Low Temperature CNT Growth and Its Application to Field Emission Displays

Gwang Bai Kim, Soo Myun Lee, Kun Hee Han,
Sang Sik Park, Hyung Soo Uh, and Sang Jik Kwon*

Dept. of Electronics Eng., Sejong Univ.,
98 Kunja-dong, Gwangjin-gu, Seoul, 143-747, Korea
* Dept. of Electronics Eng., Kyungwon Univ.,
San 65, Bokjung-dong, Soojung-gu, Seongnam-city, Korea

Carbon nanotubes(CNTs) have received a considerable attention because of the prospect of new fundamental science and many potential applications. CNTs are promising candidates, particularly, for cold cathode field emitters because of their unique electrical properties, high aspect ratios and small radii of curvature at their tips[1-2]. For applications such as flat panel displays, vertical alignment, emission properties, low temperature growth, and size control of CNTs are important.

In our experiments, CNTs were grown on Ni-coated TiN/Si substrate by microwave plasma chemical vapor deposition (MPCVD) which has been previously reported as a useful tool for the vertical alignment and low temperature growth of CNTs[3]. High temperatures than 500°C are usually not allowable to field emission displays based on glass substrate. The growth temperature can be detected by two thermometers, that is pyrometer and thermocouple. In addition, we controlled the size of CNTs by altering pre-treatment time, microwave power and mixture gas flow rate. A thin TiN layer was used as a buffer layer to improve the adhesion of CNTs to the substrate. Fig. 1 shows SEM image of the CNTs grown on the Si substrate at 500°C. Fig. 2 is the high-resolution TEM image of the CNTs grown on the Si substrate at 500℃. We could observe the successfully grown CNTs with outer diameter of 18nm, inner diameter of 4nm, 17-graphitic walls and hollow inside structure.

We demonstrated that CNT is a good candidate for field emitters by measuring field emission characteristics with diode structure. Fig. 3 shows the schematic diagram of measuring equipment of field emission(diode structure). The distance between the anode with ZnS: Al-Cu and the CNT emitters is 160μm. Fig. 4 shows I-V characteristics and corresponding Fowler-Nordheim plot. It can be found from the inset of Fig. 4 that plotting $\ln(I/V^2)$ versus 1/V yields a straight line in the region of high voltage, which indicates that the measured anode current follows the model of Fowler-Nordheim model and then can be defined as field emission current. Turn on voltage is about 3.8V/μm and maximum emission current density is 170μA/cm^2.

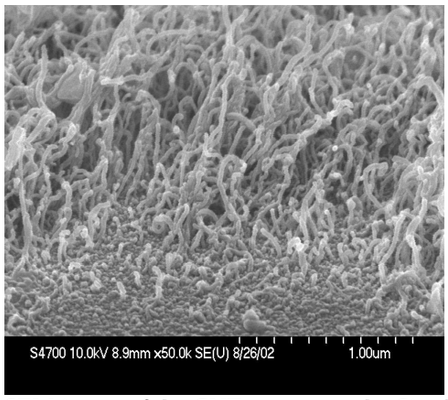

Fig 1. SEM image of the CNTs grown on the Si substrate at 500°C.

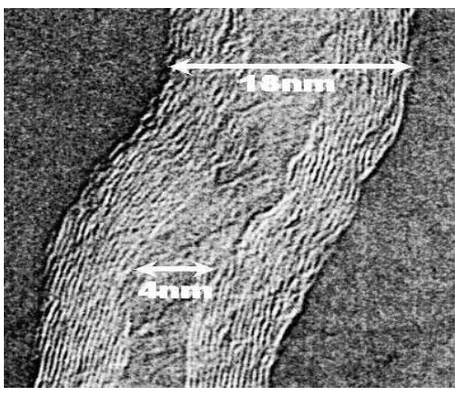

Fig 2. High-resolution TEM image of the CNTs grown on the Si substrate at 500°C.

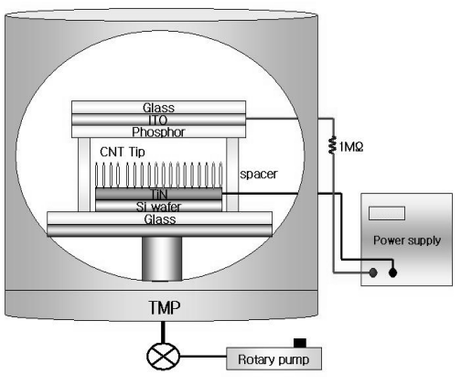

Fig 3. Schematic diagram of measuring equipment of field emission(diode structure).

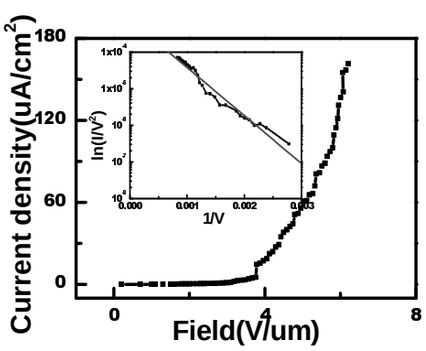

Fig 4. I-V characteristics and F-N plot of the CNTs on the Si substrate at 500°C.

Reference

[1]S. Fan, M.G. Chapline, N.R. Franklin, T.W. Tombler, A.M. Cassell, H. Dai, Science 283 (1999) 512.
[2]W. Zhu, C. Bower, O. Zhou, G. Kochanski, S. Jin, Appl. Phys. Lett. 75 (1999) 873.
[3]Y.C. Choi et al., Met., Vol. 108, (2000) 159.