External rf plasma treatment effect on multi-wall carbon nanotubes grown inside anodic alumina nanoholes at low deposition temperatures

Kyoung Soo Ahn, Jun Sik Kim, Eun Kyu Kim, Chae Ok Kim, and Jin Pyo Hong
Department of Physics, Hanyang University, Sungdong-gu, Hangdang-dong, Seoul 133-791, South Korea
Phone : +82-2-2290-0911 , E-mail : jphong@hanyang.ac.kr

Abstract

.Well-aligned multi-wall carbon nanotubes (MWNTs) were fabricated by utilizing a radio frequency plasma-enhanced chemical vapor deposition (rf-PECVD) system from Ni particles at the bottom of anodic alumina nanoholes (AAN). To remove the amorphous graphite layers on the AAN surface and to eliminate the protrusion of MWNT tips, the AAN surface with MWNTs were treated by external rf plasma source. As a result, the AAN surface almost became flat without having any protrusion of MWNT tips. The diameter, length of MWNTs and AAN were investigated by using a scanning electron microscopy (SEM). Raman spectroscopy was also used to characterize wall structure of the carbon nanotube. And the emission properties of the MWNTs were measured for the application of field emission display (FED) in near future.

1. Introduction

Carbon nanotubes have recently been attracted much attention because of its remarkable physical properties of effective field emission characteristics [1], capability for the storage of a large amount of hydrogen [2], high Young's Modulus [3], and structural diversities that make it possible for band gap engineering. Several synthesis methods, such as arc-discharge , laser ablation , pyrolysis , thermal chemical vapor deposition and microwave plasma chemical vapor deposition, have been investigated for near-future application of carbon nanotubes up to now.

In this letter, MWNTs were grown by rf-PECVD from catalytic particles in the AAN. It was expected that the AAN structure with arranged nanometer-size straight holes, assisted to align nanotube at nanohole length scale without having any protrusion of MWNTs tips. And, measurement of the emission properties confirmed the possibility of the MWNTs for the application of FED.

2. Experimental

The Cr film with a thickness of 40nm was at first deposited on the silicon wafer using a DC magnetron sputtering system in order to enhance the adhesion strength between substrate and catalytic metal. Then the Ni film was *in-situ* deposited on the Cr-coated substrate without breaking the vacuum. The thickness of the Ni thin films used in this study was 20, 30, and 40 nm. The surface of the Ni films was pre-treated by NH_3. MWNTs were grown by rf-PECVD system. [4]

3. Results and discussion

Figure 1 shows typical SEM images of carbon nanotubes grown on Si substrates. The Ni films have the thickness of 20 to 40nm, respectively. It was clear that all the samples were highly homogeneous in nature. As typically shown in figure 1, the carbon nanotubes grown on Si substrates revealed a slightly aligned morphology, even though prepared at extremely low temperatures. Each MWNT is about 3 ~ 5 μm in length for 5 min deposition time.

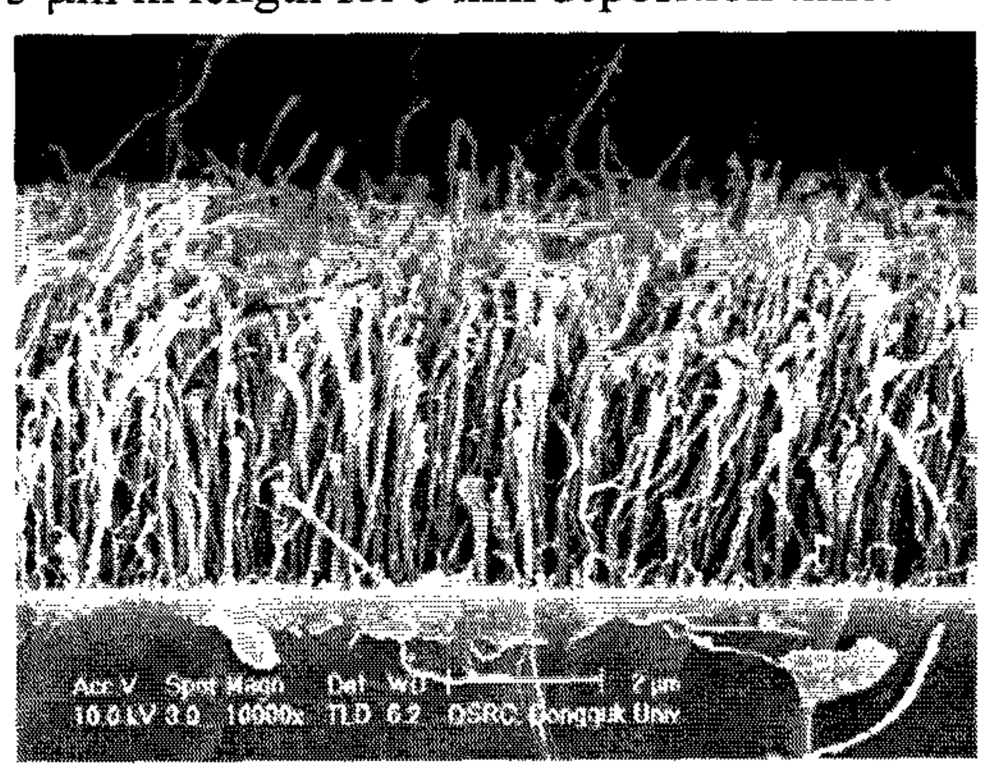

Figure 1 SEM image of MWNTs were grown by rf-PECVD

After an external rf plasma treatment was performed MWNTs on the AAN surface, the AAN surface almost became flat without having any protrusion of MWNT tips. In addition, this treatment improved the surface morphology of the MWNTs

Figure 2. shows the corresponding HRTEM image of carbon nanotubes grown at 450°C. As shown in this figure, the carbon nanotubes revealed multiwall structures with their closed caps. The diameters of multiwall carbon nanotubes were on the order of about 60 nm. There was always a Ni catalytic particle inside the tube near the cap.

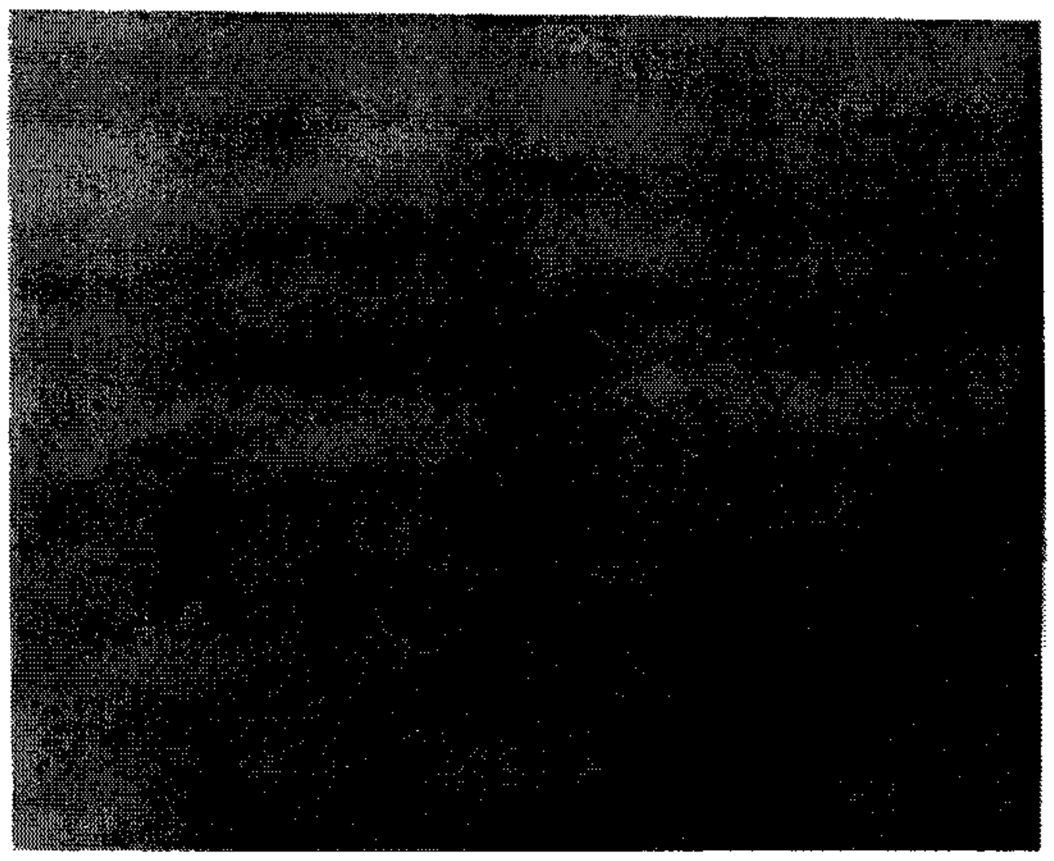

Figure 2 HRTEM image of carbon

Figure 3. shows the field emission of MWNTs. We use a phosphor-coated corning class and applied 1000 voltages. This work was *in-situ* measured. We confirmed that this result is applied to field emission devices.

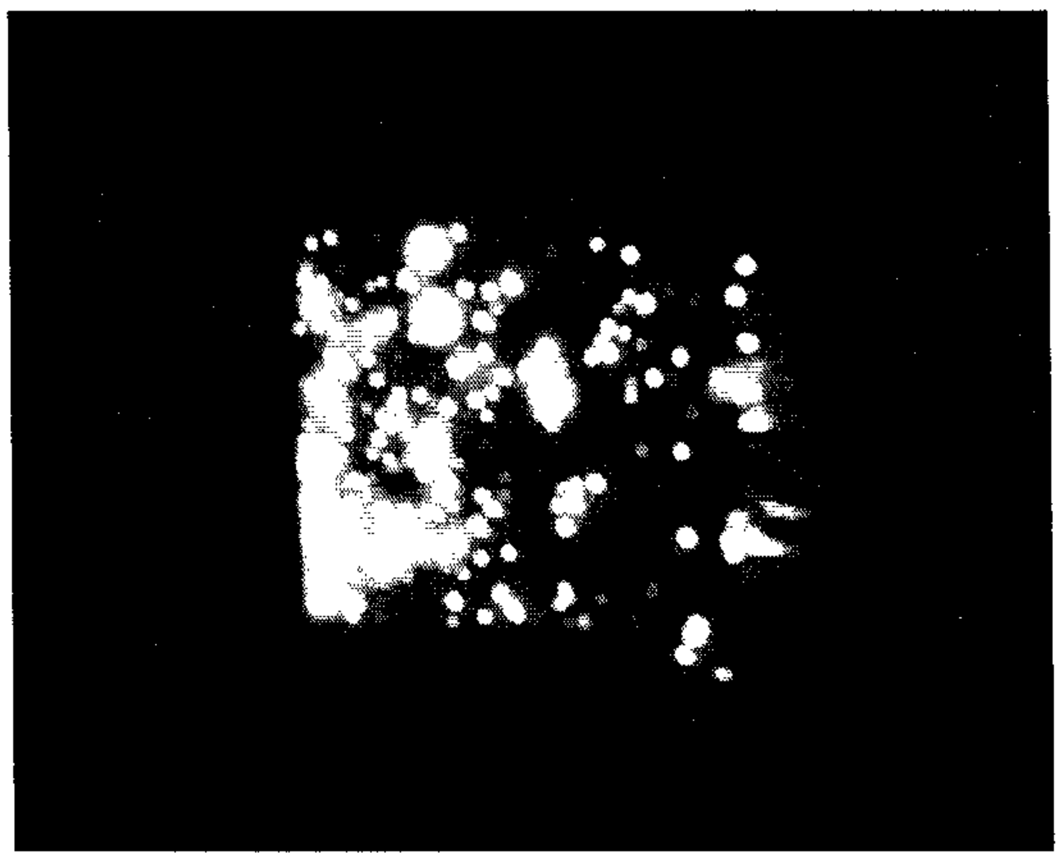

Figure 3 Field emission test

4. Conclusion

In conclusion, the MWNTs were grown by the rf-PECVD system from Ni particle at the bottom of AAN without protrusion of MWNTs tips. Also improve structure and field emission properties of MWNTs. These MWNTs would be applied to electron emitting devices.

5. References

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