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Submitted

on November 02, 06:41 AM

for mrsspring2010

Proof

CONTROL ID: 760437

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Abstract Details

PRESENTATION TYPE: Oral Presentation Preferred

SYMPOSIUM: R: Carbon Nanotubes and Related Low-Dimensional Materials

KEYWORDS: Composition & Microstructure / Material Type / nanoscale, Synthesis & Processing / Chemical Reaction / chemical vapor deposition (CVD) (chemical reaction).

Abstract

TITLE: Growth Mechanism of Single-Walled Carbon Nanotubes at Low Temperature and Low Pressure CVD Conditions

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ABSTRACT BODY: A control technique of the detailed structures of single-walled carbon nanotubes (SWNTs) is necessary for the fabrication of SWNT electric devices, and understanding the SWNT growth mechanism is important in order to improve growth techniques. On the other hand, for assembly of SWNT devices, the growth technique of SWNTs at low temperature is desired, avoiding thermal damage of the devices. While the quality of SWNTs grown at low temperature is not so high, the metal catalyst is stable at low temperature and it is possible to control the structure of SWNTs by controlling the catalyst.

In the present study, we performed SWNT growth by a catalytic chemical vapor deposition (CVD) method over wide temperature and pressure ranges, using an ultra high vacuum CVD chamber. In particular, we focused on low CVD gas pressure and low temperature conditions, and investigated the SWNT growth mechanism. SWNTs were synthesized using ethanol as the CVD gas. As the catalyst, Co/Mo metal particles deposited on silicon substrates were used. The metal particles reacted with the CVD gas and then SWNTs were grown from the catalyst particles. The ethanol gas pressure ranged from 0.001 to 100 Pa, and the CVD temperature ranged from 400 to 900 C. The yield of SWNTs was assumed to be proportional to the G-band intensity, which was measured by Raman scattering

spectroscopy. SWNT samples were observed by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). An optimum CVD temperature existed for a fixed ethanol gas pressure, which decreased with decreasing ethanol gas pressure. We obtained SWNTs even at 500 C, when the ethanol gas pressure was low (less than 0.01 Pa). In this study, the minimum temperature was 450 C at 0.001 Pa. On the other hand, when dimethyl ether (DME) was used as the carbon source, the optimum temperature slightly decreased and the relationship between the optimum CVD temperature and ethanol gas pressure was the same as the case of ethanol. At low temperature, the activity of the catalyst was also low. However, low gas pressure condition moderated the SWNT growth and increased the lifetime of the catalyst.

(No Table Selected)