

Supplementary Material

Influence of carbon nanotube attributes on carbon nanotube/Cu composite electrical performances

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Abbreviations: CNT = Carbon nanotube, CNT wire = CNTW, CNT pillar = CNTP, Singlewall CNT = SW-CNT, Multiwall CNT=MW-CNT, Transmission electron microscope(y) = TEM, Scanning electron microscope(y) = SEM, Temperature coefficient of resistance = TCR

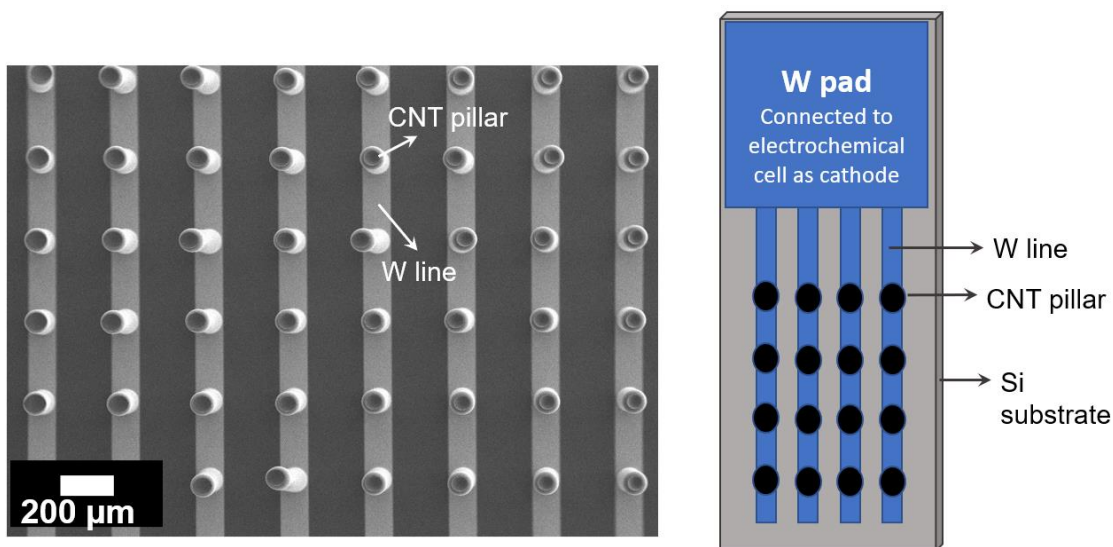


Figure S1. (Left) Top-view of SW-CNTP array on W lines that act as electrical contacts for Cu electrodeposition. (Right) Schematic of the SW-CNTP array on Si substrate (top-view) used as cathode for Cu electrodeposition.

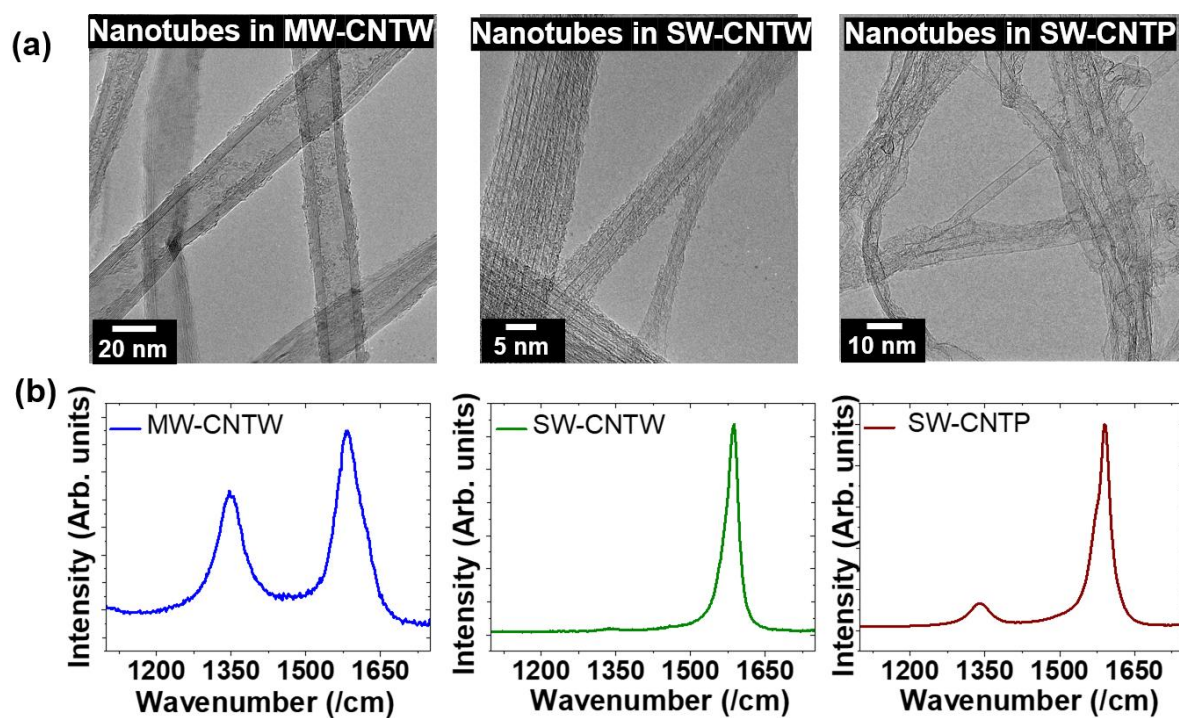


Figure S2. Example (a) TEM images and (b) Raman spectra of MW-CNTW, SW-CNTW and SW-CNTP samples used for Cu/CNT fabrication.

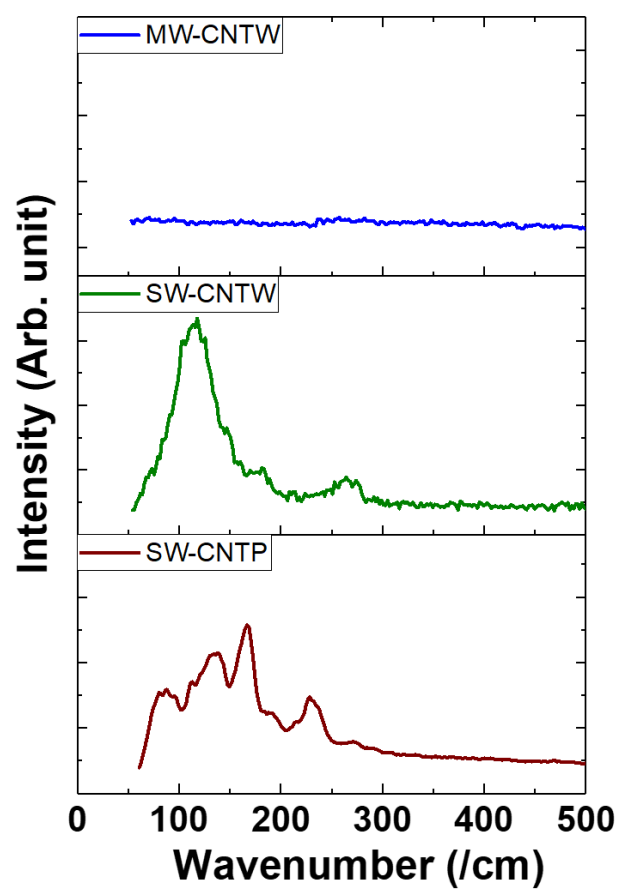


Figure S3. Radial breathing mode region in the Raman spectra of nanotube templates used for Cu/CNT fabrication.

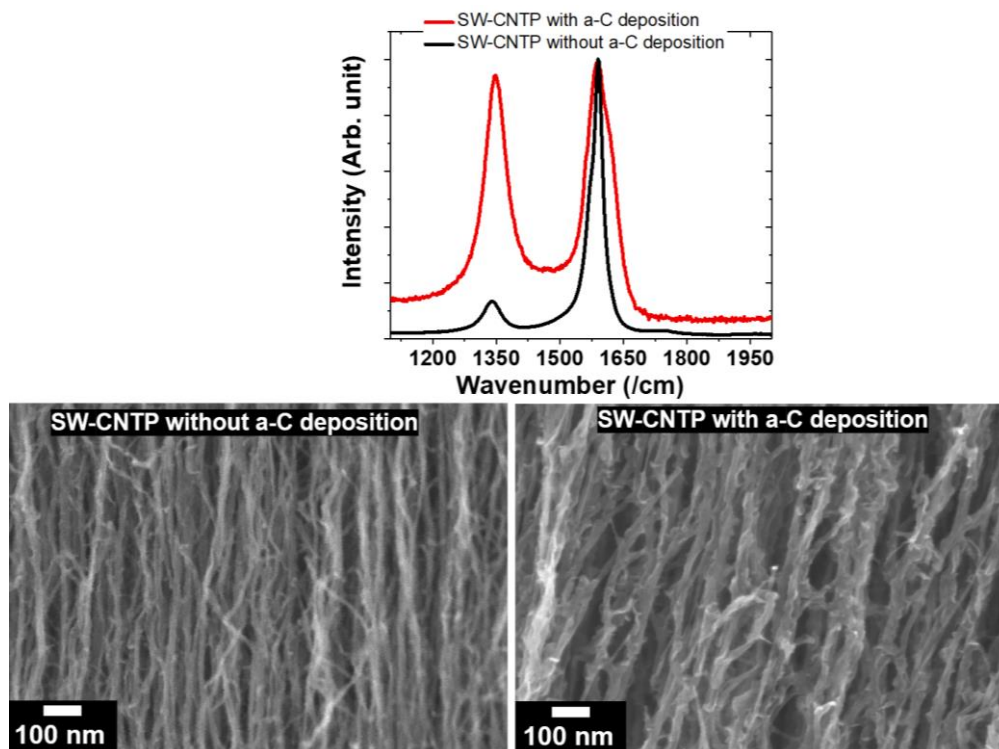


Figure S4. Raman spectra and SEM images of SW-CNTP before and after carbon coating.

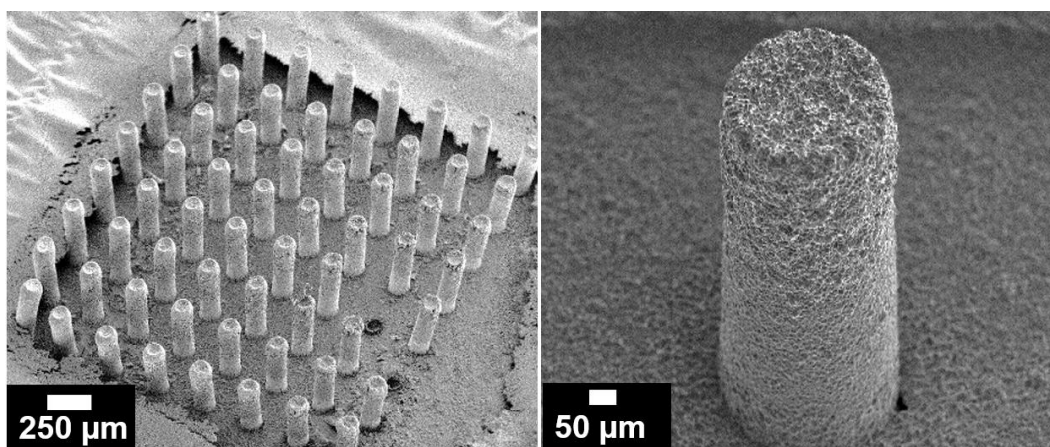


Figure S5. SEM images of SW-CNT/Cu pillars (array and individual pillar)

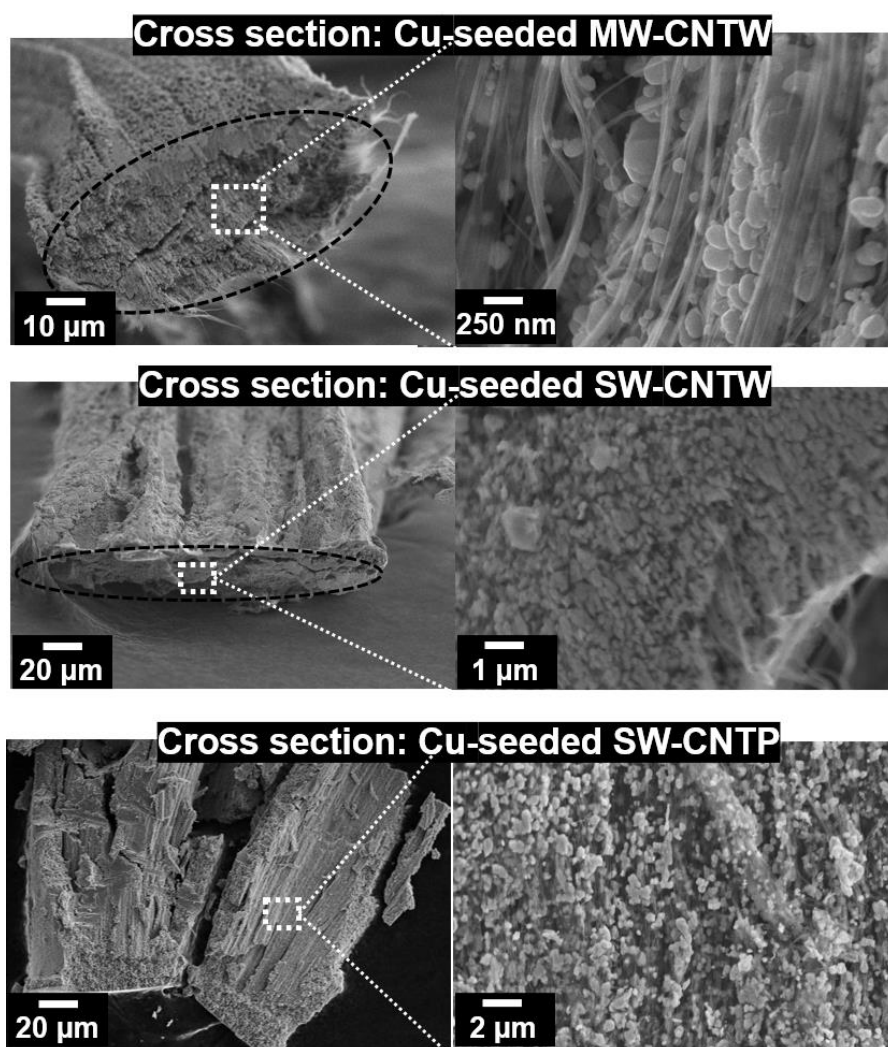


Figure S6. Cross section SEM images of the Cu-seeded MW-CNTW, SW-CNTW and SW-CNTP samples after organic Cu electrodeposition and H_2 reduction.

Table S1. Cu content (wt%) in and cross section areas of CNT/Cu composites

Sample	Cu content (wt%)	Cross section area (μm^2)
MW-CNT/Cu Wire	~98-99 wt%	8.06×10^3
SW-CNTW/Cu Wire	~98-99 wt%	1.01×10^5
SW-CNT/Cu Pillar	~99 wt%*	1.16×10^4

*To note: Cu wt% in SW-CNT/Cu pillars were estimated using sample densities and dimensions instead of measuring weight changes after Cu deposition. CNT pillar masses before Cu deposition could not be experimentally obtained due to sample masses falling below measurement limits and difficulties in dislodging the fragile pillars intact from substrates in quantities required to register a measurable weight. For Cu wt% estimation, starting CNT pillar densities for the estimations are assumed to be equal to forest densities ($\sim 0.037 \text{ g/cm}^3$) previously reported for supergrowth CNTs [1].

1. Futaba, D.N.; Hata, K.; Namai, T.; Yamada, T.; Mizuno, K.; Hayamizu, Y.; Yumura, M.; Iijima, S. 2006. 84% catalyst activity of water-assisted growth of single walled carbon nanotube forest characterization by a statistical and macroscopic approach. *The Journal of Physical Chemistry B* **2006**, 110(15), 8035-8038.

Table S2. Conductivity and TCR of CNT templates used for CNT/Cu fabrication

Sample	Conductivity (S/cm)	TCR (/K)
MW-CNTW	261.1 ± 10.1	$-8.8 \times 10^{-4} \pm 7.1 \times 10^{-5}$
SW-CNTW	129.1 ± 51.2	$1 \times 10^{-4} \pm 5.9 \times 10^{-5}$

To note: SW-CNTP conductivity and TCR could not be measured due to sample fragility and inability to make reliable electrical contacts.

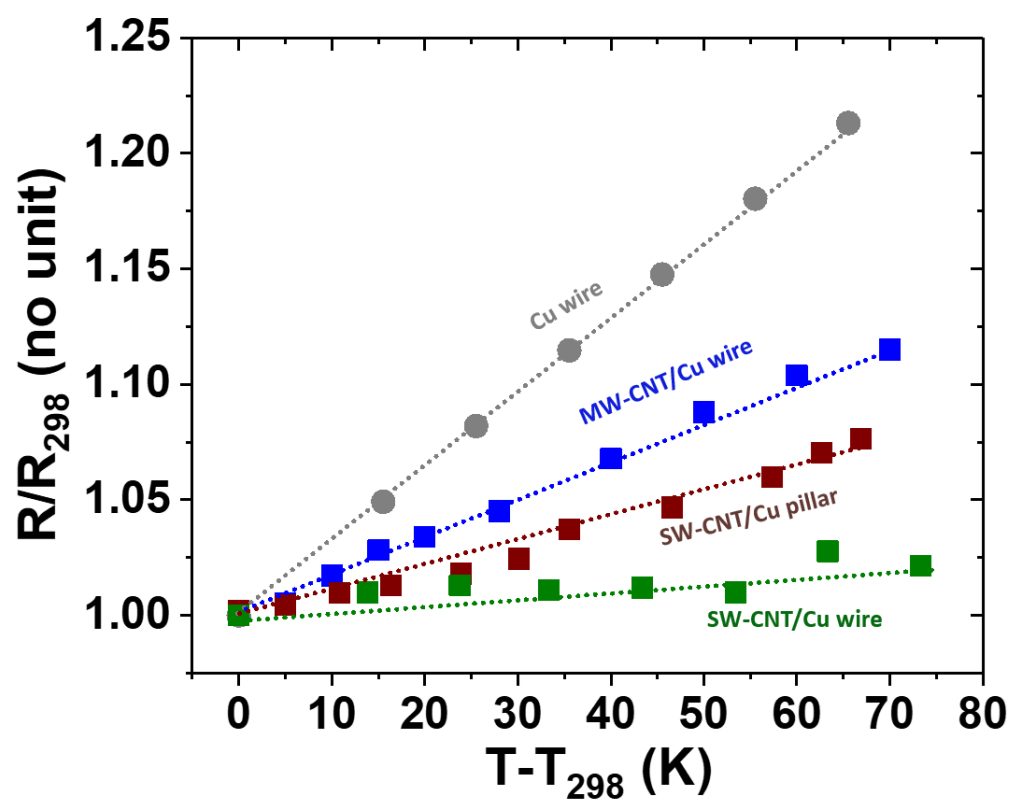


Figure S7. Measured resistance normalized by room temperature resistance, R/R_{298} vs. difference between measurement temperature and room temperature, $T-T_{298}$