CARBON NANOTUBE NETWORKS: EXCEPTIONAL ELECTRICAL PROPERTIES

B. Cardin St-Antoine, C. M. Aguirre, C. Ternon, D. Ménard and R. Martel.

Carbon nanotubes network open a promising route for the integration of nanotubes in electronics for that they circumvent major issues related to their fabrication. [1] Another advantage of networks over individual carbon nanotube transistors is their reduced device-to-device discrepancies because their electrical and optical properties derive from an ensemble of different nanotube species.

In our laboratory, we developed different fabrication schemes to obtain networks with either metallic or semi-conducting behaviour. Most interestingly, both kinds of networks were made with a blend of metallic and semi-conducting nanotubes from the same source (laser ablation). Metallic networks are produced by a filtration based technique while semi-conducting are made by spin-coating nanotube solution on a functionalised surface. We believe that the different electrical properties of those networks originate from the thickness variations of our films. In semi-conducting networks, the coverage is precisely controlled in order to allow the percolation of semi-conducting nanotubes, while remaining below the metallic percolation threshold.

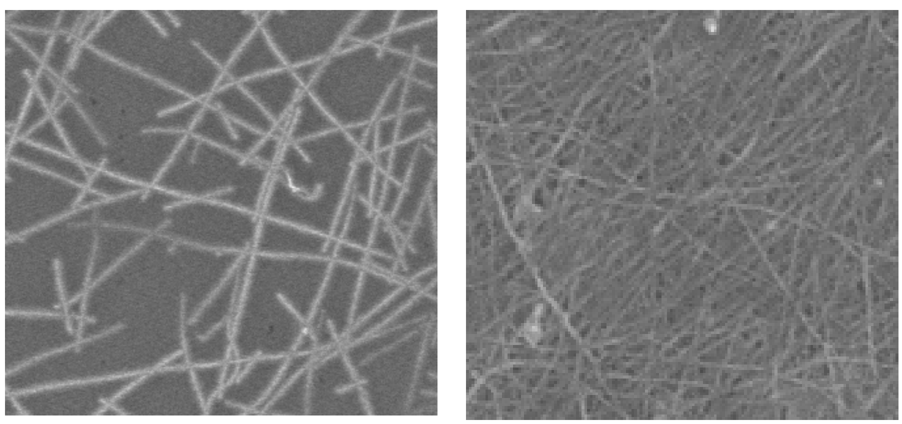

Figure 1. SEM images. On the left, a very sparse network which exhibits semi-conductive behaviour. On the right, a much more dense film with metallic properties.

The performances of those semiconducting network are very exciting. The transistors are stable in air and present a I_{on}/I_{off} ration of over 6 orders of magnitude. Semi-conductive carbon nanotube networks are generally p-type transistor but we achieve ambipolarity by encapsulating our devices with an organic layer. We measure mobility superior to 1 cm^2 s^{-1} V^{-1}, for the p type regime. Such mobility is outstanding when compared to other organic transistors. Combined with the mechanical flexibility of carbon nanotube films, it forecasts a bright future for carbon nanotube network transistors.

Filtration allows much thicker films, so that metallic nanotubes are above the percolation threshold. It is possible to fabricate thinner but still continuous films with this technique and monitor the transition from metallic to semi-conducting networks. Those networks were also optimised to improve their conductivity while keeping a good optical transparency, for OLED application.

Finally, we achieve to suspend metallic carbon nanotube networks in air. Free standing films are known to exhibit an enhanced photoresponse, because of the absence of interaction with the substrate.[2] Their study will lead to a better understanding of the transport mechanisms involved in networks and could open up interesting applications like infrared detector.

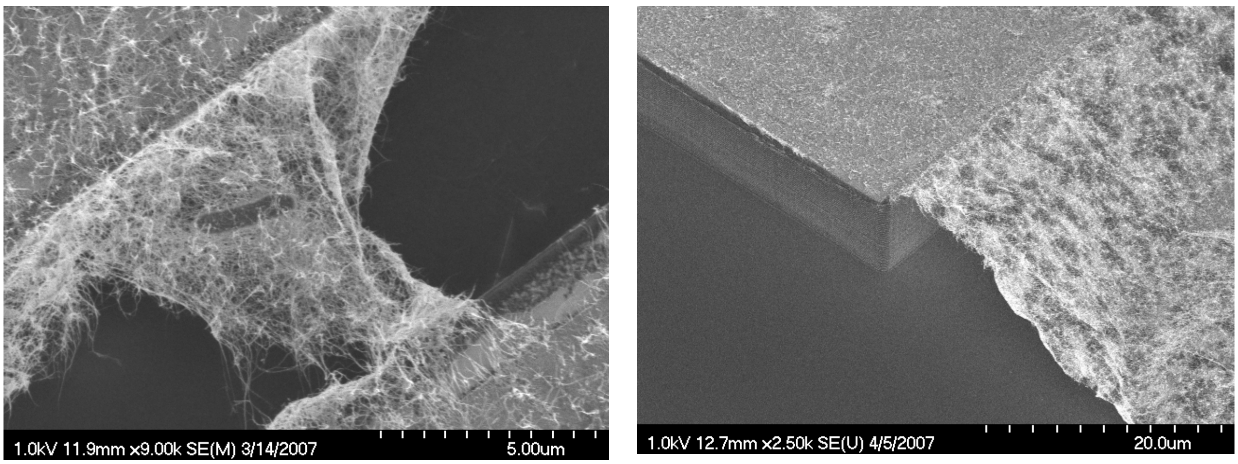

Figure 2. SEM images of suspended carbon nanotube networks. On the left, the network is bridging a 8 microns width trench. On the right, the network is connecting a pillar to the substrate.

(1) E.S. Snow, P.M. Campbell, M.G. Ancona, *Appl. Phys. Lett.*, **2005**, 86, 033105.

(2) M.E. Itkis et al. Science **2006**, 312, 403.