

Synthesis of Carbon Nanotubes and Nanobelts on Thin Iron Film by Thermal Chemical Vapor Deposition Method

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ABSTRACT

The carbon nanotubes (CNTs) were synthesized from acetylene gas (C_2H_2) by thermal chemical vapor deposition method for the formation of catalytic iron nanoparticles was used Hydrogen (H_2) as the environment gas. The CNTs were synthesized on iron nanoparticles as catalyst and on the wall of stainless steel chamber. The size of carbon nanobelts was about 300 nm (wide).

Key words: chemical vapor deposition, nanobelt, carbon nanotubes

INTRODUCTION

Carbon nanotubes (CNTs) have captured the imagination of physicists, chemists and materials scientists alike. Physicists have been attracted to their extraordinary electronic properties, chemists to their potential as nanotest-tubes and materials scientists to their amazing stiffness, strength and resilience.

Synthesis of carbon nanotubes has been extensively investigated by research groups, since the first observation in 1991. Various synthetic methods of CNTs were arc discharge, laser vaporization, pyrolysis, plasma-enhanced and thermal chemical vapor deposition (CVD). The synthesis of CNTs using CVD method has attracted attentions because of many advantages such as high purity and controlled growth. CNTs have been known to have superb applications to the energy storage in super capacitors and secondary batteries, various transistors and field emissions displays.

MATERIALS AND METHODS

The quartz substrates were deposited with 100 nm iron thin film thickness by DC sputtering (Hongo *et al.*, 2002; Lee *et al.*, 2002; Chiu *et al.*, 2006; McCaldin *et al.*, 2006). Figure 1 shows the schematic diagram of thermal CVD apparatus. The stainless steel chamber was pumped down to less than 10^{-3} bar at 750°C and then helium gas (He) was fed into the chamber with flow rate of 30 sccm (standard cubic centimeters per minute). The pressure of chamber was more than one atmosphere, hydrogen gas (H_2) was fed into the chamber with flow rate of 200 sccm for 30 minutes and the C_2H_2 was fed with flow rate of 120 sccm for 30 minutes. The CNTs were synthesized in this step. The oven was turn off and we flow He gas. The sample was cooled to room temperature. Figure 2 shows schematic diagram of pretreatment and growth of CNTs.

The CNTs were examined by scanning electron microscope (SEM) and transmission

electron microscope (TEM) to measure the size of samples.

RESULTS AND DISCUSSION

Figure 3 shows SEM image of CNTs grown on the wall of chamber using thermal CVD of acetylene gas for 30 minutes at 750°C. The average diameter of CNTs is 90 nm. The graphite sheets grown all around the CNTs.

Figure 4 shows SEM image of CNTs grown on thin iron film using thermal CVD of C_2H_2 for 30 minutes at 750°C. The average diameter of CNTs is 36 nm. The carbon nanobelts were found near CNTs.

Figure 5 shows SEM image of carbon nanobelts and graphite sheets grown on thin iron film. The width of carbon nanobelts is approximately in a scale of 300 nm and 700 nm for graphite sheets.

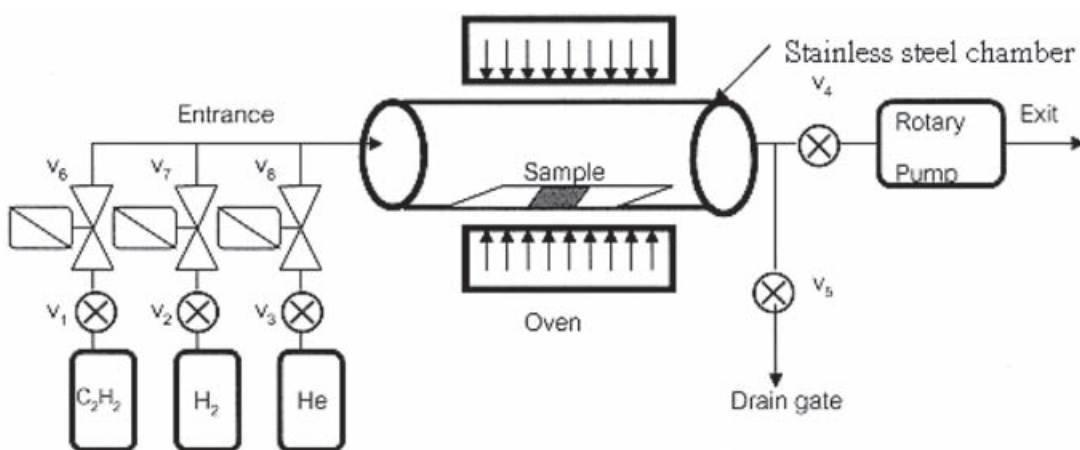


Figure 1 Schematic diagram of thermal CVD apparatus, v_1, v_2, v_3, v_4 and v_5 are the ball valves, v_6, v_7 and v_8 are the metering valves.

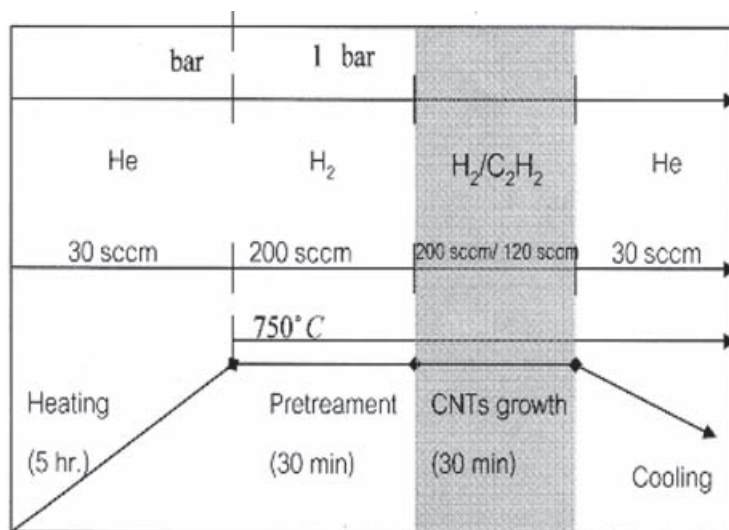


Figure 2 Schematic diagram of pretreatment and growth of CNTs in stainless steel chamber.

Figure 6 shows (a) TEM image of carbon nanofiber (CNFs) and (b) carbon nanobelts on thin iron film. TEM images examination revealed that the width of CNFs and carbon nanobelts is approximately 200 nm and 90 nm, respectively, indicating a very large size.

Figure 7 shows TEM image of CNTs on thin iron film. TEM image studies show that the interlayer spacing of the synthesized CNTs, which indicated the sample, was tube.

CONCLUSIONS

The CNTs, CNFs and carbon nanobelts were synthesized on Fe catalyst and on the wall of stainless steel chamber using thermal CVD at 750°C. The CNTs, which synthesized on thin iron film catalyst have shorter average diameter than the CNTs without catalyst. The carbon nanobelts and CNFs were synthesized because of the diffusion of carbon into the surface of the large nanoparticles.

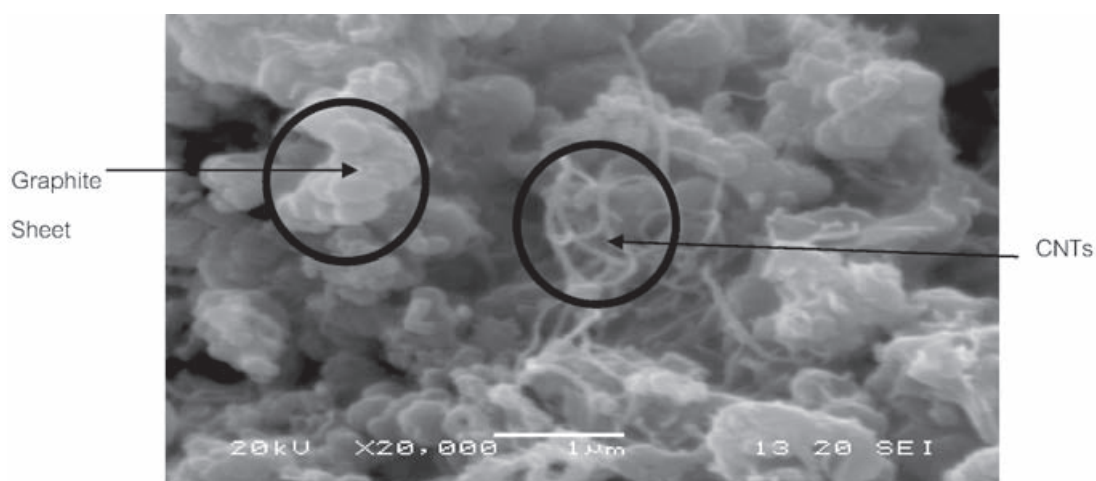


Figure 3 SEM image of CNTs on the wall of chamber.

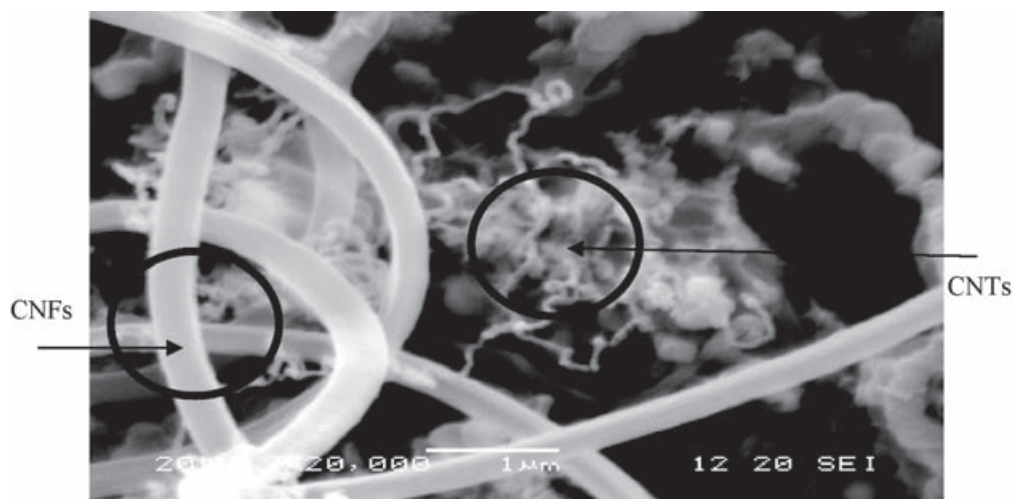


Figure 4 SEM image of CNTs on thin iron film.

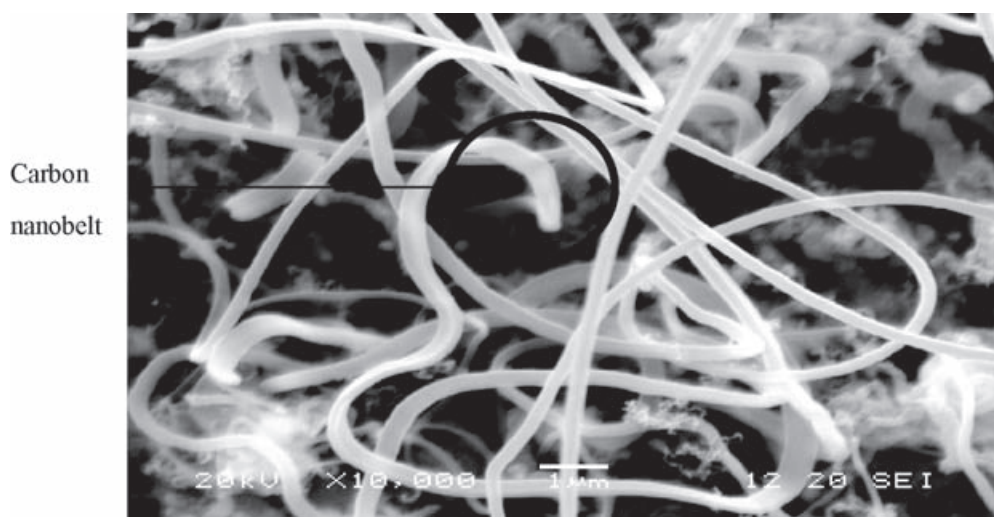


Figure 5 SEM image of carbon nanobelts on thin iron film.

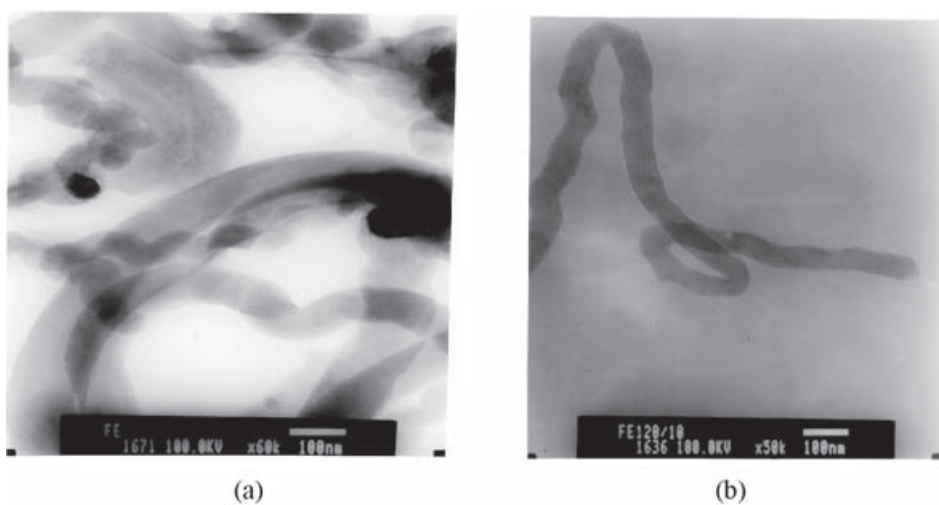


Figure 6 TEM image (a) carbon nanofibers, (b) carbon nanobelts on thin iron film.

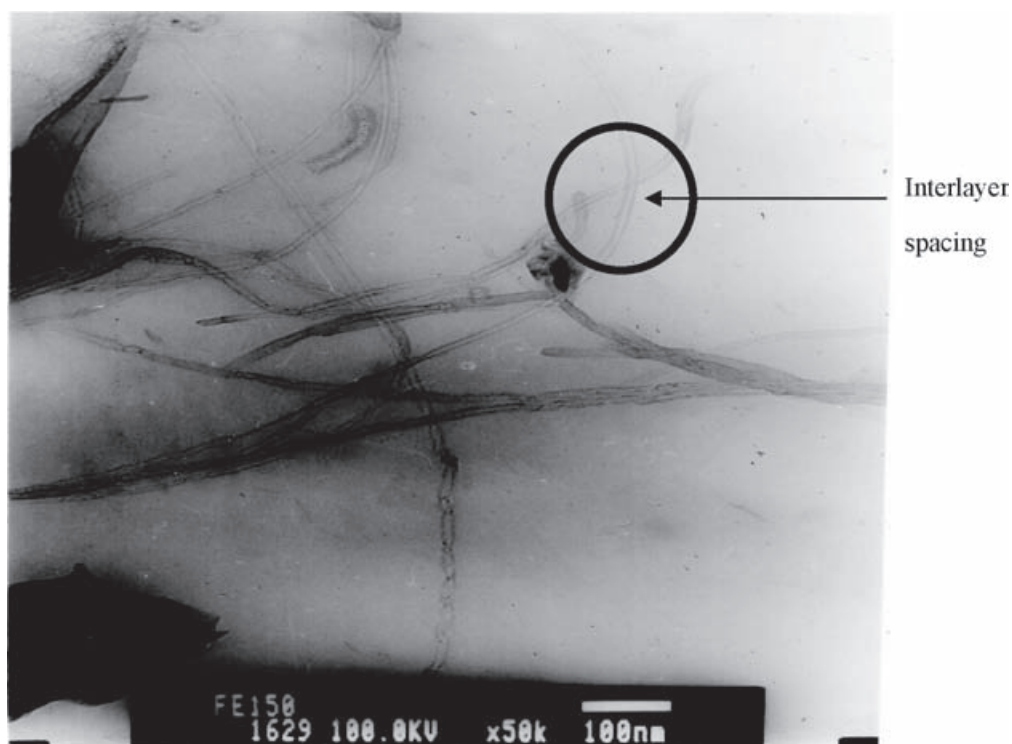


Figure 7 TEM image of CNTs on iron thin film.

In summary, The role of iron thin film catalyst is the growth of carbon nanobelts, CNFs and CNTs.

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