

Carbon Nanopipes for Nanofluidics Devices and *In-Situ* Fluid Studies

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In order to design nanotube-based nanofluidic devices, the behavior of fluids in carbon nanopipes (CNP)¹ (inner diameter 50-200 nm) and small diameter nanotubes (1-10 nm) must be carefully examined. The behavior of the fluids inside nanotube channels may be different from that in micrometer-size channels because of effects of surface tension, capillary forces and interaction with tube walls. We investigated CNP produced by chemical vapor deposition (CVD) using an alumina template [1]. Fig. 1 shows a sequence of Environmental Scanning Electron Microscopy (ESEM) images of these CNP obtained when the partial pressure of water in the ESEM chamber was raised in a controlled manner. These experiments were performed with the sample cooled to 4°C, in order to create environmental conditions corresponding to liquid/gas equilibrium.

Nanotubes can also be sorted and assembled in devices (Fig. 2) by means of dielectrophoretic forces [2]. In the experiments, we applied a 12 V_{pp} potential at 2 MHz between a pair of electrodes spaced 8 μm apart, exposing the CNT solution to the electric field for about 30 seconds.

This research program has visualized multiphase fluid motion in real time at length scales approaching molecular dimensions. We are developing new assembly and fabrication techniques for the manufacturing of nanofluidic systems. The project is likely to contribute to fundamental physics by providing information on the behavior of liquids under extreme confinement. Additionally, the project is likely to contribute to the fields of biology, medicine, and homeland security by facilitating the development of nanoscale biosensors and cellular probes.

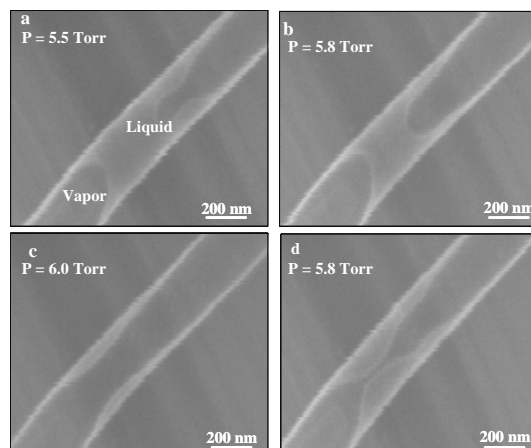


Fig. 1: Sequence of images obtained in the ESEM using CVD nanopipes, while observing a single open carbon nanotubule, which was originally empty (no fluid).

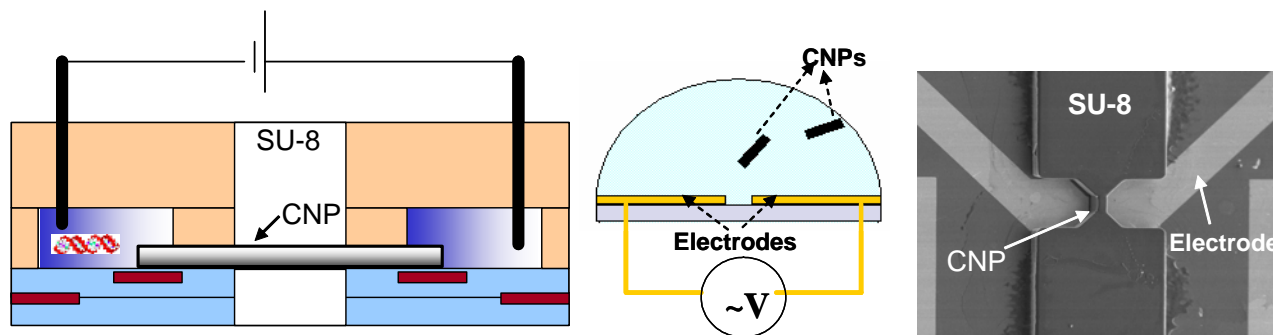


Fig. 2: Schematic of a CNP-based nanofluidic device, dielectrophoretic assembly and a SEM micrograph of the device.

References

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2. Riegelman, M., Liu, H., Evoy, S. & Bau, H. H. in *Proceedings of NATO-ASI: Nanoengineered Nanofibrous Materials* (Antalya, Turkey, 2003) Eds. S. Guceri, V.L. Kuznetsov, Y. Gogotsi, Kluwer, 2004.