

## **Electron Microscope Investigation at the initial growth stage of Carbon Nanotube**

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### **Abstract**

The growth mechanism and the geometry of carbon nanotubes are affected by the several parameters such as formation process and catalytic materials. Due to the small size of the tubes and the relatively small quantities of material available, high-resolution electron microscopy is the major technique to study growth mechanism of nanotubes. Synthesis of carbon nanotubes using various methods has been intensively studied by many research groups. However the growth mechanism has still not been completely understood. In order to understand the growth mechanism of carbon nanotubes, it is essential to observe the carbon nanotubes at the initial growth stage.

We synthesized CNTs directly on TEM grid (300mesh) so that we can preserve and investigate the original form of CNTs from the initial to final growth state without any artifacts which might be introduced during TEM specimen preparation. Also, With reliability understanding the result, we prepared different methods for TEM specimen.

CNTs were grown by using thermal chemical vapor deposition at various temperature. The catalytic film was pretreated by NH<sub>3</sub> gas for 5min. Samples were examined by a scanning electron microscope (SEM) and Transmission electron microscopy (TEM).

From the electron microscopy study, it is found that the amorphous carbon layer supplied by the decomposition of hydrocarbon source is firstly formed on the catalytic metal particles at the initial growth state. Then, graphitic layers of CNT wall are formed by three different growth modes (tip-growth, base-growth and intermediate-growth). They occur simultaneously at the initial growth state with the same process parameters.

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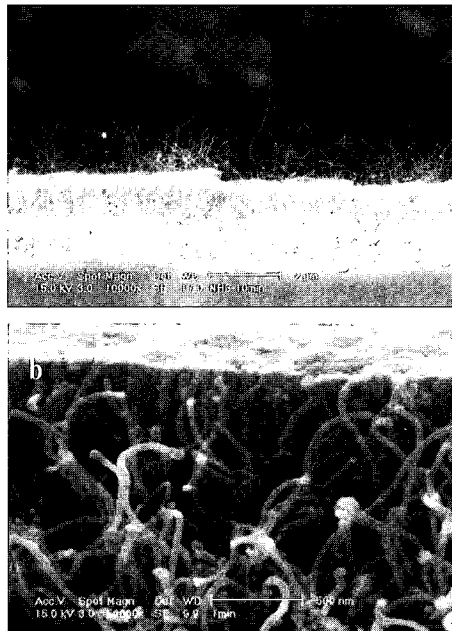


Fig. 1 SEM micrographs of CNTs grown a) on a side wall of the Ni deposited TEM grid at 700°C for 30 sec and b) on Ni / TiN / Si wafer at 650°C for 1min

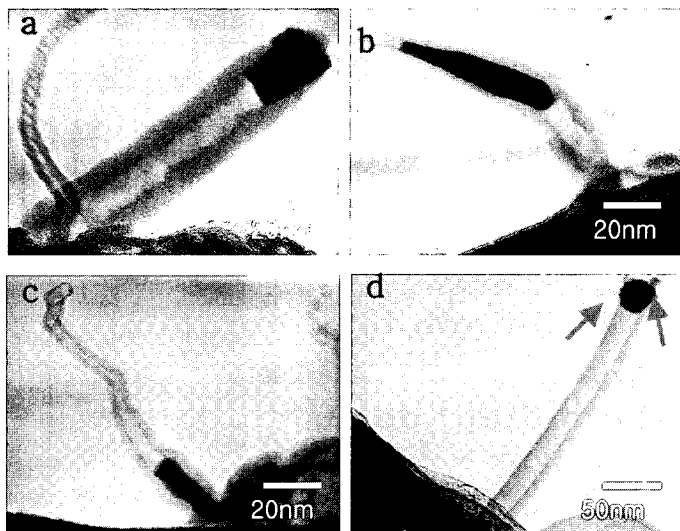


Fig. 2 TEM images showing three representative types of CNT growth; a) tip-growth mode, b) intermediate-growth mode and c) base-growth mode. For (a) ~ (c), CNTs were grown on the Ni-deposited TEM Cu mesh-grid at 700°C for 30sec. (d) is a image of CNT which has protrusions on the metal particle at the tip of CNT as marked by arrows.