Controlled Growth of Carbon Nanotubes on Carbon Paper by CVD

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Catalytic chemical vapor deposition (CVD) is thought to be the most promising method to produce carbon nanotubes (CNTs) with high yield, high purity and vertical alignment. During the growth of CNTs, transition metals such as Ni, Co and Fe or their alloys, which are used in the catalytic decomposition of carbon-based materials, play a significant role in the formation of the CNTs. The key challenges involve the control of the size and the distribution of the catalysts, as well as an understanding of the chemistry of catalytic materials and their interaction with the support. This report presents the direct growth of multi-wall carbon nanotubes (MWCNTs) on carbon paper in a specially designed CVD reactor that heats the carbon paper by the Joule effect [1]. In this report, emphasis will be placed on: (i) the use of binary catalytic alloys and their dispersion on the support; (ii) the yield and the quality of the produced CNTs.

MWCNTs have been grown at 700°C from ethylene using Co-Ni, Fe-Ni, Fe-Co catalytic sites supported on the fibres of carbon paper by a silicate intermediate layer. Different CNT growths are obtained by varying the elemental ratios of the binary alloys. The ratio yielding the largest amount of CNTs is always 1:1. Other ratios result in large changes in behavior. X-ray energy-dispersive spectrometer (EDX) reveals that the composition of the catalytic particles at the tip of the CNTs fully corresponds to that of the starting chemicals used to produce the alloys. In addition, silicon was also detected in the same catalytic particles. Fig.1 shows a TEM micrograph of the MWCNTs grown on Ni/Co (1:1) catalytic particles supported by silicate on carbon paper.

A modified method to disperse the catalytic particles using a chemical compound other than silicate has been recently developed [2]. Fig.2 shows a TEM micrograph of the MWCNTs grown from ethylene by using this new dispersion procedure. It illustrates the remarkable abundance of individual CNTs and their high purity and structural quality. These carbon fiber-supported MWCNTs may have potential applications as field emitters, fuel cell and lithium battery electrodes, and for gas (including hydrogen) adsorption and storage.

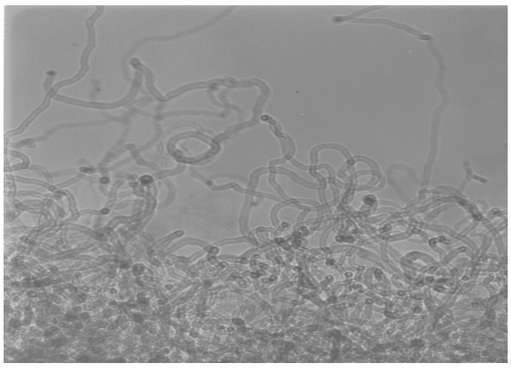

Fig.1 TEM micrograph of the MWCNTs grown on Ni/Co catalytic particles supported by a silicate intermediate layer

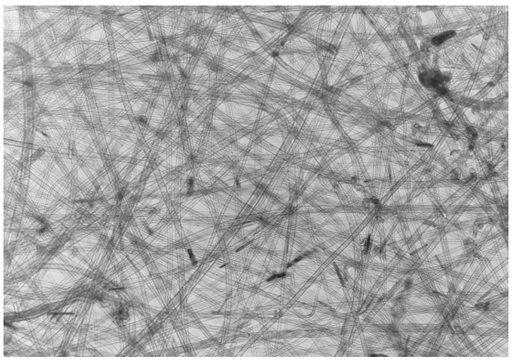

Fig.2 TEM micrograph of the MWCNTs grown on Ni/Co catalytic particles dispersed by a modified method

References

[1] O. Smiljanic, T. Dellero, A. Serventi, G. Lebrun, B.L. Stansfield, J.P. Dodelet, M. Trudeau, S. Desilets, Chemical Physics Letters, 342 (2001) 503-509

[2] J.P. Dodelet, X. Sun and S. Desilets, patent filed.