Revealing floating-catalyst carbon nanotube quality by ultraclean individual CNT transistor array

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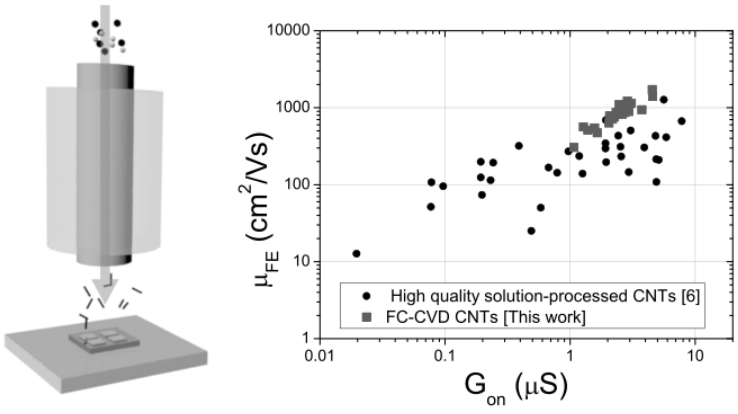

Carbon nanotubes (CNTs) grown by the floating-catalyst chemical vapor deposition (FC-CVD) are known to make fast thin-film transistors [1,2], however, the electronic quality of individual FC- CVD CNTs has not been clearly understood, as compared solution- processed and substrate-grown CNTs [3-5]. Here, we introduce a dry method for fabricating a statistically significant number of ultraclean single CNT field-effect transistors using FC-CVD CNTs, revealing the quality of FC-CVD CNTs with a mean field-effect mobility 3.3 times higher than that of high- quality solution-processed CNTs [6], and on-off current ratios higher than 107.5. This method enables a fast, reliable and fine-grained inspection of FC-CVD CNT population, and provided a strong direct evidence about their near-perfect electronic quality[7]. This new understanding explains the good performance of FC-CVD CNT films and TFTs, and the obtained large number of ultraclean single-walled CNT transistors provide new possibilities to study the properties of pristine CNTs.

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References

[1] D. Sun *et al. Nat. Nanotechnol.* 6, 156 (2011).
[2] D.-M. Sun *et al. Nat. Commun.* 4,2302 (2013).
[3] A. E. Islam, J. A. Rogers, and M. A. Alam *Adv. Mater.* 27, 7908 (2015).
[4] Q. Cao, S. Han, G. S. Tulevski, A. D. Franklin, and W. Haensch *ACS Nano* 6, 6471 (2012).
[5] E. A. Laird *et al. Rev. Mod. Phys.* 87, 703 (2015).
[6] P. Stokes and S. I. Khondaker *Appl. Phys. Lett.*96, 83110 (2010).
[7] X. Zhou, et al. *Phys. Rev. Lett.* 95,146805 (2005)