Precision Material Modification and Patterning with Helium Ions

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The helium ion microscope has been primarily developed as an imaging tool, but being a charged ion beam instrument it also possible to do milling and sputtering tasks more commonly associated with a conventional Ga ion beam system (FIB). One distinct advantage of a helium ion system in milling and sputtering soft materials is the extremely low milling and sputtering rates. The Helium ion microscope being optimized for high resolution, boasts an extremely small probe size in the order of 0.5 nm or better, combined these two features make the system one of the most precise direct fabrication tools for suitable materials currently available. This presents the possibility of better device fabrication with novel physical properties.

There has been much interest in the formation of nanopores for development of methods of DNA and protein sequencing. It is possible to fabricate nanopores using the He ion beam. This is attractive since the pores produced do not suffer from ionic contamination. Nanopores can also be fabricated in substrates that have thin metal layers, (even multiple layers); such layers can be either thermally or e-beam evaporated onto a membrane. One application of interest is to fabricate a nanoscale fuel cell, using ionic flow through nanopores. An example of a Pt membrane with nanopores is shown below in Figure 1. Since the pore size is controlled and can be made uniformly symmetrical, such pores can also be used as apertures in near-field optical instruments and semiconductor devices.

In addition to employing resists like in the conventional lithography manner[1] (see paper presented at this conference). There are advantages in patterning directly due to the interaction volume of the helium ion beam and the physical interaction mechanisms (Figure 2). The Orion Helium ion microscope in use for these experiments has used a Nabilty pattern generation system (NPGS) to produce milling, etching test patterns and devices. We will present results of sputtering and milling rates of different materials and examples of precision milling and ion etching.

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1. D. Winston, B. M. Cord, M. K. Mondol, J. K. W. Yang, K. K. Berggren B. Ming, A. E. Vladar, M. T. Postek, D. C. Bell, W. F. DiNatale, L. A. Stern "Helium-ion Lithography with Hydrogen Silsesquioxane Resist", Proc. EIBPN 2009.

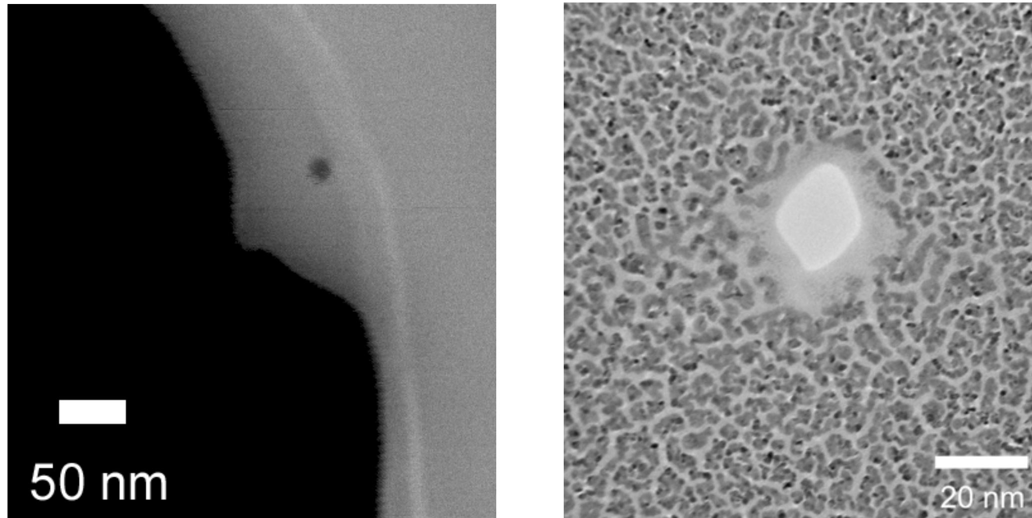

Figure 1. Left, nanopore drilled in a carbon based substrate. Right, Nanopore drilled with the helium Ion beam in a metalized layer coated SiN membrane.

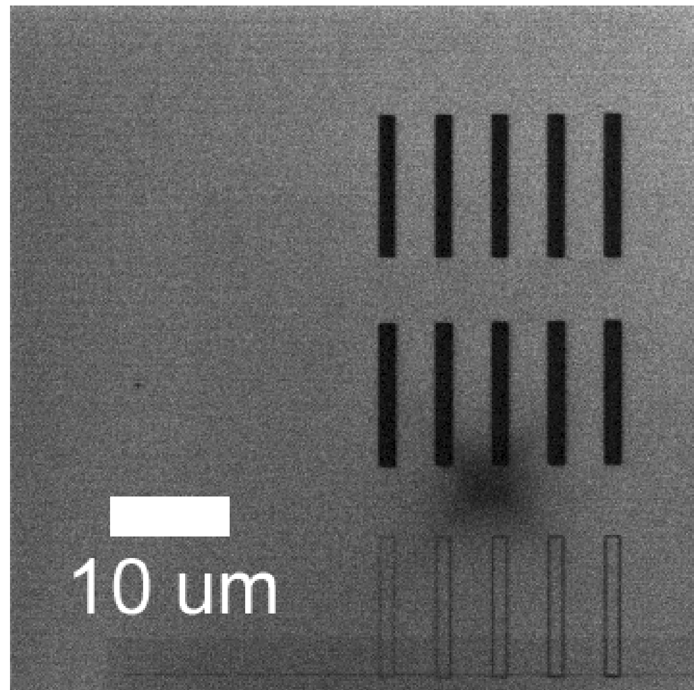

Figure 2. Direct writing etch patterns in SiO layer, indicating the ability to remove material and etch thin lines in suitable substrates.