Introducing the Zeiss ORION NanoFab at the Birck Nanotechnology Center (BRK 1089): *Nanoscale Imaging and Nanofabrication*

The recent donation allows to bring to the Birck Nanotechnology Center the cutting-edge capabilities of the Zeiss ORION NanoFab (Figure 1), which is a revolutionary helium ion microscope taking nanoscale imaging and nanofabrication to new heights. This tool offers a tremendous range of new capabilities, from imaging, to analysis, to nanofabrication and to characterization. The high brightness, highly focused ion beams have only recently been available, and as such offer many new possibilities for usage in a wide range of applications.

Figure 1. Zeiss ORION NanoFab, HIM for Nanofabrication and technology at BRK 1089.

The ORION NanoFab uses a beam of helium ions, produced by a sharp tungsten tip, held at a temperature below 60 Kelvin and subjected to a high electric field, which is focused and scanned across the sample. Figure 2 shows three tungsten atoms at the tip's apex. The source technology, the sample interaction, and the contrast mechanisms are distinctly different from the traditional scanning electron microscope (SEM). The helium ion offers high brightness and a small energy spread, and hence allows the beam to be focused to small probe sizes. The ion beams can be precisely controlled with variable energy, variable beam currents, and with steering to achieve sub-nanometer beam positioning with sub-microsecond timing. As the ion beam interacts with the sample, the beam penetrates relatively deeply before it diverges and hence there is a narrow sample interaction region near the surface. The helium beam generates secondary electrons, from which images can be generated or analysis can be performed.

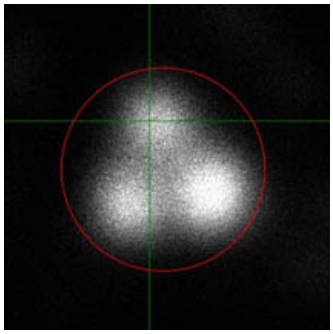

Figure 2. Trimer: three tungsten atoms at the tip's apex.

In short, the NanoFab serves as the operator's "eyes and hands" at the nanoscale. As "eyes", the ion beams generate images with incredibly high resolution. Depending on the sample and the imaging conditions, the images can reveal information through a range of contrast mechanisms that can include topography, compositional differences, crystal grains, and voltage contrast (see Figure 3).

In addition to imaging, the NanoFab can be used at higher dosages as "hands" in the nanoworld; that is, tools to modify and manipulate samples. For example, the ion beam's sputtering process can create precision cuts and drilled holes that are smaller than 5 nm (see Figure 4). Ion beams can also be used to implant dislocations into a material with an otherwise orderly atomic structure and correspondingly change the physical properties in the prescribed area.

Key Features and Benefits:

1. Unrivaled Resolution: The ORION NanoFab's helium ion beam delivers sub-nanometer imaging capabilities, revealing surface structures, defects, and compositions.
2. Charge Neutralizer: Since low ion current (in the pA range) is used, the surface charge can be relatively easy handled by the charge neutralizer.
3. Enhanced Nanofabrication: With the ORION NanoFab, precise nanoscale milling, etching, and deposition are at your fingertips, enabling the creation of customized structures and devices with exceptional accuracy.
4. Versatility for Diverse Applications: The ORION NanoFab caters to a wide range of research areas, including materials science, nanotechnology, semiconductor industry, life sciences, and more. Its adaptability and flexibility make it a powerful tool for exploring and pushing the boundaries of scientific discovery.

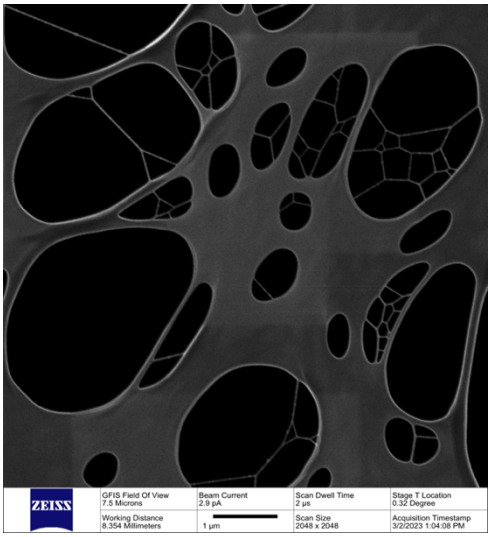

Figure 3. Graphene and carbon nanotubes

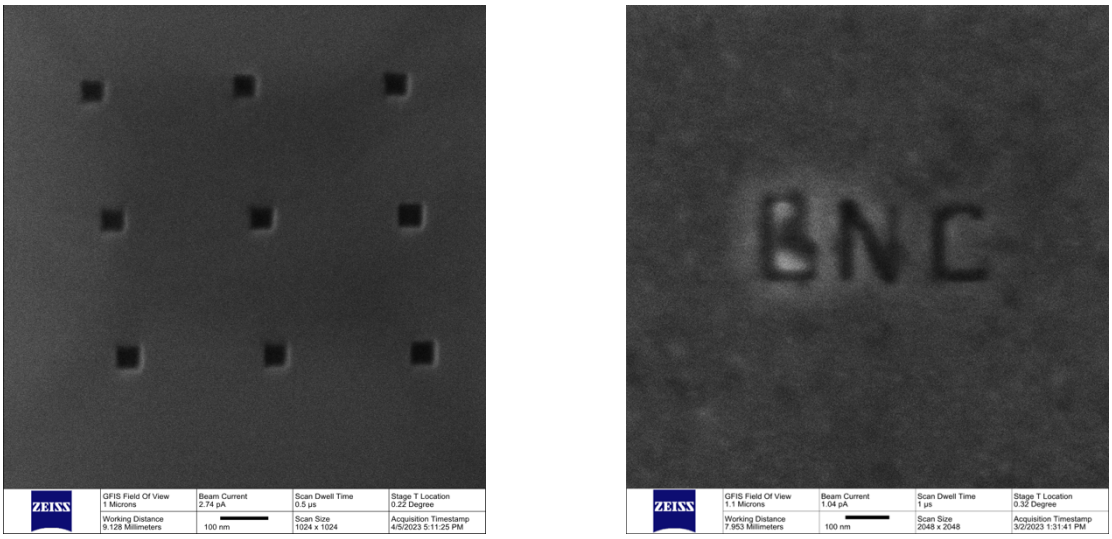

Figure 4. Examples of milling with He beam using the Zeiss ORION NanoFab.

Usage:

Please contact Dr. Dmitry Zemlyanov (BRK 1274, *dzemlian@purdue.edu*) if you want to use this versatile tool for high resolution imaging and manipulating matter on the nanometer scale.