HYDRGEN-FUNCTIONALIZED CARBON-NANOTUBE RECTFIER AT ROOM TEMPERATUER

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The conventional synthesis approaches provide carbon nanotubes (CNTs) mixed with different chiralities, which are not separable at current technology. This has often been a bottleneck in the application of CNTs to electronic devices such as nanotransistors and memories that require preexisting semiconducting CNTs. One alternative approach is to transform the electronic structure of the CNT to one with a large band-gap semiconductor by a post process treatment. Functionalization of a CNT wall sometimes leads to serious modification of the electronic structure. For instance, fluorination of the CNT modifies the electronic structures to be either metallic or semiconducting, depending on the coverage and method of fluorine decoration [1]. This approach induces a large strain on the tube wall and sometimes deteriorates the CNT. Although metallic multiwalled CNTs could be transformed to semiconducting ones by an effective peeling, this cannot be easily accessible from technical point of view [2]. A more reliable way to transform from metallic CNTs to semiconducting ones with a minimal alteration on the CNT-wall stability is highly desirable.

We present a method for CNT functionalization by exposing CNTs to hydrogen atoms. To demonstrate the effect of hydrogen functionalization, we fabricated a CNT-metal junction on a silicon substrate by electron-beam lithography, where one half of the CNT was buried in SiO_2 layer of 100 nm and the other half was exposed to air, as shown in Fig.1 (a). We prepared two samples: One is metallic, referred to as MS sample and another is semiconducting with an energy gap of 0.8 eV, referred to as SS sample. Both samples show an ohmic behavior at near room temperature, as shown in the inset of Fig. 1 (b). The I-V (current-voltage) characteristics are significantly changed after hydrogenation, as shown in Fig. 1 (b). Rectifying effects are observed for both samples. We emphasize that both samples are operable as a rectifier at room temperature. The differential conductance, dI/dV is finite near the zero-bias region at 5.6 K in the pristine MS sample (inset of Fig. 2 (a)), suggesting this sample to be nearly metallic. The pristine SS sample reveals a vanishing conductance near the gap region (inset of Fig. 2 (b)), suggesting it to be a semiconducting CNT. After hydrogenation, a clear energy gap of 1.88 eV is observed in the MS sample and the conductance increases almost linearly above the gap region, as shown in Fig. 2 (a). The energy gap is modified to 4.4 eV in the hydrogenated SS sample, as shown in Fig. 2 (b), which is more severely widened compared to that of the hydrogenated MS sample. The details of the study will be discussed in the meeting.

Reference.

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1. E. T. Mickelson, I. W. Chiang, J. L. Zimmerman, P. J. Boul, J. Lozano, J. Lui, R.E. Smalley, R. H. Hauge, J. L. Margrave, J. Phys. Chem., 103, 4318 (1999).
2. P. G. Collins, M. S. Arnold, Ph. Avouris, Science, 292, 706 (2001).

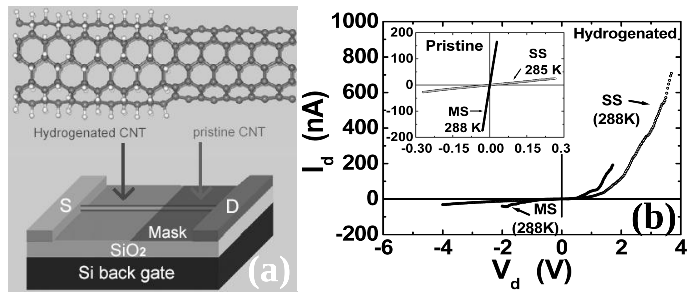

Figure 1. (a) A schematic of the hydrogenated CNT-FET, where one half of the CNT is buried by SiO_2 with a thickness of 100 nm and the other half is open to atomic hydrogen. (b) Typical I-V curves for both samples of MS and SS measured at 288 K after hydrogenation. The inset shows I-V curves of the pristine samples, which show an ohmic contact near room temperature. After hydrogenation both samples show rectifying behavior.

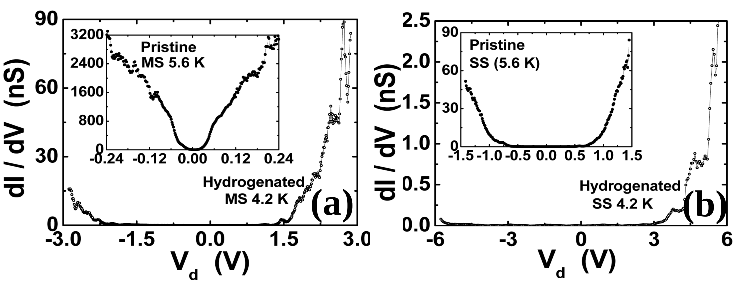

Figure 2. (a) The differential conductance of the hydrogenated MS sample as a function of source-drain voltage at 4.2 K and the pristine one at 5.6 K (inset). (b) The differential conductance of the SS sample. The units in the insets are the same as those of graphs..

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