Wafer-scale Ion Beam Lithography of Nanopore Devices

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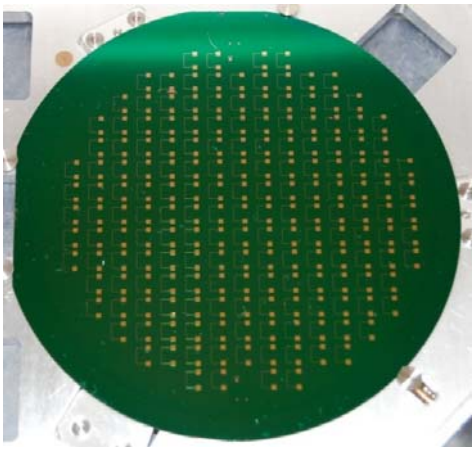
The quality and repeatability for fabrication of membrane-based solid state nanopore devices for applications such as DNA sequencing, molecule analysis and biological filtering is of scientific as well as commercial interest [1]. Pores used for single molecule transit can be judged by many attributes, they should be < 20 nm, of high quality (high degree of roundness), and have high aspect ratio. If pores are fabricated by direct ion milling, care should be taken to minimize substrate damage and contaminant ion implantation. Maintaining tight control over distribution of size and quality is also important for device response repeatability and therefore places certain constraints on the fabrication process.

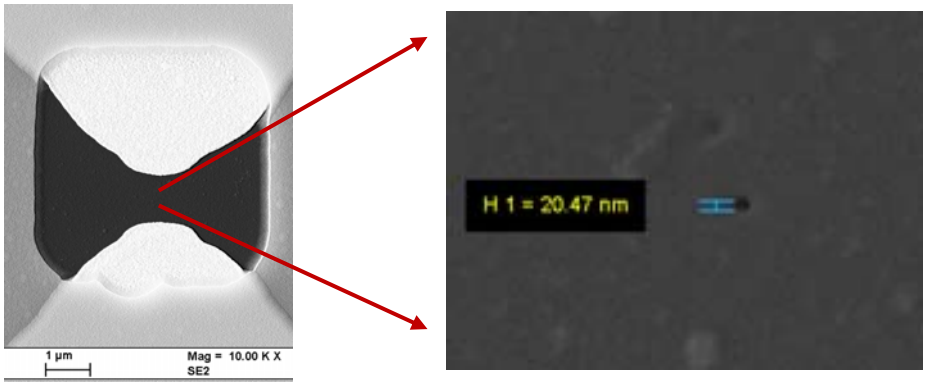
Solid state membrane-based nanopore devices have been fabricated using various direct write approaches (ion mill based like FIB-SEM and HIM, but also TEM) and resulted in varying degrees of quality, precision, repeatability and yield [1]. Here we report on results obtained using the Raith *ionLiNE*, a FIB tool designed exclusively and foremost as a lithography nanofabrication instrument. Nanopore devices are fabricated across a 4 inch wafer in an automated step-and-repeat manner using highly accurate laser interferometer controlled sample stage and automated height sensing system to maintain consistent beam focus. Results are given of high quality and repeatable 20 nm pores on 100 nm thick Si_3N_4 membranes which are distributed across the entirety of a 4 inch wafer.

References:

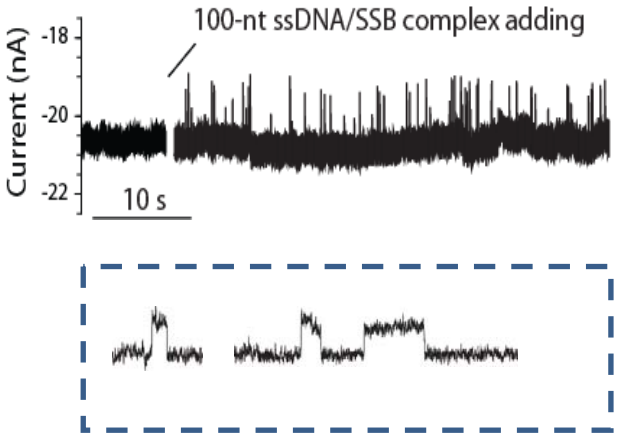
[1] J. Edel, T. Albrecht, Nanopores for Bioanalytical Applications: Proceedings of the First International Conference (ROYAL SOC OF CHEMISTRY, 2012).



4 inch wafer of 175 devices. Visible are connection pads and read-out electrodes.
Figure 1.



20 nm pore in 100 nm thick Si_3N_4 membrane between read-out electrodes of single device.
Figure 2.



Example of nanopore measurement of 100 nucleotide single strand DNA.
Figure 3.