Production and Purification of Double-wall Carbon Nanotubes by High-temperature Pulsed Arc Discharge

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Double Wall Nanotubes (DWNTs) have been produced by the CCVD, the arc discharge, and the peapod methods. The produced DWNTs usually have lots of defects, and large diameters (~5 nm). The peapod method also has difficulties on large scale production. To study and utilize DWNTs for further applications, such as field emitters and chemical modifications, it is necessary to improve the quality and the quantity, and to control the diameters. The DWNTs by the arc discharge method require sulfur-doped catalyst and hydrogen sources, suggesting that these non metallic catalysts play crucial roles in the production processes. Here, we report the production and purification of DWNTs with high quality and a narrow diameter (~2 nm) by the high-temperature pulsed arc discharge method. Here, we present the production of DWNTs with catalytic alloy of yttrium/nickel (Y/Ni), which has been known to produce only SWNTs. Furthermore, we have succeeded to purify thus produced DWNTs up to ~90 %.

DWNTs are produced by the high-temperature pulsed arc discharge [1]. The arc conditions of 600 μs, 50 Hz, and 50~70 Hz are utilized in Ar (1 atm, 1373~1673 K) using Y/Ni/C (0.7/4.2/95.1 at. %) electrodes. Transmission electron microscopy (TEM) measurements show that the crude DWNTs have 1.0~1.2 and 1.8~2.0 nm of the inner and the outer diameters, respectively, with 30 ppm of water at 1523 K (Fig. 1). The interlayer distances (0.37~0.40 nm) are substantially larger than that of graphite (0.34 nm). DWNTs are produced only at higher temperatures above 1473 K The temperature dependence clearly shows that outer tubes of DWNTs correspond to SWNTs of large diameters. Raman spectroscopy of the purified DWNTs produced at 1473 K in Ar 1 atm at 633 nm excitation also shows that the inner and the outer diameters are about 1.1 and 1.8 nm, respectively (Fig. 2).

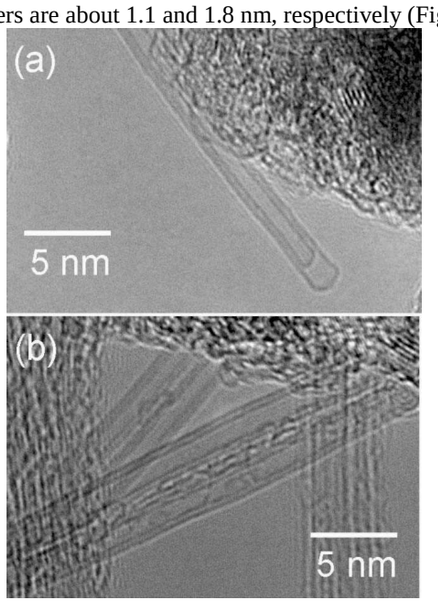
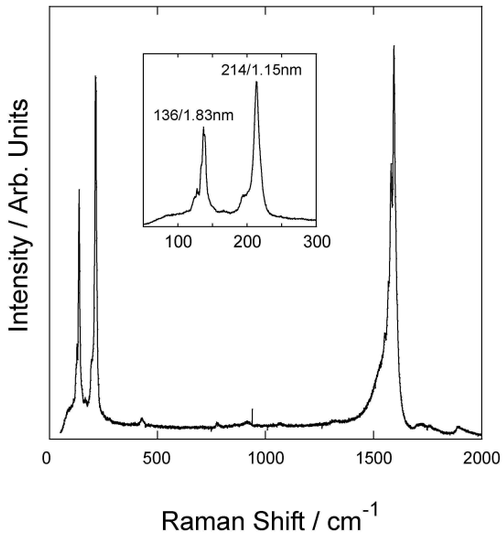


Fig. 1 TEM Images of crude DWNTs



Raman Spectra of Purified DWNTs

[1] T. Sugai, H. Omote, S. Bandow, N. Tanaka and H. Shinohara, *J. Chem. Phys.* **112**, 6000 (2000).