Investigating Properties of Carbon Nanotube Sensors by Modification of the Nanotubes.

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The possibility of using an individual semiconducting single-walled carbon nanotube (SW-CNT) as an FET transistor was demonstrated by Tans *et al*. Chemical sensors based on carbon nanotubes have recently attracted a great deal of attention (1, 2). We have also found that CNT sensors can detect an antibody binding to the immobilized antigen on the opposite side of the CNT sensors (results in preparation). Nanotubes are expected to exhibit excellent properties as transducers. Moreover, they are an ideal material for ultra-small sensors because they have a large surface area and are known to exhibit charge-sensitive conductance.

Protein sensors based on CNT were reported by Star *et al*. (3). They established that interaction between biotin and streptavidin on CNT is detectable by measuring I-V_{gate} curves. Their study showed that the biotin moiety was absorbed irreversibly on the CNT wall. Chen *et a l*(4). reported that the mechanism of the CNT sensors and their studies showed that the junction between the CNT and electrodes was important to detect antigen and antibody. In this work, we have selected NTA and Ni cation as target substances for CNT sensors. The NTA and Ni cation seem to have a simpler structure than bio-molecules such as antigens or antibodies. The present study immobilized N- (5-Amino-1-carboxypentyl)iminodiacetic acid (NTA), which can bind Ni cation, on the surface of CNT via pyrene residues.

The CNT was grown thermally from Fe-Mo catalysis to other Fe-Mo catalysis on the silicon oxide layer. Each catalyst was covered by Au to form a pair of source drain electrodes. 1-Pyrenebutanoic acid was immobilized on the CNT followed by reaction with NTA in *N,N*-dimethylformamide. Current between the source and drain electrodes was measured by applying the potential to the anterior of the CNT sensors. The effect of the back gate potential on the current is shown in Fig. 1. The current decreased with decreasing back gate potential from 10 to –10 V, suggesting that CNTs have properties of field effect transistors (FETs). *I-Vsd* curves were measured before and after addition of NTA and $NiCl_2$. Figure 2 shows a typical *I-Vsd* curve. By modification of CNT by NTA, the current was decreased, whereas the addition of the Ni cation increased the current. Because the NTA has tree carboxylic acid and it charges strongly to negative, the effective potential around the CNT or the junction of CNT and electrode might be changed to negative by binding the NTA to CNT via pyrenebutanoic acid. Current after addition of $NiCl_2$ increasing seemed to be caused by production of the complex of NTA and Ni,

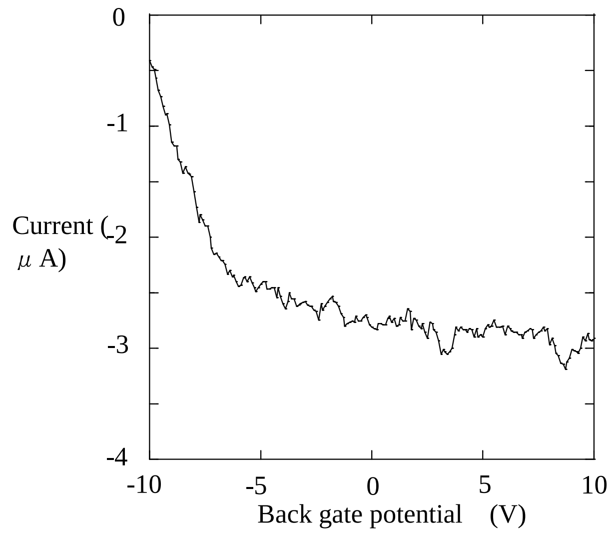

Figure 1 Effect of back gate potential on the source drain current of the CNT.

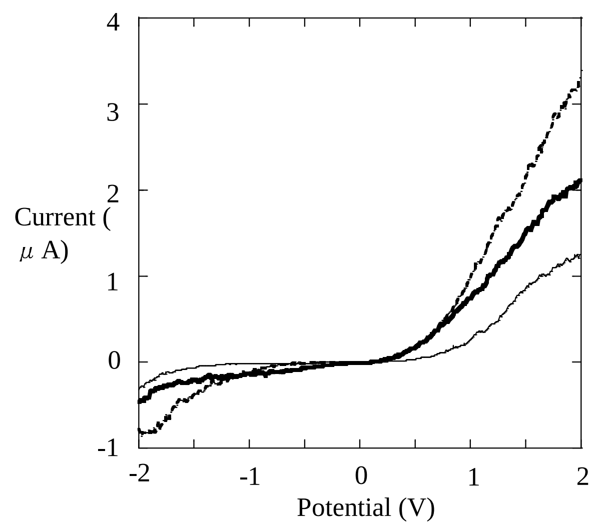

Figure 2. I-Vsd curves of the CNT sensors before and after modification of CNT. Thick, thin and dotted lines show before addition of NTA, after addition of NTA, and after addition of Ni, respectively.

which reduced the negative charge of NTA compared to NTA. Current after addition of NTA and Ni without pyrene modification of CNT did not showed current changes as in Fig. 2 (data not shown). This result suggested that binding of anions or cations to CNT might influence the electronic property of the CNT.

We will discuss the application of CNT sensors for detection of bio-molecules such as antibodies.

References

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