Electronic Supplementary Information for

Facile Manipulation of Individual Carbon Nanotubes Assisted by Inorganic Nanoparticles

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1. Supplementary Figures

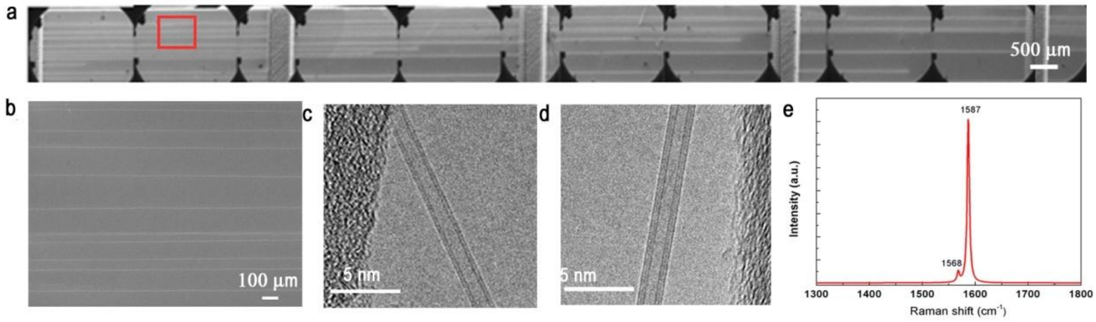

Figure S1. As-grown ultralong CNTs. a) and b): SEM images of as-grown CNTs with different magnifications. c) and d): TEM images of as-grown CNTs (double-wall CNTs and triple-wall CNTs). e) A typical Raman spectrum of as-grown CNTs.

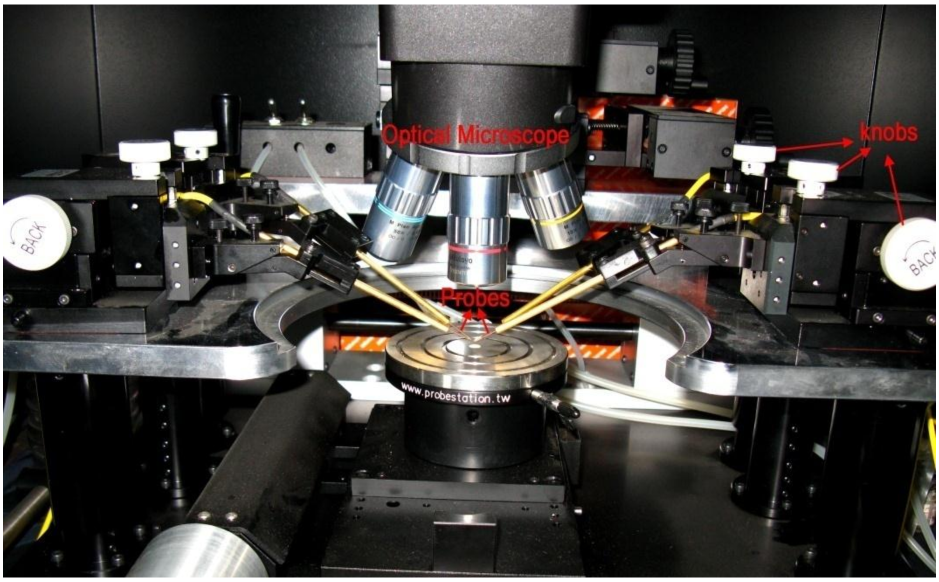

Figure S2. Image of optical microscope-based working platform for manipulation of ultralong CNTs.This is a long working distance metallography microscope (FS-70Z). There are four probes positioned on four pedestals on the microscope framework. The probes can be moved precisely in X, Y and Z directions by wheeling the knobs fixed on the pedestals. When the suspended CNTs decorated with SnO_2 nanoparticles are observed in the optical microscope, the probes can then be slowly moved to the suspended CNTs, which can be fixed onto the probes once in contact with them by van der waals interaction. After that, one of the probes is moved in a certain direction to stretch the suspended CNT. The deformation of the CNT can be observed through the ocular of the optical microscope.

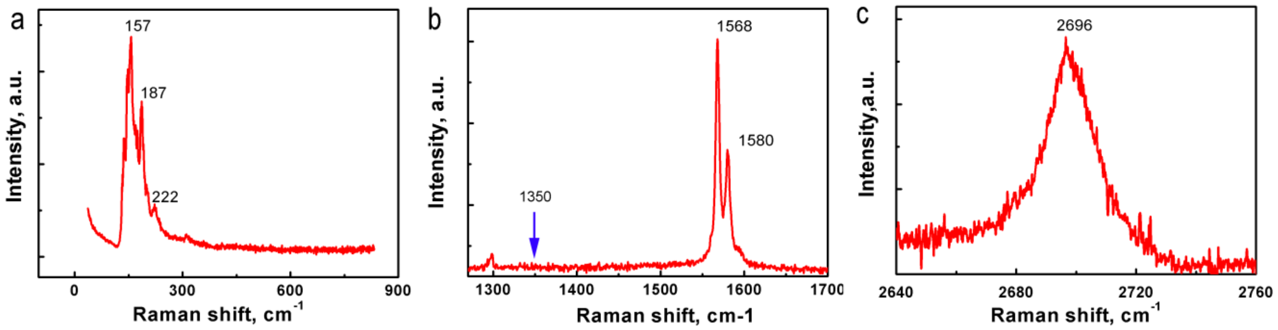

Figure S3. Raman spectra of a transferred CNT. (a) RBM-band. (b) D-band and G-band. (c) G'-band.

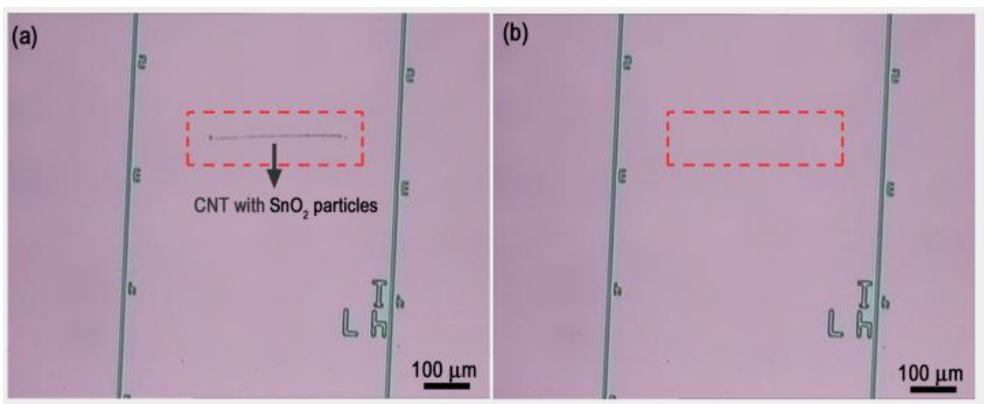

Figure S4. Removing of SnO_2 NPs. (a) Optical image of a substrate with SnO_2 NPs (indicated by the black arrow). (**b**) Optical image of the same substrate after treated in hot KOH solution for 2 h.

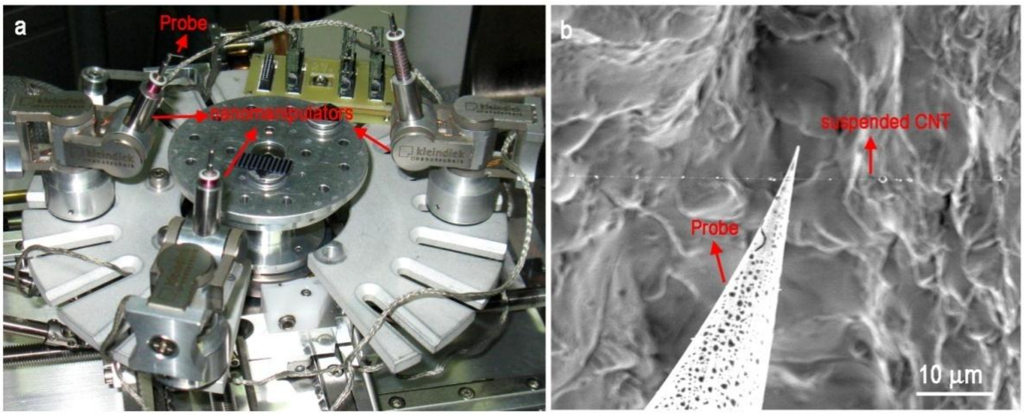

Figure S5. Nanomanipulator and probes fixed in a SEM. a) Nanomanipulator fixed in a SEM. b) A probe fixed on the nanomanipulators.

Supplementary Discussion

Formation mechanism of SnO_2 NPs on suspended CNTs

$SnCl_4$ is a highly volatile metal halide, which forms misty smog of SnO_2 and HCl upon contact with humid air. When $SnCl_4$ vapor gets into contact with suspended CNTs, tiny SnO_2 NPs nucleate on the CNTs. The suspended CNTs play a role of templates in tailoring the size of SnO_2 NPs. The van der Waals force dominates the interactions between the SnO_2 NPs and the CNTs. The SnO_2 NPs are hydrophilic while the pristine CNTs are hydrophobic. As a result, the following formed SnO_2 in the gas phase preferrs to attach on the SnO_2 nucleates. The –OH groups on the surface of SnO_2 NPs also catalyze $SnCl_4$ hydrolysis, resulting in the vapor phase epitaxial growth of the pre-existing SnO_2 NPs. The small SnO_2 NPs attached on the outer wall of the suspended CNTs gradually grow large and wrap the CNTs with the continuously epitaxial growth, forming coaxial strucutures. Meanwhile, a large amount of newly nucleated SnO_2 NPs formed and adhered to the suspended CNTs. Therefore, small and large SnO_2 NPs coexist on the suspended CNTs.

Effect of SnO_2 NPs on the properties of CNTs

Mechanical properties of CNTs: From Figure 1 in the main text we can see that between the adjacent SnO_2 nanoparticles, there is the pristine tube, and the space between the adjacent SnO_2 NPs can be as long as several microns, which is far larger than the diameter of SnO_2 NPs (usually less than 1 μm). For a CNT decorated with SnO_2 NPs under tensile strain, the strain is only exerted on the CNTs.

Raman spectra of CNTs: From the statement above, the space between the adjacent SnO_2 NPs can be as long as several microns, which are far larger than that of Raman laser spot. So the Raman laser spot can be focused on pristine tubes. Besides, it has been reported that the frequency downshift rate of G-band of CNTs with strain spanned from −6.2 to −23.6 cm^{-1}/% strain[7]. For the suspended CNTs decorated with SnO_2 NPs, the tensile strain caused by the gravity of these TiO_2 NPs is usually smaller than 0.00025%, which is too small to be taken into consideration. Therefore, we can conclude that the deposition of SnO_2 NPs has nearly no influence on the Raman spectra of ultralong suspended CNTs.

Electrical properties of CNTs: The deposition of TiO_2 NPs on the walls of CNTs has been reported before and it was found that the electrical properties of pristine CNTs changed only when TiO_2 NPs were exposed to UV light, not visible light[8]. Thus, under visible light, the TiO_2 NPs has almost no effect on the electrical properties of CNTs. For SnO_2-deposited CNTs, the SnO_2 NPs have neither influence on the electrical properties of CNTs.

Supplementary References

1. M. Rigo, P. Canu, L. Angelin and G. Della Valle, *Ind. Eng. Chem. Res.*, 1998, **37**, 1189-1195.
2. V. Georgakilas, D. Gournis, V. Tzitzios, L. Pasquato, D. M. Guldi and M. Prato, *J. Mater. Chem.*, 2007, **17**,

2679-2694.

3. D. Eder and A. H. Windle, *J. Mater. Chem.*, 2008, **18**, 2036-2043.
4. N. Sakai, R. Wang, A. Fujishima, T. Watanabe and K. Hashimoto, *Langmuir*, 1998, **14**, 5918-5920.
5. G. Hummer, J. C. Rasaiah and J. P. Noworyta, *Nature*, 2001, **414**, 188-190.
6. Y. Li, Y. Fan and Y. Chen, *J. Mater. Chem.*, 2002, **12**, 1387-1390.
7. C.-C. Chang, I.-K. Hsu, M. Aykol, W.-H. Hung, C.-C. Chen and S. B. Cronin, *Acs Nano*, 2010, **4**, 5095-5100.
8. S. Liu, J. Li, Q. Shen, Y. Cao, X. Guo, G. Zhang, C. Feng, J. Zhang, Z. Liu and M. L. Steigerwald, *Angew. Chem. Int. Ed.*, 2009, **121**, 4853-4856.