

## Electronic Supplementary Information

# Influence of supported PtPd nanoparticles on the tensile strength of individual multi-walled carbon nanotubes: Strength decrease by the interaction of metal and nanotube

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## **Synthesis of vertical MWCNT forests**

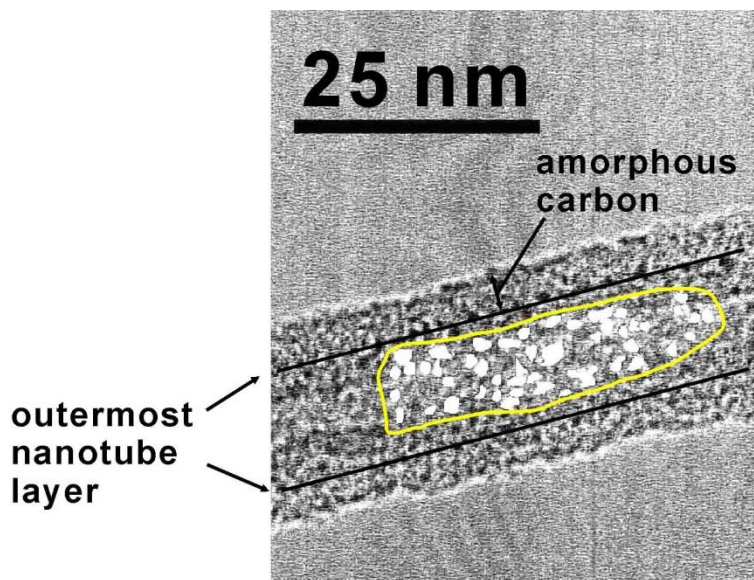
A p-type silicon wafer containing a thermal oxide layer was used as a substrate, while the Fe film with a thickness of 3.0 nm deposited by electron beam (e-beam) evaporation served as a catalyst. The wafer was cut into rectangles with dimensions of  $10 \times 30$  mm, which were subsequently placed on a quartz plate with a size of  $0.5 \times 25 \times 120$  mm and then slid into the reactor central position. After closing the reactor, it was evacuated and then filled with He gas (99.9999% purity). The He flow rate was equal to 496 sccm, while the reaction temperature was ramped up to 678 °C within the first 20 min and then maintained at this level for additional 10 min. Aligned MWCNT forests were synthesized by treating the prepared wafers with a gas mixture containing 3 mol% acetylene (99.9999%) in He for 15 min at an atmospheric pressure, temperature of 678 °C, and total gas flow rate of 512 sccm. The height of CNT forest is around 210  $\mu\text{m}$ .

## Coverage of PtPd nanoparticles on MWCNT surfaces

The coverage of PtPd nanoparticles on MWCNT surfaces was estimated using ImageJ, as follows. First, we selected the surface (yellow circle) of a MWCNT, shown in Figure S1, and recorded the surface area ( $A_{\text{tube}}$ ). Next, the areas (white areas) of all the PtPd nanoparticles on the selected nanotube surface were selected and recorded. Here, the total area of all the PtPd nanoparticles is referred to as " $A_{\text{PtPd}}$ ". The PtPd nanoparticles supported on the front and back of the nanotube were counted, and the coverage  $C$  of the PtPd nanoparticles on the surface of a MWCNT was calculated using the following expression:

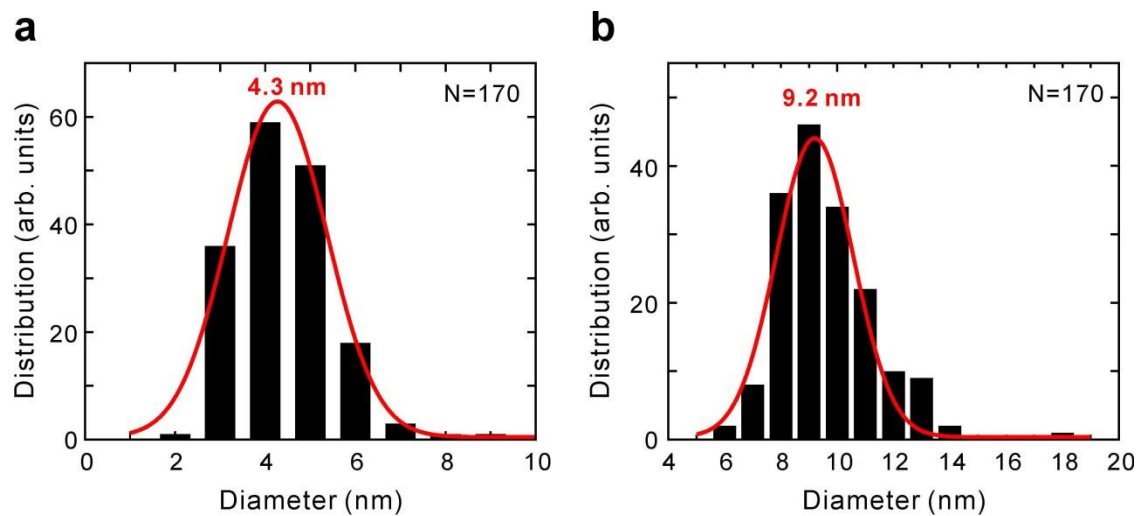
$$C = \{A_{\text{PtPd}} / (2A_{\text{tube}})\} \times 100$$

The coverages on three different surfaces per nanotube were measured and ten PtPd-MWCNT samples were examined.



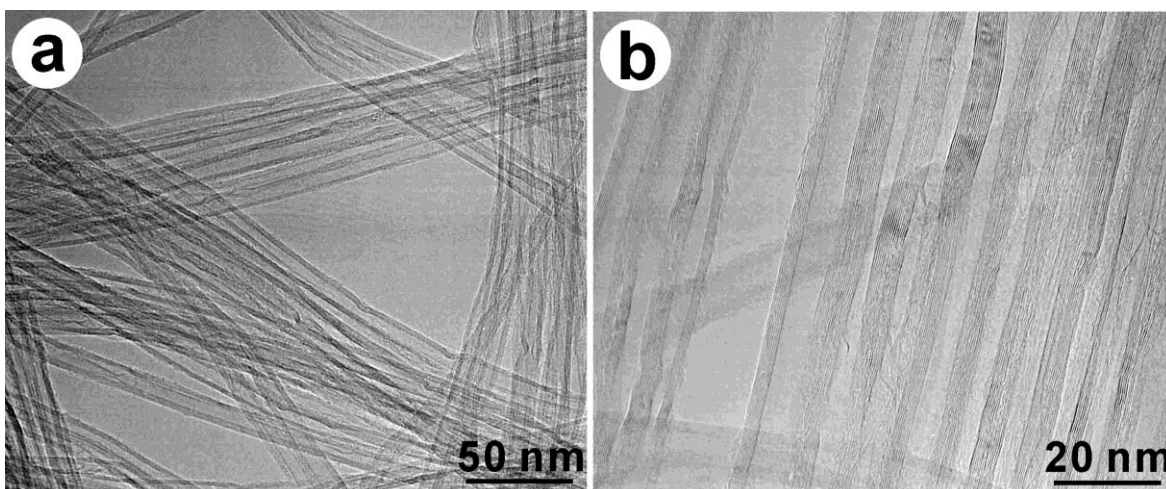
**Figure S1** Typical TEM image of PtPd-supported MWCNT used for estimating coverage of PtPd nanoparticles on nanotube surface.

## Histograms for the diameters of the as-grown MWCNTs



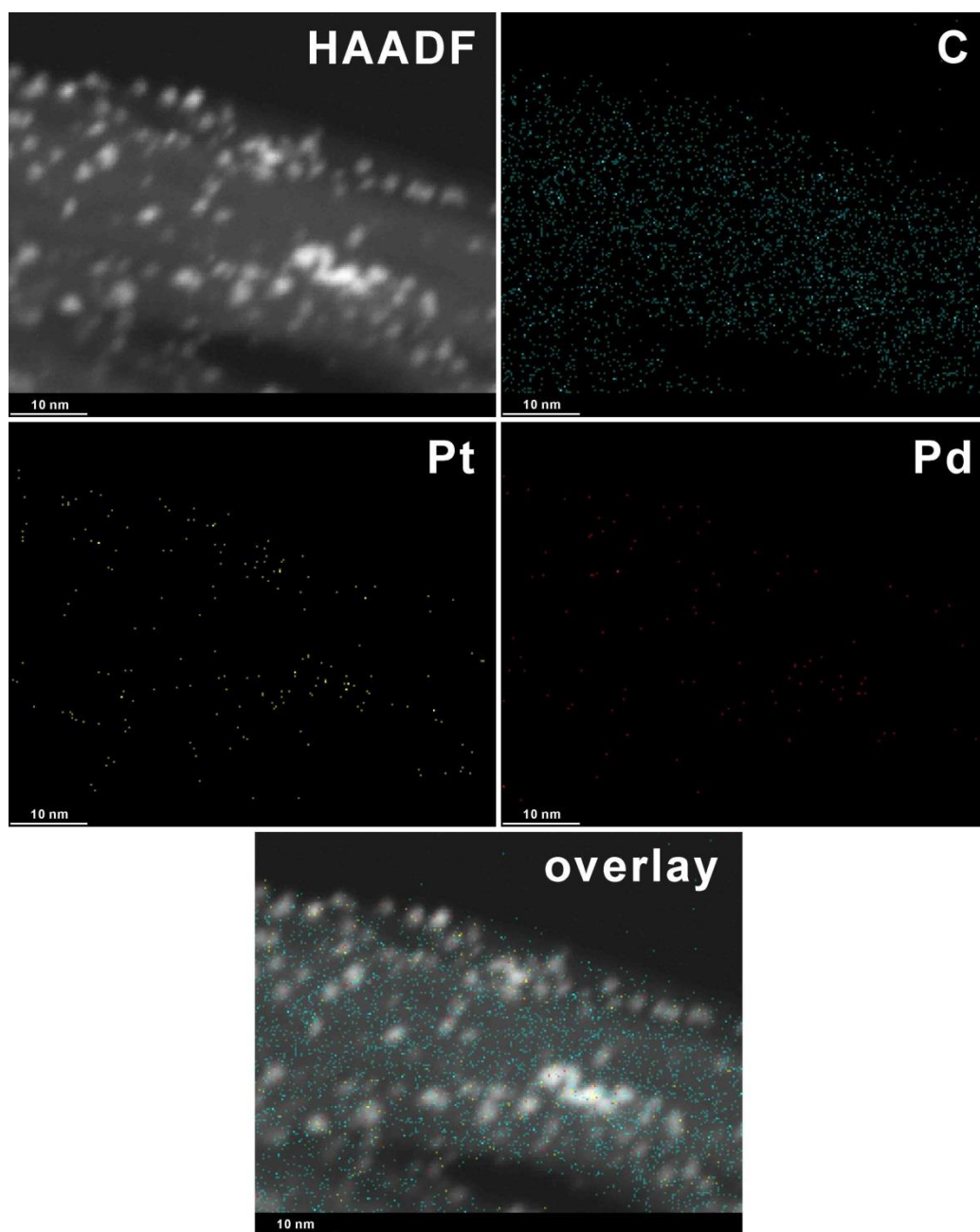
**Figure S2** Histograms obtained for (a) inner and (b) outer diameters of as-grown MWCNTs.

## Morphology of the as-grown MWCNTs



**Figure S3** (a) Low- and (b) high-magnification HRTEM images of as-grown MWCNTs.

**STEM–EDX mapping images of the PtPd nanoparticles supported on the as-grown MWCNTs**



**Figure S4** STEM–EDX mapping images (HAADF image, C, Pt, and Pd mapping images, and their overlay images) of PtPd-supported MWCNTs.

## Tensile strengths of individual MWCNTs measured before and after PtPd deposition

**Table S1** Tensile strengths of individual MWCNTs measured before and after PtPd nanoparticle deposition.

<b>as-grown MWCNT</b>					<b>PtPd-MWCNT</b>				
Sample No.	Failure Load (nN)	Diameter (nm)		Effective Strength (GPa)	Sample No.	Failure Load (nN)	Diameter (nm)		Effective Strength (GPa)
		Inner	Outer				Inner	Outer	
1	160.32	3.89	8.49	3.58	1	147.94	3.94	10.22	2.12
2	210.32	5.05	10.32	3.30	2	128.15	3.05	8.31	2.73
3	277.10	5.47	9.48	5.89	3	233.13	3.36	8.14	5.40
4	117.29	4.99	8.90	2.75	4	333.99	4.91	12.83	3.03
5	312.43	3.99	8.87	6.34	5	219.03	3.87	12.98	1.82
6	330.95	3.18	10.02	4.66	6	391.89	4.07	11.81	4.06
7	175.55	2.67	11.13	1.91	7	110.74	5.13	11.94	1.21
8	103.11	3.80	6.26	5.30	8	293.01	2.80	9.89	4.14
9	384.05	8.29	14.37	3.55	9	296.50	4.68	11.80	3.22
10	175.75	3.12	11.28	1.91	10	210.60	4.23	11.76	2.23
Average				3.92	Average				3.00
SD				± 1.57	SD				± 1.26