FIB etching of h-BN membranes for osmotic energy conversion.

S. Linas,[1] R. Fulcrand,[2] B. Poinsot,[1] F. Cauwet[1] and A. Brioude.[1]

[1] **LMI**, Laboratoire Multimateriaux et interfaces, 22 avenue Gaston Berger, 69622 Villeurbanne, France
[2] **ILM**, Institut lumière matière, 10, rue Ada Byron, 69622 Villeurbanne, France
sebastien.linas@univ-lyon1.fr, arnaud.brioude@univ-lyon1.fr

Confinement of fluids in channels is a versatile topic involved in promising applications such as energy generation [1], ultra-filtration [2] or DNA sequencing [3] . As the fluid confinement reaches the nano-scale, new phenomena arise and the nature of channels' walls gain more and more influence on the behavior of the fluid. Experimentally, nanotubes are an ideal nano-object for nanofluidics, offering channels from few to tens of nanometers in diameter over micrometer length-scale. Compared to carbon nanotubes (CNTs), boron nitride nanotubes (BNNTs) possess many advantages such as an improved chemical stability, better biocompatibility or a resistance to oxidation at high temperature. By highlighting the importance of the nature of the walls of the channels, BNNT are seen to be superior to CNT for nanofluidic applications: molecular dynamics calculations suggest that waters flows through BNNT of smaller diameter than CNT [4]. Due to a giant surface charge, BN is a good candidate for conversion of osmotic energy. A very recent experiment based on single BNNTs have shown that osmotic energy conversion reaches power density in the order of kW.m^{-2} [5] exceeding by several orders of magnitude the power density of other exchange membranes [1].

These extremely encouraging results concerning BN based membranes concern samples that are hardly producible at large scale. In order to benefit from the superior properties of BN while producing large-scale and high density membranes, demonstrate the use of a thin hexagonal boron nitride (h-BN) film patterned by focused ion beam (FIB) to etch nanochannels (Fig. a) [6]. FIB has been used to pattern the h-BN membrane with an arbitrary pattern (Fig. b) and to produce nano-channels arrays (20 to 100 nm in diameter) in a h-BN membrane specially designed for nanofluidic measurements that are currently ongoing.

References
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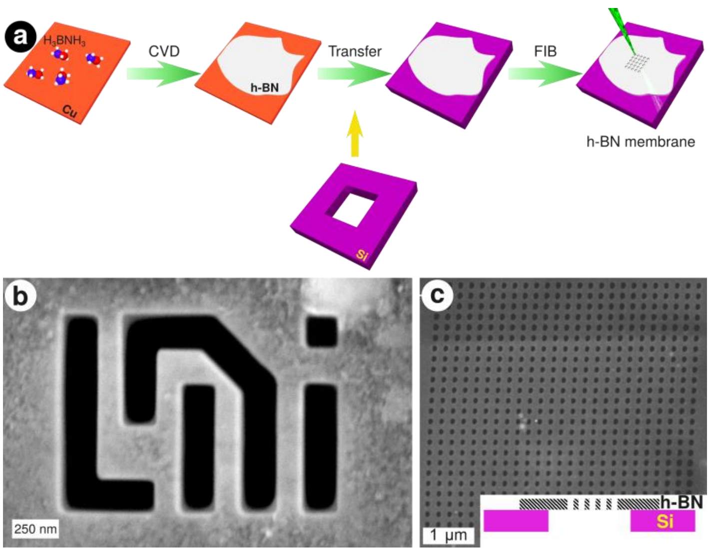

Fig. (a) Fabrication process of h-BN membranes. h-BN is first grown on copper foils, the copper is then etched in an ammonium persulfate solution. The floating h-BN film is transferred onto a hollow silicon substrate and patterned by FIB.

(b) "LMI", the logo of our laboratory patterned using FIB on a h-BN membrane.

(c) SEM image of the device schematized in the inset: a hollow Si/SiN substrate covered by a h-BN membrane patterned by FIB. This sample has been designed for nanofluidic experiments.