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Modification of Electronic Structures of a Carbon Nanotube

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Electronic structures of carbon nanotubes (CNTs) can be modified with gas adsorption. 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 and fluorine 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 SiO2 layer of 100 nm and the other half was exposed to atomic hydrogen. 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. The I-V (current-voltage) characteristics of samples are significantly changed after hydrogenation. 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, suggesting this sample to be nearly metallic. The pristine SS sample reveals a vanishing conductance near the gap region, 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. The energy gap is modified to 4.4 eV in the hydrogenated SS sample, which is more severely widened compared to that of the hydrogenated MS sample.[3] We will also present results of fluorine functionalization if time is available.