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Morphology of Carbon Nanotubes Using Thermal Chemical Vapor Deposition

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ABSTRACT

A growth of carbon nanotubes (CNTs) on Ni-glass substrates at 700°C was achieved by thermal chemical vapor deposition (CVD) of acetylene gas. Acetylene gas was heated at 950°C, then flowed into area which was maintained at 700°C. The configuration and morphology of the CNTs was investigated using scanning electron microscope (SEM) and transmission electron microscope (TEM) which showed the bamboo-shaped CNTs and the curl-shaped CNTs with the diameter of 270 nm – 330 nm, and the length of 5-10 μm.

Key words: CNTs, thermal CVD

INTRODUCTION

Carbon nanotubes (CNTs) have been synthesized by numerous methods such as laser vaporization, arc discharge, pyrolysis and plasma-enhanced or thermal chemical vapor deposition (CVD). Among the large variety of these methods, the CVD method has many advantages over other methods in that CNTs can be synthesized with high purity, high yield, selective growth, and vertical alignment (Iijima, 1991 and Lee *et al*., 2000). Moreover, CNTs have been considered for many technological applications exploiting their unique electrical and mechanical properties (Meyyappan, 2005) Using CNTs as field emitters in the flat panel display is one of the most promising applications because of their unusually high aspect ratio, mechanical and chemical stability, and good conductance.

In this paper, we report a growth of CNTs at 700°C on a large area of Ni glass substrate by thermal CVD. The configuration and structural characteristics of CNTs were investigated using scanning electron microscope (SEM) and transmission electron microscope (TEM).

MATERIALS AND METHODS

The Ni catalytic film thickness in average of 30nm were thermally deposited on a 20 × 30 mm^2 size glass substrate using RF magnetron sputtering. After that, the oxide on the substrates surface were eliminated by etching in 1 %-HCl solution and in10%-NH_4OH solution, and then rinsing with methanol. The quartz reactor for the thermal CVD is shown in Figure 1. The Ni-glass substrates were placed in the heating zone of the temperature about 700°C They are in the face up

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direction and with inclination of 45° to the horizontal axis in the quartz reactor. The temperature inside the quartz reactor was measured by a thermocouple. The air in true reactor was first pumped out to obtain oxygen free atmosphere. Then helium gas was passed into the quartz reactor in order to prevent the oxidation of the Ni catalytic film while increasing the temperature. The Ni catalytic films were pretreated by using H_2 at a flow rate of 200 standard cubic centimeter per minute (sccm) as a carrier gas for 60 min at 700°C. The acetylene gas with a flow rate of 120 sccm was fed for 30 min at the same temperature and at atmospheric pressure. The CNTs were grown on the substrates, then the reactor was cooled down to room temperature. The morphology and distribution of CNTs on Ni deposited glass substrates were examined by SEM and TEM**.**

RESULTS AND DISCUSSION

Figure 2 (a) shows the SEM micrograph of the bamboo-shaped CNTs revealed the closed tip of CNTs with randomly orientation, which is a typical feature of the CNTs grown by thermal CVD method (Lee *et al*., 2000). The average diameter of CNTs is approximately 300 nm. The surface of CNTs are clean without any carbonaceous particles. The homogeneity of CNTs is rather

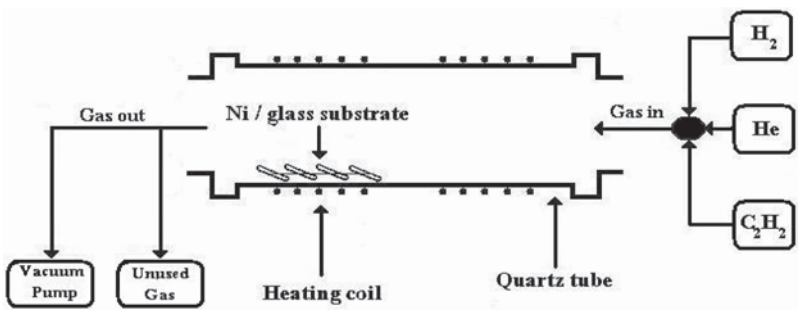
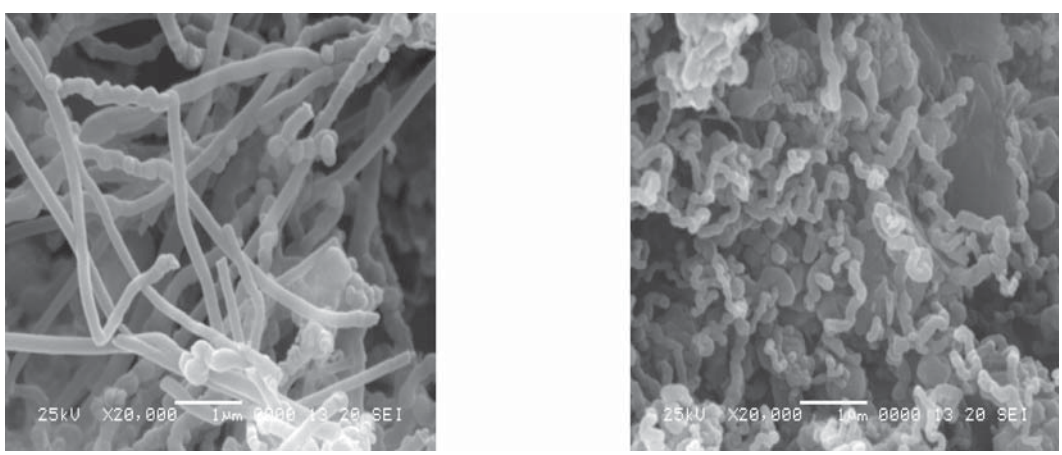


Figure 1 Schematic diagram of the quartz reactor, the Ni-deposited glass substrates was placed in the face up direction.



(a) (b)

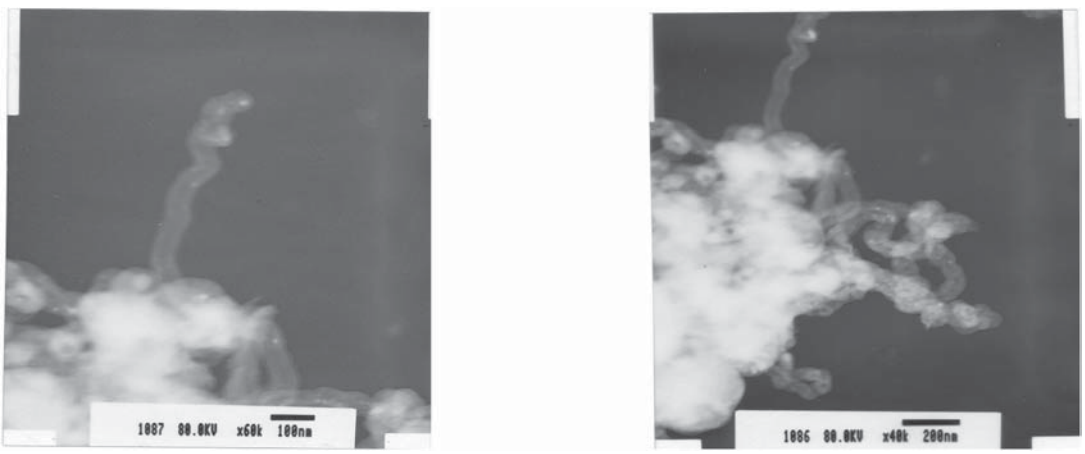
Figure 2 SEM micrographs of (a) the bamboo-shaped CNTs and (b) the curl-shaped CNTs grown on Ni-deposited glass substrate (20,000x) .

unsatisfied because of short growth time. Even though more study is necessary to elucidate the growth mechanism, this method can be practically applied to achieve the growth of CNTs on Ni-glass substrates.

Figure 2 (b) shows the curl-shaped CNTs. The diameter of CNTs are in the range of 270-330 nm, and the length of about 5-10 μm. They were laid on the substrate. The CNTs lattice was deformed by heat and could not reform when cool down.

The TEM micrographs of the bamboo-like structure of as shown in Figure 3 indicated hollow segments of CNTs. Catalytic Ni particles were inside the closed tips of CNT.

Figure 4 is a plot of the diameter versus the length of the CNTs grown on the Ni deposited glass substrate at three different areas. It reveals that the length of the CNTs depend on geometry and diameter of CNTs.



(a) (b)

Figure 3 TEM images of the CNTs showing hollow tubes with the diameter of 270-330 nm (a) (60,000x) and (b) (40,000x).

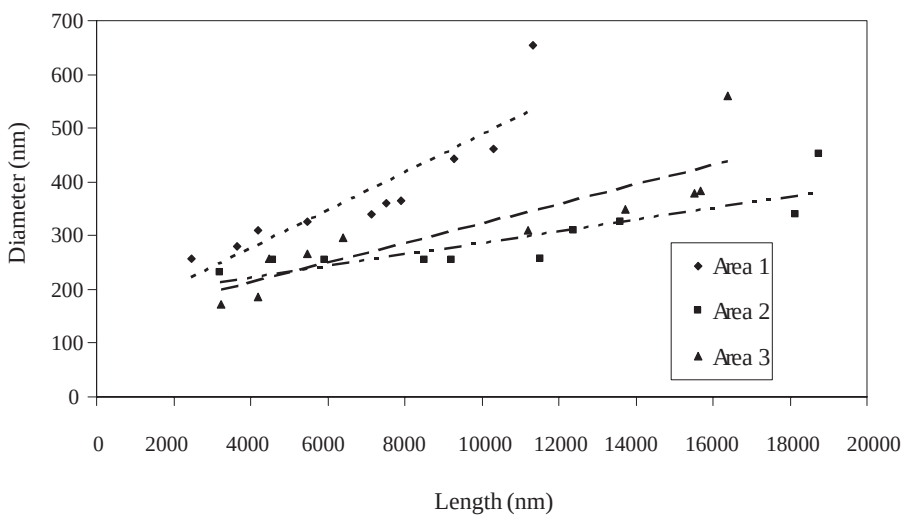


Figure 4 The relationship between diameter and length of CNTs at three different areas of CNTs.

CONCLUSION

Carbon nanotubes (CNTs) were grown on Ni-glass substrates by thermal chemical vapor deposition (CVD) of acetylene gas. The configuration and morphology of the CNTs was investigated using scanning electron microscope (SEM) and transmission electron microscope (TEM) which showed the bamboo-shaped CNTs and the curl-shaped CNTs with a diameter of 270 nm – 330 nm, and the length of 5-10 μm.

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