Fabrication of Nanopores using a Helium Ion Microscope

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The production of artificial nanopores has become an area of intense research due to their potential use in diverse applications such as DNA sequencing and sub-wavelength optical confinement and amplification. Traditional nanopore fabrication is most often accomplished using either TEM or Ga-FIB based tools. Significant challenges are associated with both these techniques relative to fabrication speed and control of pore size and shape. In some applications, such as plasmonics, the implanted gallium from a Ga-FIB may result in additional complications due to localized changes in the electrical properties of the device. In this paper we present a new nanopore fabrication method using a Helium Ion Microscope (HIM).

The OrionPlus HIM is capable of delivering a helium ion beam focused to a spot size below 1 nm. Using this system, we have fabricated nanopores in substrates of various composition and thickness. In this paper, we report on the methods utilized for fabricating nanopores in silicon nitride membranes, having diameters down to 5 nm. Arrays of nanopores, such as shown in Figures 1 & 2, are easily produced using the HIM, with each pore taking less than one second to create. In addition to discussing the fabrication process, we also investigate ionic current through individual nanopores; a key feature in many promising bioanalytical applications.

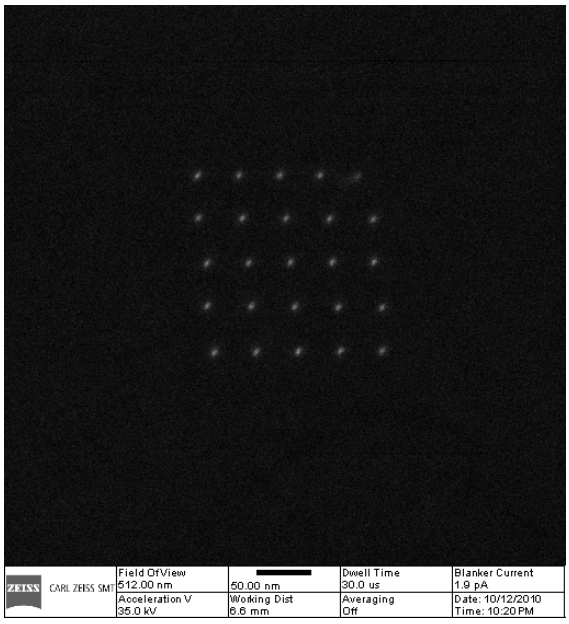

Figure 1: 5 x 5 Nanopore array created in a 50nm-thick silicon nitride membrane using a Helium Ion Microscope (I= 2pA). Pore diameters are ~5 nm using a dwell time of 0.5 s. Pores are imaged using a transmission detector within the HIM. The center-to-center hole spacing is 40nm. The entire array was produced in approximately 10 seconds.

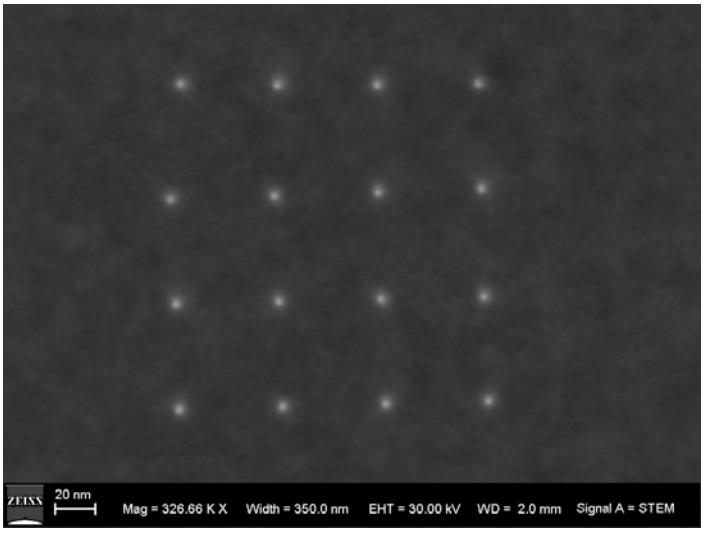

Figure 2: Scanning electron micrograph (using STEM detector) of a second array of nanopores created in a 30 nm-thick silicon nitride membrane using a Helium Ion Microscope (I=1 pA). Nanopore diameters are ~5 nm using a dwell time 0.3 seconds.