A PARAMETRIC STUDY OF THE CARBON NANOTUBES PRODUCED BY MPECVD

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Introduction

Microwave plasma-enhanced chemical vapor deposition (MPECVD) method has been regarded as one of the most promising candidates for the synthesis of CNTs; due to the vertical alignment, the large area growth, the lower growth temperature, uniform heat distribution and the good control of the different growth parameters. In this work we present results of preparation of carbon nanotube with different morphologies by using microwave plasma enhanced chemical vapor deposition MPECVD[1].Well aligned, curly and coiled carbon nanotubes have been prepared. Moreover the magnetic properties of CNTs have been also investigated by using electron paramagnetic resonance EPR [2]. Single wall CNTs were grown on diatomite [3] we have also investigated the effect of the different growth condition parameters such as pressure, the hydrogen to methane flow rate ratio nitrogen gas addition and plasma power on the morphology of the carbon nanotubes.

Experimental

CNTs synthesis was grown by using SEKI AX5200S microwavePECVD reactor. Thin catalyst layers (Co, Ni or Fi) of different thicknesses were deposited on the silicon substrate by the magnetron sputtering. After pretreatment process these samples were leaded to the PECVD which evacuated at a base pressure about $1x10^{-7}$Torr. We have changed the different growth parameters, for more details you can see [1-3].Our samples are subjected to the investigations by Analytical scanning electron microscope JEOL JSM-6490LA with resolution (3 nm) and operating potential 30 kV, the energy dispersive X-ray analysis (EDX) which is attached to the electron microscope and Raman spectroscopy was performed on the surfaces of the carbon deposits to characterize the diameter distributions of the smaller CNTs and their graphitic ordering by using (NT-MDT, NTEGRA Spectra) with excitation Ar laser 473 nm at room temperature.

Results and Discussion

The results showthat there is a great dependence of the morphology of carbon nanotubes on theparameters varied in the study. There is a linear relation between the growth rate and the methane to hydrogen ratio. We found that the growth rate has a great dependence on the amount of methane. For example the growth rate varied from the value 1.34μm/min when the methane flow rate was 10 sccm to more than 14μm/min when the methane flow rate was raised to 50 sccm, see Figure 1. Raman measurements showed that quality of the CNTs was increased by increasing the gas pressure from 11 to 26Torr; see Figure 2 [1]. Moreover the yield of the CNTs was effectively increased with the increase in the pressure.

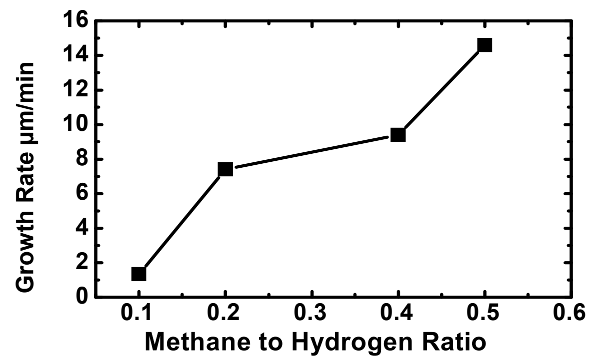

Fig. 1 Effect of the ratio between methane and hydrogen on the growth rate of the CNTs.

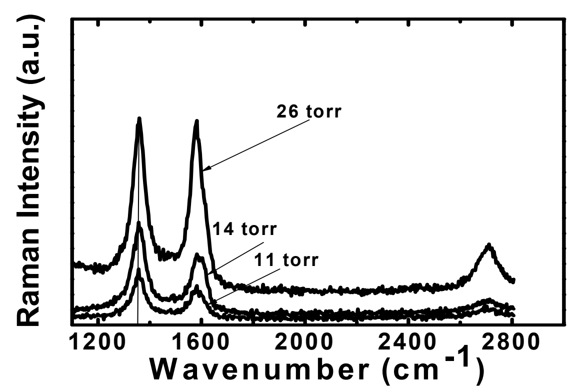

Fig. 2 Effect of gas pressure on the quality of carbon nanotubes.

The effect of the nitrogen addition was studied using SEM and Raman spectroscopy. The results showed the potential to produce slim and clean CNTs with controlling $N_2/H_2/CH_4$ proportion, which is a requirement for field emitter application.

There was a linear relation between the N_2 percent and the ratio I_G/I_D which indicates that the quality of the CNTs was increased by increasing the N_2 percent, Figure 3.Moreover the intensity of the D-band decreases as the N_2 increased which give the same result. Very high or low values of the plasma power are not a conducive condition for the growth of the

CNTs.Results showed that there was an optimum value, 500 watt, for the plasma power used in the growth of the CNTs by using MPECVD.

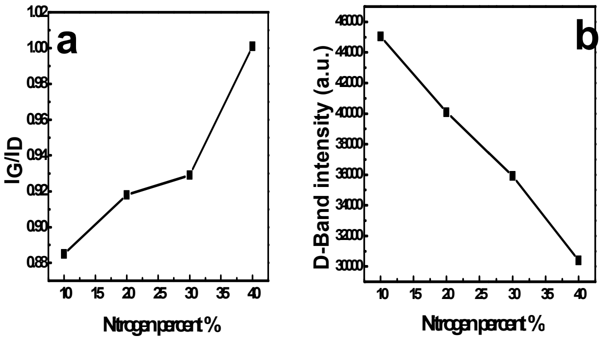

Fig. 3 Effect of nitrogen addition on the CNTs a) relation between the ratio I_G/I_D and the nitrogen portion, b) Relation between the nitrogen portion and the D-band intensity.

These results indicate that; by using the N_2we can obtain clean CNTs with good quality. Moreover we can adjust the CNTs diameters not only by the catalyst thickness but also by the adjustment of the gas in the reaction field. For the first time we have reported the observation of the carbon nanosheets at the end and the middle of the CNTs [1].

Table 1.I_G/I_D variation with methane flow rate at different catalyst's thicknesses.

CH_4flow rate(sccm)	30 (nm)	60 (nm)	120 (nm)
10	0.8921	0.9883	1.0715
20	0.9950	0.9980	1.1140
40	0.9960	0.9965	1.1143
50	0.8903	0.9889	1.0724

These carbon nanosheets were attached to the carbon nanotube at different positions, such as the top or the middle, the investigations by the SEM showed that these nanosheets are strongly attached to the tube. Also we report the formation of the coned coiled carbon nanotubes as shown in Figure 4 and its growth mechanism was discussed [3].

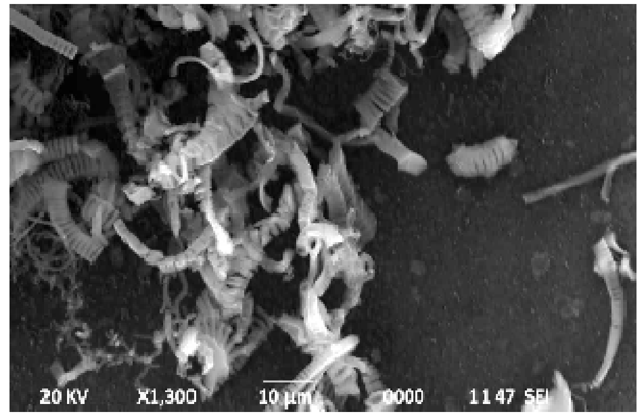

Fig. 4 Coned nanocoil and nanoribbon.

Table 1 represents the variation of the ratio (I_G/I_D) with methane flow rate at different thickness. From these data one can conclude that for all thicknesses the ratio increases to maximum value and then go down again and this suggested that there is an optimum value for the methane flow rate at about 30 sccm.

Conclusions

In summary we have prepared CNTs with different morphology (such as well aligned, irregular coiled and regular coiled) CNTs by using MPECVD. The effect of the methane to hydrogen ratio on the morphology and the structure of the CNTs have been studied by using SEM and Raman spectroscopy. There is an optimum value of methane to hydrogen ratio at which we can obtain CNTs with good structure and less carbonaceous particles. Single wall CNTs have been grown on diatomite and this new material has a promising application in water purification. Nitrogen gas can be used to obtain clean CNTs with adjustablediameters. The quality of CNTs is increased as the gas pressure increased from 11 to 26 Torr. The optimum value for the plasma power was 500 watt.

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References

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