Electronic Supplementary Information

1. Preparation of ss-DNA and BPSM

ss-DNA preparation: Single strand DNA (ss-DNA) was prepared by the following steps: Bordetella pertussis genomic DNA was used as a template to synthesize a PCR fragment of 805 base pair using Go Taq Green Master Mix (Promega) kit protocol. Primers used for the PCR were from Sigma Aldrich, HPLC purified vipC forward primer (5'TTGAATTCGAGTTCGAGCCGGTGCTGG3') and vipC reverse primer (5'TTAAGCTTTTGCTGGTAAGGAATGCGCTG3'). Annealing temperature of 64.5ºC was used and the denaturation, annealing and extension cycle was repeated 25 times. Final elongation step was carried out at 72ºC for 10 min. The ds-DNA generated was then kept at 95ºC for 5 min to separate the two DNA strands to generate ss-DNA. PCR reaction was set up using Bio-Rad iCycler-thermal cycler PCR. Haemagglutinin was purchased from Zuellig Pharma. Other chemical reagents were purchased from Sigma Aldrich and used without a further purification. NaCl and HCl solutions were prepared using deionized (DI) water from a water purification system (Millipore SAS 67120 MOISHEIM).

Bacterial preparation: BPSM (Bordetella pertussis streptomycin resistant strain) was grown on sheep blood agar plates for 4 days. A loopful growth was taken to inoculate 10 ml SSAB media with streptomycin. The culture was grown for 24 hours at 37 ºC with continuous shaking. The OD (optical density) was measured and adjusted to 1×107 cfu/mL bacteria in PBS.

2. Detailed fabrication process for CNT nanofilter

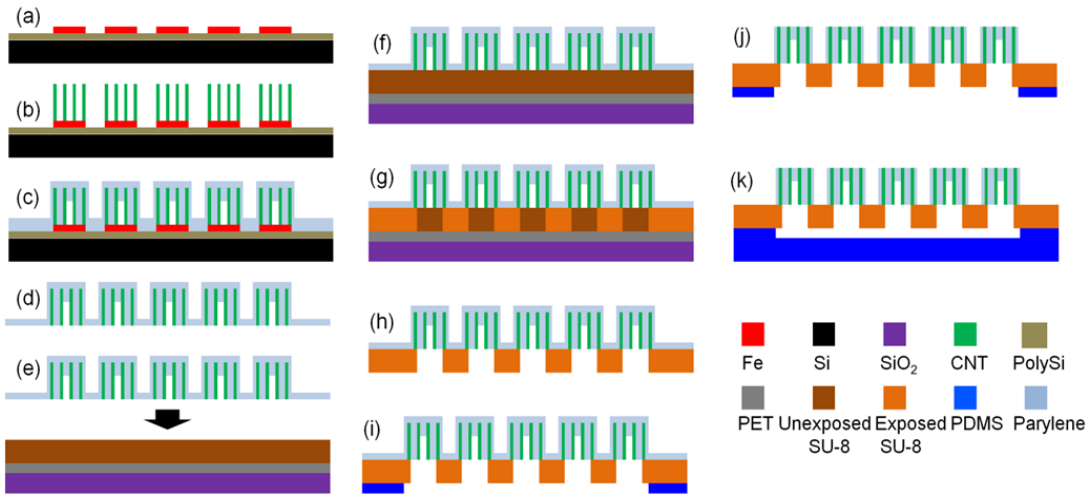

Figure 1. Fabrication process for stretchable membrane based nanofilters using patterned array of vertically grown carbon nanotubes

Figure 1 illustrates the fabrication process. The process began with thermal oxidation of single crystal silicon substrate to form a etch stop oxide layer. After the CVD of poly-silicon as a sacrificial layer, a 5 nm thickness of pattered Fe film, which acted as the catalyst film for the selective growth of CNTs, was prepared onto the silicon substrate (Figure 1(a)). As illustrated in Figure 1(b), the vertical aligned CNT bundles of 50 μm in height were grown via pyrolysis of acetylene at 800ºC with an Ar/NH_3 flow for 15 min. The CVD parylene-C was then

employed to fill into vertically aligned CNTs to reinforce the inter-tube binding at room temperature. Thus, the top side of CNTs was covered with parylene-C, and the discrete CNTs were bound together by parylene-C (Figure 1(c)). This step was the most critical process for forming the mechanical supporting layer for CNT bundles. The thickness of the flexible parylene-C layer was determined by the CVD process. To achieve reliable mechanical strength for following handling and process, 10 μm thick parylene layer was deployed. The parylene layer was peeled off together with CNT bundles from the substrate. Since the catalyst layer blocked the bottom ends of CNTs, the catalyst layer at the bottom of CNT bundles was etched by oxygen plasma from backside (Figure 1(d)). Then a prebaked SU-8 layer of 200 μm thickness on PET was prepared. PET is a kind of transparent soft film having low adhesion with SU-8. The PET film was fixed on glass slide by tapes to provide a rigid substrate for processing. The parylene layer was attached on the surface of SU-8 layer. The SU-8 layer was then melted at 95 ºC and cooled to room temperature. A good bonding between parylene and SU-8 was achieved (Figure 1(e) and 1(f)). After this bonding, well aligned microchannels under CNT bundles were patterned by UV lithography (Figure 1(g)). The diameter of the channel is 40 μm, smaller than the diameter of the CNT bundles, to ensure the SU-8 under parylene sidewalls around CNT bundles was exposed. The bonding between SU-8 and parylene sidewalls would finally provide sufficient mechanical bonding strength to fix the CNT membranes on SU-8 substrate. After UV lithography, the sample was post baked at 65 ºC for 10 min and 95 ºC for 30 min. Then the PET film together with SU-8 and parylene layer was released from glass slide by removing the tapes. The SU-8 layer together with the parylene layer was dry released from PET by slightly bending the PET film (Figure 1(h)). The released SU-8 layer was developed to form the microchannels. A bonding technique was developed for bond SU-8 with PDMS[1]. A thin PDMS film of 200 μm thickness with center area larger than the dimension of CNT bundle array cut off was prepared. The surface of this PDMS layer was treated with nitrogen plasma and attached to the bottom surface of SU-8 layer. The sample was baked at 120 ºC for 30 min. A permanent bonding between SU-8 and PDMS was achieved (Figure 1(i)). In this step, the thickness of PDMS must be kept low enough to avoid the poor quality bonding, which is due to the non-conductivity and the low plasma efficiency of the PDMS layer. After the bonding, the parylene layer was etched by oxygen plasma to open the sealed top ends (Figure 1(j)). In this process, the whole parylene layer was etched away except the parylene sidewall around the CNT bundles due to the anisotropic property of RIE . The adhesion between parylene and SU-8 was good enough to hold suspended CNT bundles as mentioned above. In the RIE etching process, the plasma generated large amount of heat. The temperature of SU-8 layer would rise to several hundred ºC during the long period of the 10 μm thick parylene etching. This high temperature would degenerate the bonding between SU-8 and PDMS. Thus, the whole etching process was divided into several periods to avoid over heating for samples. After etching away parylene on CNT bundles, the membrane was bonded with a thick PDMS layer (Figure 1(k)). This process is a conventional bonding between PDMS surfaces. Both PMDS surfaces were treated with oxygen plasma and bonded together. This thick PDMS layer allows us to connect tubes for further fluidic tests.

Reference

(1) Zhang, Z.; Zhao, P.; Xiao, G.; Watts, B. R.; Xu, C., Sealing SU-8 microfluidic channels using PDMS, *Biomicrofluidics* **2011**, 5, 46503–465038.