Simulation and Testing of Helium-Ion Machined Fluidic Nanochannels

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We have developed a novel technique of 'directly writing' nanochannels by exploiting the 'unfavorable' bubble coalescence and swelling phenomenon in silicon substrates observed while machining with the Helium Ion Microscope (HIM). In previous work[1], we have demonstrated the ability to machine long, hollow cavities in this direct-write process. To our knowledge, no effort has been made to access the fluid conductivity of these nanochannels. This effort seeks to determine factors maximizing fluid flow and ultimately assess the fluidic viability of the nanochannel. Transitioning our efforts to virtual methods during Covid-19 restrictions we employed the use of the design of experiments (DOE) and finite volume methods to simulate fluid flow behavior in the nanochannel contributing to improved experimental parameters. Using DOE and modeling we gathered insight on optimized experimental parameters that would influence better flow across our device. Esmek et al.[2] have studied similar open-channel structures written using conventional FIB to create a stamping imprint method and analyzed the flow of single-molecule DNA in micro- and nanofluidic devices using fluorescence imaging techniques. Similarities in our nanochannel size and fabrication process merits adoption of this testing approach and our experimental results will be discussed. If successful, our approach may prove unique in the direct-write fabrication of small channels *embedded* in surfaces, which could be useful for the rapid-prototyping design of fluidic devices to transport nano-liter volumes of fluids for medical or thermal management applications.

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[1] K.L Klein, *et al*, EIPBN conference paper, 2017.
[2] F.R. Esmek, *et al*, Nanoscale 11, 13620 (2019).

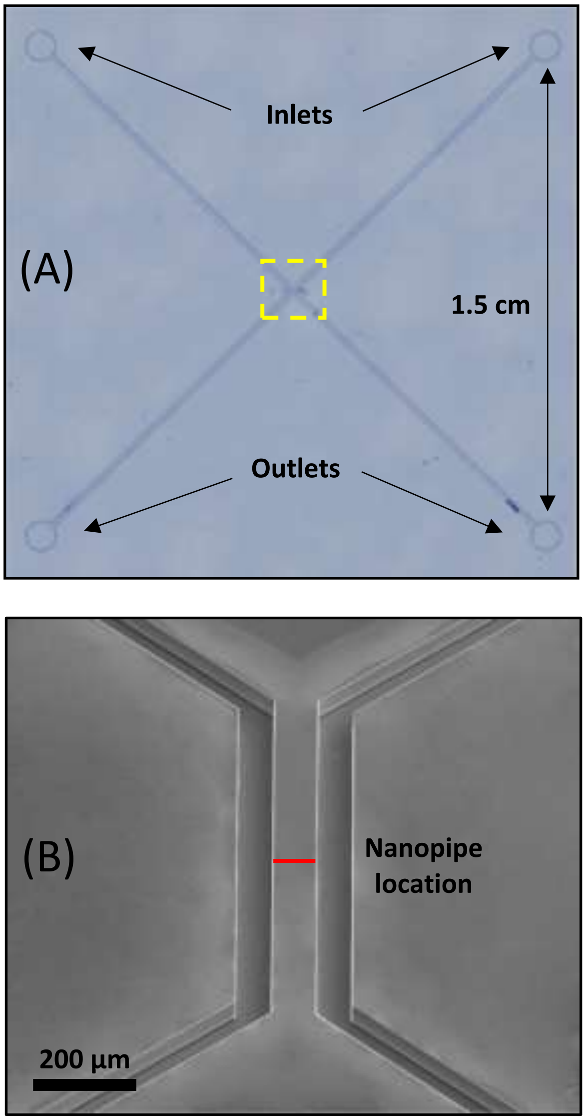

Figure 1: Fluidic test device.
(A) Optical image of a silicon chip showing the etched microchannels and scanning electron image showing the location (B) of the connecting helium ion machined nanopipe.