"GROWTH AND CHARACTERIZATION OF CARBON NANOTUBES GROWN ON Fe AND Fe-Pd FILMS"

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Abstract

Carbon Nanotubes (CNTs) due to their one-dimensional aspect exhibit remarkable electronic and mechanical properties, some stemming from close relation between carbon nanotubes and graphite. CNTs can be considered as tubular forms of carbon that can be envisaged as graphitic sheets rolled into cylindrical form. These have diameters of few nanometers and lengths up to several micrometers. The nanotubes are endowed with exceptionally high material properties like electrical and thermal conductivity, stiffness, toughness and strength. Owing these extra-ordinary properties, CNTs have been of great interest both from a fundamental point of view and for future application. The most eye catching features include mechanical, optical, electronic and chemical characteristics that have opened the way to future applications. Some of its important applications include chemical sensors, probe tips, flat-panel displays, lithium-ion batteries, etc.

The present research work involves growth and characterization of carbon nanotubes using low-pressure CVD (LPCVD) and Electron Cyclotron Resonance CVD (ECR-CVD) method.

For, the growth of CNTs using CVD, firstly choice of proper catalyst is required. It is seen that the higher yield of CNTs with bi-metallic catalysts is attributed to particle melting point reduction, increase in the carbon solubility and the formation of well-dispersed metal clusters upon segregation during CNT formation. Therefore in the present work we have used Fe based alloy films of $Fe_{70}Pd_{30}$ and $Fe_{70}Pt_{30}$. Alloys of Fe_{70} Pd_{30} and Fe_{70} Pt_{30} were prepared using arc-discharge method. After arc-discharge, the ingots of both the alloys were collected to synthesize their nanocrystalline films on silicon substrate using vapour condensation technique. The nano-crystalline films of Fe_{70} Pd_{30} and Fe_{70} Pt_{30} were used as catalyst to grow CNTs using LPCVD method.

The pressure and temperature were maintained at 10 torr and 800°C respectively. For the growth of nanotubes gaseous mixture used was N_2:C_2H_2:H_2 . The as-grown CNTs were then characterized using scanning electron microscope (SEM), transmission electron microscope (TEM), high-resolution TEM (HRTEM), Raman Analysis etc.

However, for the growth of CNTs using ECR-CVD, an r.f magnetron sputtering system was used for the thin film deposition of Fe (which acts as a catalyst) on silicon substrate.

Fe deposited silicon wafer was then placed on the substrate holder in an assembled ECR-CVD system at a working pressure of 10^{-3} mbar and base pressure of 10^{-6} mbar. Argon was used as a plasma gas. The other gases used were C_2H_2, NH_3 and H_2. Temperature was maintained at 650°C. The as-grown CNTs were then characterized using scanning electron microscope (SEM).

Besides the growth of CNTs, we have concentrated more on the electrical conduction mechanism of multi-walled carbon nanotubes grown on Fe and Fe based alloy films. For electrical transport measurements, we have used four-probe method. A specially designed sample holder with standard lock-in technique was used to measure R-T curves.

The electrical transport measurements of carbon nanotubes can be interpreted in terms of variable-range hopping conduction. In disordered systems, the electrical conduction does not obey the classic process of diffusion, but follows the variable-range hopping (VRH) theory of Mott that explains the low temperature behavior of the resistivity in strongly disordered systems possessing localized states.

The electrical transport mechanism of multi-walled carbon nanotube is studied over a temperature range (298-4.2K). Temperature dependence of conductivity suggested variable-range hopping (VRH) for the entire temperature range (298-4.2K). Various Mott's parameters like conductivity (σ_0), density of states $N(E_F)$, degree of disorder(T_0), hopping energy (W) etc. have been calculated.