Highly conductive and transparent single-walled carbon nanotube film fabricated by floating catalyst chemical vapor deposition using liquid carbon source

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Single-walled carbon nanotube (SWCNT) films have a great potential to replace indium tin oxide films for the applications in transparent and conductive electronics. Here we report SWCNT transparent conducting films (TCFs) fabricated by floating catalyst chemical vapor deposition (FCCVD) method using liquid carbon source. Ethanol [1,2] and toluene [3] are separately selected as carbon sources since neither of them has been employed for the direct fabrication of SWCNT TCFs from a FCCVD reactor. Utilizing ethanol as carbon source, the fabricated SWCNT TCFs exhibit low sheet resistances of 78 Ω/sq. at 90% transmittance at 550 nm. The sheet resistance value decreases to 63 Ω/sq. at the same transmittance when toluene is adopted. Meanwhile, various characterizations, including diameter and length of SWCNT bundles, are performed to elucidate the causes of the excellent optoelectronic performance of our SWCNT TCFs. It turns out that long and narrow bundled SWCNTs with large diameters are synthesized. Depicting chirality maps of SWCNTs by analyzing statistically counted electron diffraction patterns is the most significant part, which fills the gap in chirality distribution of SWCNTs. With ethanol as carbon source, the majority SWCNTs are close to armchair type with 77% semiconducting species. As for those SWCNTs obtained from toluene, a bimodal chirality distribution of both near zigzag and armchair types are found. Our studies provide fundamental basis to SWCNT research, and highlight the potential of SWCNT TCFs to be extensively applied in high performance flexible electronics.

[1] E.-X. Ding, H. Jiang, Q. Zhang, Y. Tian, P. Laiho, A. Hussain, Y. Liao, N. Wei and E. I. Kauppinen, Nanoscale, **9**, 17601 (2017).

[2] E.-X. Ding, Q. Zhang, N. Wei, A. T. Khan and E. I. Kauppinen. Accepted by Royal Society Open Science on 4th May, 2018.

[3] E.-X. Ding, *et al*. In preparation, 2018.