Journal Name

RSCPublishing

Electronic Supplementary Information

Honeycomb-Like Single-Wall Carbon Nanotube Networks

Shisheng Li, Peng-Xiang Hou, Chang Liu*, Tianyuan Liu, Wen-Shan Li, Jincheng Li and Hui-Ming Cheng

SYNTHESIS OF SWCNTS: To grow parallel SWCNT arrays on ST-cut quartz substrates, the substrates were first annealed at 900 ^{o}C in air for 8 hrs. They were then washed with acetone, ethanol, and deionized water sequentially. After 5 min sonication in deionized water, the substrates were blow dried with N_2. A Co film with thickness of ~0.1 nm was deposited by ion-beam assisted deposition onto the substrates as catalyst. SWCNT growth was conducted at 900 ^{o}C using 50 sccm H_2 as the carrier gas, and 200 sccm Ar bubbled through C_2H_5OH (0 ^{o}C) as the carbon source. The growth time was 5 min. To grow random SWCNTs, the ST-cut quartz substrates were used without pre-annealing at 900 ^{o}C and a thin layer of amorphous SiO_x (~30 nm) was deposited before Co catalyst deposition. The growth time of random SWCNTs was 10 min. As a consequence, the random SWCNTs usually have a higher density than parallel SWCNTs (Fig. S4).

OPTICAL TRANSMITTANCE MEASUREMENT OF SWCNT NETWORKS: The transmittance of the SWCNT networks was recorded using a Varian Cary 5000 UV–vis–NIR spectrometer. Random and parallel SWCNTs with a similar density were used. After the transmittance measurement of parallel SWCNTs, the same parallel-aligned SWCNTs were transferred to a new double-polished quartz substrate to fabricate a honeycomb-like SWCNT network. The honeycomb-like SWCNT network was then used for transmittance measurements.

ELECTRICAL MEASUREMENTS OF SWCNT NETWORKS: Electrical measurements were conducted by transfer-printing a 5 mm x 7 mm SWCNT network onto a Si/SiO_2 substrate with pre-deposited 100 nm-thick Au electrodes. The SWCNT network has a channel length of 4 mm and channel width of 5 mm as shown in Fig. S5. For comparison, parallel SWCNT arrays with a density of ~6 tubes/μm and optical transparency of ~98.4% at 550 nm, and random networks with a slightly higher density of ~8 tubes/μm and optical transparency of ~97.8% at 550 nm were used as references. Before electrical measurements, all devices were annealed at 180 ^{o}C under an Ar atmosphere for 30 min and Ag paste was also used to improve the electrical contact between the SWCNTs and Au electrodes. The channel resistance of all the SWCNT networks was measured using a Keithley SCS-4200 instrument.

CHEMICAL DOPING OF SWCNT NETWORKS: Chemical doping was conducted by exposure of the SWCNT networks to 8 M HNO_3 vapor for 30 min. After doping, all the SWCNT networks were exposed to air before electrical measurements.

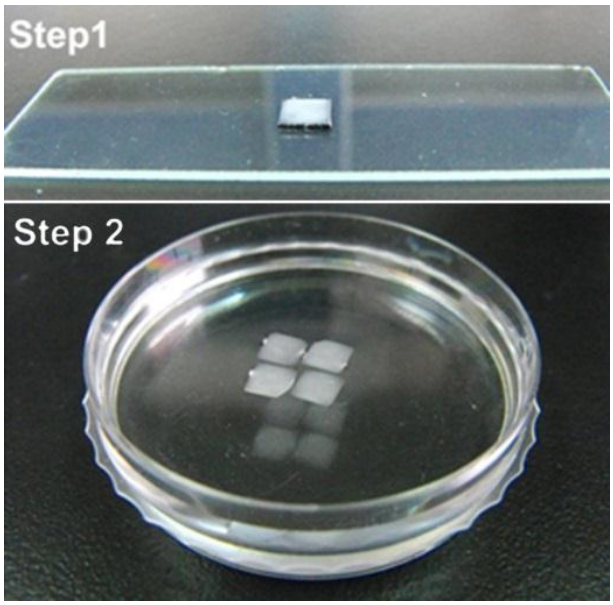

Fig. S1 Optical images of the paraffin-mediated transfer-printing process. Step 1 shows the paraffin film coated on the surface of a substrate with as-grown SWCNTs. Step 2 shows the harvested paraffin/SWCNT films floating on water.

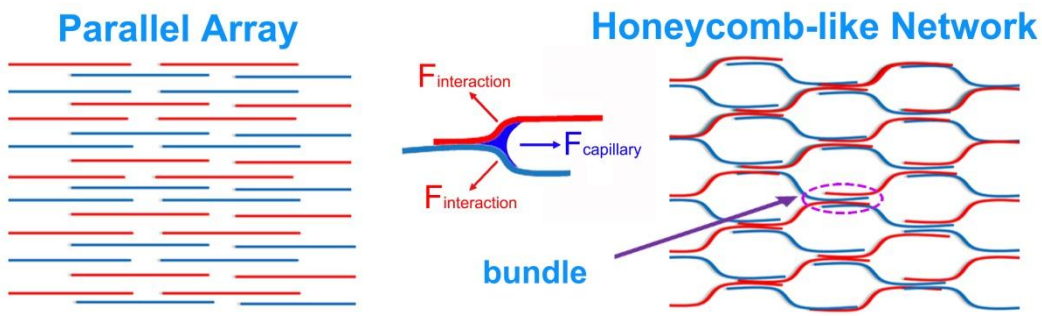

Fig. S2 Schematic of the formation mechanism of the honeycomb-like SWCNT network induced by capillary forces generated during the evaporation of toluene.

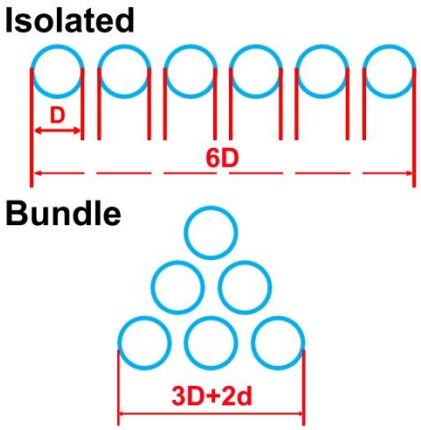

Fig. S3 Schematic showing the cross-section of a parallel array and a bundle composed of 6 SWCNTs. The diameter of a SWCNT is D, supposing the inter-tube distance is d=0.35 nm, and all tubes have the same length L.

Table S1 Examples of surface coverage reduction by forming SWCNT bundles

No. of tubes in bundles	D	surface coverage		Coverage reduction
		Isolated	bundle	
3	e.g. 2 nm	3DL	(2D+d)L	(D-d)/3D
		6L	4.35L	~27%
6	e.g. 2 nm	6DL	(3D+2d)L	(3D-2d)/6D
		12L	6.7L	~44%

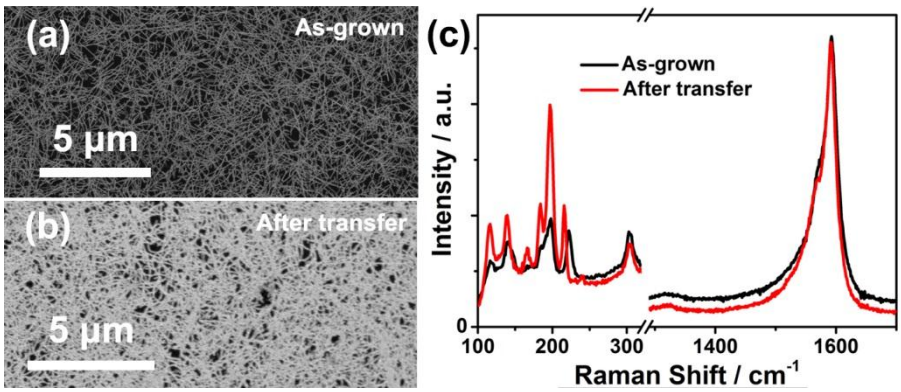

Fig. S4 SEM images of (a) the as-grown random SWCNTs on a Si/SiO_2 substrate and (b) the SWCNTs after being transferred to a Si/SiO_2 substrate. (c) Raman spectra of the as-grown and transferred SWCNTs.

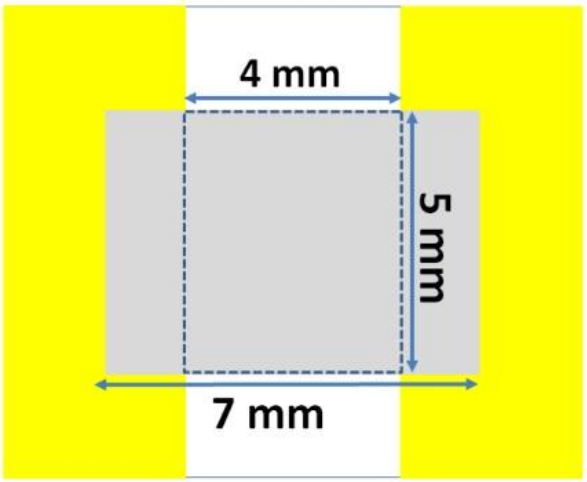

Fig. S5 Schematics of the SWCNT networks transferred to Au electrodes for channel resistance measurements. The as-grown SWCNT networks have a size of 7 mm x 5 mm.