In situ MANIPULATION OF CARBON NANOTUBE INSIDE FE-SEM

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Various nanostructured materials such as CdSe, Au, SiNT, and carbon nanotubes have been successfully produced by precisely controlling the size of constitute elements and building blocks. These nanostructured materials have opened tremendous possibilities for the application in medicine, display, energy storages and memory devices with the result of better human welfare. However, one of most difficult challenges in this field is locating, positing, and handling those materials and it is turned out that conventional approaches are not effective for the operations because of small dimension. Therefore, specialized techniques should be developed.

We have installed two nanomanipulators (Klocke Nanotechnik) inside FE-SEM (JSM-6700F from JEOL Co.) with a maximum resolution of 1 nm at 15 kV. These manipulators are made of piezoelectric materials. Each manipulator is able to travel over 20 mm with the accuracy of 10 nm and they are small enough to fit into the space between sample stage and magnetic lens.

Using these manipulators, we conducted various operations inside FE-SEM. For instance, we precisely placed an individual MWCNT on four electrodes, which are aligned in parallel within 1 μm, as shown in Fig. 1(a). In addition, a MWCNT was attached at the end of AFM tip with a blunt apex, as shown in Fig. 1(b). For the secure attachment, we shined the electron beam on the junction between tube and AFM tip. The electron-beam irradiation method is known to deposit hydrocarbon as a consequence of decomposition and agglomeration of hydrocarbons [1]. During the manipulation, we observed that electrostatic force was exerted between the tube and AFM tip. Although we were not able to estimate the strength and direction of the electrostatic force, it is observed that the electrostatic force is very influential to the motion of the nanostructured materials.

With more number of degree of freedom, another advantage of using two manipulators is *in-situ* characterizations. We measured field emission properties of a single MWCNT inside FE-SEM by bringing a single MWCNT emitter over the surface of the other manipulator. Also, we examined the electromechanical properties. For this study, two manipulators were connected by a tube, as shown in Fig. 2(a). Then, I-V curves in Fig. 2(b) were measured with the increase of stress by bending the tube. The details of the study will be discussed.

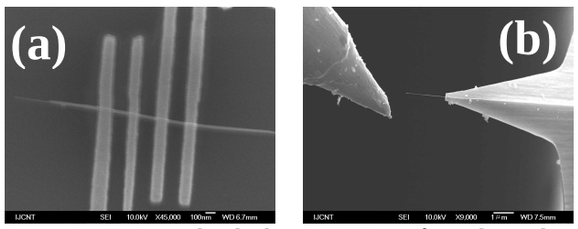

Figure 1. (a) An individual MWCNT on four electrodes within 1 μm. (b) A MWCNT-attached AFM tip.

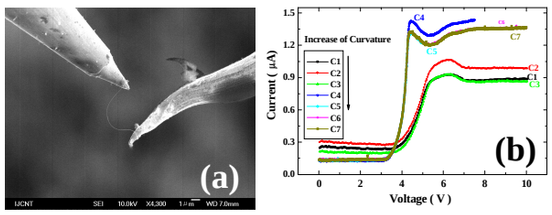

Figure 2. (a) A MWCNT connecting the two manipulators. The curvature of the tube is increased by bending the tube. (b) The variation of I-V curves in the function of the tube curvature.

Reference.

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