Thin film electronics based on aerosol-synthesized single-walled carbon nanotubes

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Single-walled carbon nanotube (SWCNT) networks show significant potential as a future material for electronics, both as transparent and flexible conductive electrodes [1] and as thin film transistors (TFTs) [2,3]. For the realization of SWCNT-based integrated circuits, controlled and reproducible fabrication of SWCNT networks with an appropriate density, a high fraction of individual SWCNTs, and controlled SWCNT dimensions is particularly important.

We have recently developed novel methods for the controlled synthesis of SWCNTs using floating catalyst CVD reactors. By controlling the concentration of iron catalyst particles, created either by the thermal decomposition of a precursor compound or the physical evaporation of iron targets by an electric spark discharge, the concentration of SWCNTs grown in the gas phase can be precisely controlled. This allows us to fabricate SWCNT networks consisting mainly of individual SWCNTs using either membrane filtration or direct deposition of the SWCNT aerosol.

SWCNT networks deposited using these methods exhibit small mean tube diameters of 1.1-1.2 nm and mean CNT lengths of 3 to 5 μm, depending on the synthesis conditions.
Arrays of SWCNT-TFTs fabricated on Si/SiO_2 substrates, exhibit excellent electrical characteristics with charge carrier mobilities in excess of 100 cm^2/Vs while simultaneously possessing ON/OFF current ratios from 10^5 to 10^7.
The SWCNT networks are uniform over the 1 cm^2 test array, consisting of several hundred individual devices.
By using direct deposition from the aerosol, we are also able to fabricate clean samples of individual SWCNTs on a variety of substrates without exposing the SWCNTs or the substrate to chemicals, opening up interesting possibilities in CNT spectroscopy.

[1] A. Kaskela et al. Nano Letters 10, 4349–4355 (2010)

[2] D.-M. Sun et al. Nature Nanotechnology 6, 156-161 (2011)

[3] D.-M. Sun et al. Nature Communications 4, 2302 (2013