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Experimental Methods for Nanofluidics: Focus On Sealing Technology for Delicate Nanomaterials

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Being the primordial solvent of life, water is essential to living organisms and human societies. The primordial role of water can be related to its unique physical properties particularly due to the structure of its hydrogen bond network or its dipolar moment. In extreme confinement situation, such as inside nanoscale channels, important modifications of these features are expected. Thus, many theoretical predicted that confined water in extremely small diameter pores exhibits unusual phase behavior[1] and structure compared to bulk water. Thanks to their stiffness, hydrophobic smooth surface and high aspect ratio, Single Wall Carbon Nanotubes (SWCNT) can be considered as a model nanochannel to get insight into the confinement of water molecules. As for instance, it was calculated that the phase of confined water in SWCNT which diameter is smaller than 1.4nm, behaves as ice-like water with structures from single file water chain to pentagonal or hexagonal structure depending on the SWCNT diameter [2]. On the other hand, it has been shown from experimental [3] and theoretical [4] calculations that water diffusion in SWCNT is significantly enhanced. Expanding our fundamental understanding of water properties when it is confined in SWCNTs can yield to substantial progress in desalination, drug delivery, energy harvesting, etc. applications. Although there are many numerical simulations reported on this system, only a few experimental works have been achieved and it remains a challenging task to get experimental proof on water behavior in such confined environment.

One of the main challenges to experimentally measure the properties of nanoconfined water is to be able to fabricate fully sealed microchips. Sealing is a central process for micro and nanofluidic chip fabrication, yet only a few materials can be used as they must be chemically inert, vacuum compatible, resistant to temperature change and must have no electrical effect.

In this poster, we will present a new sealing technology based on SU8 epoxy resist. We show that our bonding method is reliable and versatile for microfluidic, as it can be patterned by photolithography down to micrometric dimensions. It is thus found that a 30 μm high and 20 μm thick wall made of SU8 can sustain relatively pressures up to ~5 bars. We also measured ions permeation through the SU8 walls and found that it is similar or even better to PDMS. Electrical test shows no significant perturbation of electrical devices down to the sensitivity of our measurement set-up, i.e. pA, which makes the SU8 wall resistivity several orders of magnitude higher than that of carbon nanotubes. In addition, our sealing technology turned out to be chemically stable even at high temperature or under energy plasma. It is therefore perfectly suited for the fabrication of such as nanomaterials.

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