In-situ patterning of carbon nanotube thin-film structures by selective vacuum filtration

Chaehyun Lim, Chang-Seung Woo, Bonghyun Park, Dong-Hoon Min and Seung-Beck Lee*

Department of Nanotechnology and Division of Electronics and Computer Engineering, Hanyang University, 17 Haengdang-Dong, Seongdong-Gu, Seoul Korea, 133-791

*Email:sbl22@hanyang.ac.kr

Two dimensional network of carbon nanotubes are a promising electronic material for future applications to flexible thin-film electronic devices[1]. Of the various methods used for the fabrication of carbon nanotube network (CNTn), vacuum filtration method produces the most uniform distribution of carbon nanotubes and also allows density control making it possible for the CNTns to have reliable electrical characteristics[2].

Here, we report on a method which allows in-situ formation of device patterns while the CNTn is being formed. By lithographically patterning a resist layer on the filter membrane, the nanotubes will be guided to the exposed areas of the filter surface during vacuum filtration and the resulting CNTn will conform to the defined resist pattern. The schematic diagram of the selective filtration process is shown in Fig 1. Also, by directly molding a layer of poly-dimethylsiloxane(PDMS) on the surface of the membrane with the CNTn pattern, it is possible to directly imbed the CNTn device pattern into the elastomer surface resulting in the fabrication of a flexible and transparent CNTn device structure. The flexible CNTn device structure on PDMS is shown in Fig 2. The electrical characteristics of the flexible CNTN devices with various dimensions showed uniform square resistances and was reliably controlled with CNT density. Characteristics of NH_3 gas sensing operation is shown in Fig 3 which showed nanotube density dependent sensitivity to gas exposure. We will also present tensile strain and pressure dependent conductivity of the flexible CNTn devices and demonstrate mechanical reliability and its possible application as mechanical strain and pressure sensors.

[1] E. S. Snow, J.P. Novak, P.M. Campbell, and D. Park, Appl. Phys. Lett. 82, 2143 (2003).
[2] Z. Wu, Z. Chen, X. Du, J.M. Logan, J. Sippel, M. Nikolou, K. Kamaras, J.R. Reynolds, D.B. Tanner, A.F. Hebard, and A.G. Rinzler, science 305, 1273 (2004).

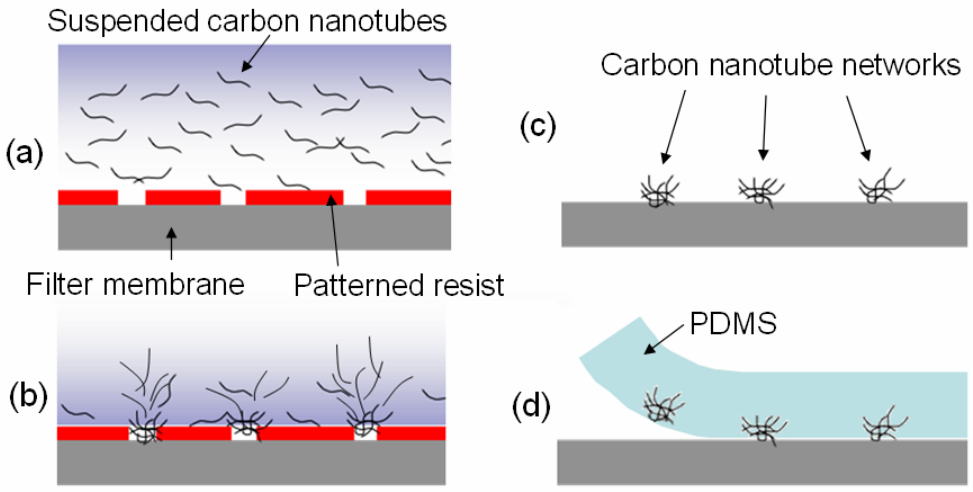

Fig. 1. Schematic diagram of the selective vacuum filtration process. (a) Before vacuum filtration, (b) during vacuum filtration, (c) after CNTn pattern formation and lift-off, and (d) PDMS direct molding and CNTn transfer

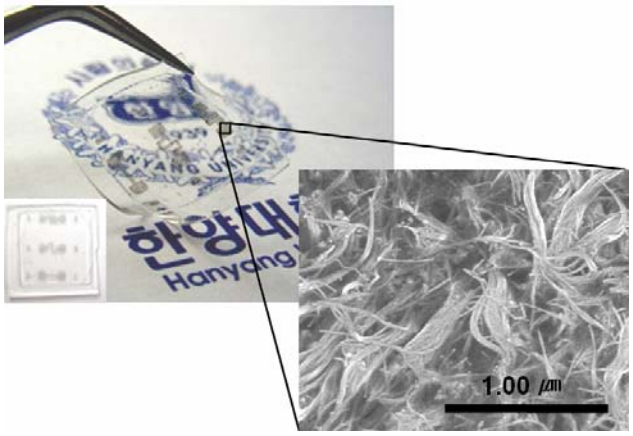

Fig. 2. Flexible CNTn devices fabricated by PDMS direct molding on patterned filter membrane surface. The magnified portion of the device surface shows the SEM image of the CNTn imbedded in the PDMS surface.

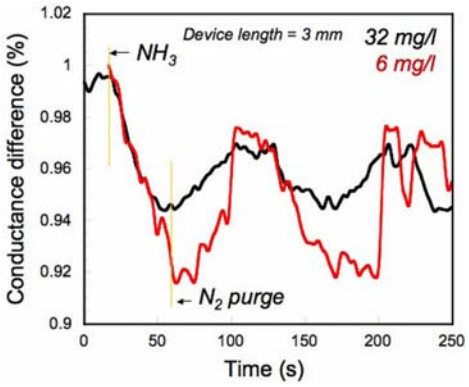

Fig. 3. Gas sensing characteristics of the flexible CNTn devices. The CNT density was controlled by setting the CNT amount in solution for the selective vacuum filtration.