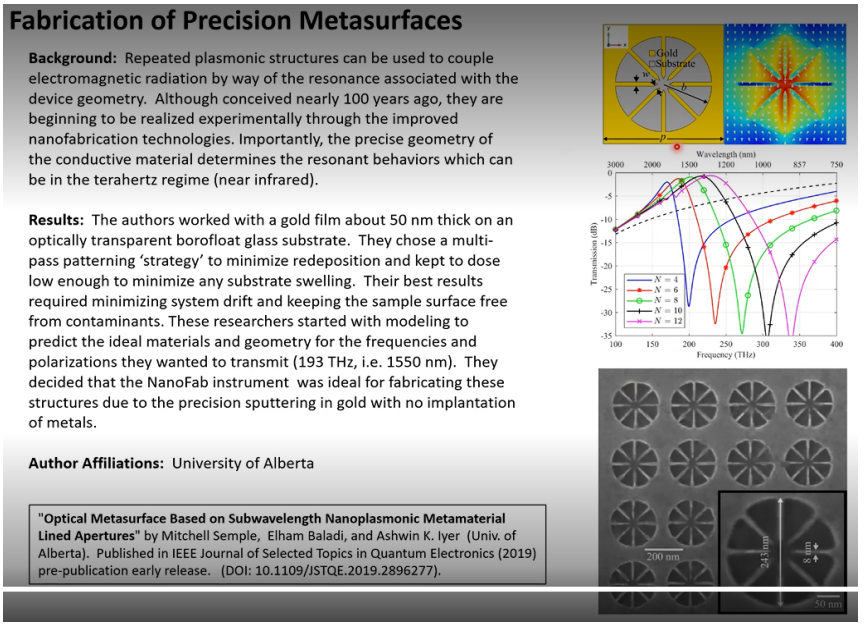
Results: These researchers compared coaxial resonators fabricated with the Gallium FIB to those created with the helium focused ion beam on the ORION NanoFab instrument. The substrate was a 100 nm thick layer of gold on fused silica. The helium beam produced much narrower gaps, and parallel sidewalls, and (of course) with no residual gallium. For these reasons, the researchers were able to achieve a resonant Q-factor as high as 11, near the theoretical limit for this geometry and these materials.



Author Affiliations: Lawrence Berkeley National Laboratory, Zeiss

Reaching the Theoretical Resonance Quality Factor Limit in Coaxial Plasmonic Nanoresonators Fabricated by Helium Ion Lithography, *by Melli, M., A. Polyakov, D. Gargas, C. Huynh, L. Scipioni, W. Bao, D. F. Ogletree, P. J. Schuck, S. Cabrini, and A. Weber-Bargioni. Published in Nano Letters 13, no. 6 (2013): 2687–2691. (dx.doi.org/10.1021/nl400844a)*





User Feedback:

- **Peng Li,** application scientist and manager at the **Nanofab at Alberta University**
  1. Their system has a Ga FIB additionally to the He microscope, but both modes don't compliment each other. They only use He patterning mode for fine lines and imaging but do not use He beam to pattern on top of a Ga pattern for example. Helium doesn't get rid of Ga implantation.
  2. The He orion nanolab is part of a core facility in their nanofabrication and characterization lab. They trained users with no experience and with vast experience in SEMs and FIBs, in both scenarios staff scientists guide or train the user, and set up the microscope for imaging and patterning.

3. They do not have a dedicated staff member for this one tool. There are a total of 5 staff scientists taking care of the characterization tools. Each staff manages 4 tools, but there is a primary and a secondary staff maintaining the tool and training/services. In this model for instance, the staff scientist in charge of SEM, XPS, and FIB Plasma, is also in charge of the He microscope.
4. When they bought the system, they paid in advance for a 4 year service contract. After the 4 year contract, they opted for not having a service contract anymore, they pay as the machine breaks which is not that often.
5. They opted out from using Ne as the lifetime of the trimer is reduced significantly. Later on they bought a plasma FIB which has other sources with similar capabilities as Neon.
6. Depending on the model and year, the system is easy to use and easy to train, but applications are very specific and limited to small lines or geometries.

- **Olga Ovchinnikova,** staff at **Oak Ridge National Laboratory**
  1. This instrument will need to be staffed by a full time position at post-doc level
  2. The highest level service contracted would be needed to keep the instrument running
  3. This is a fabrication tool and not an electron microscope when thinking about where it would be housed and managed.
