Vertically aligned carbon nanotubes synthesized by plasma chemical vapor deposition

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Carbon nanotubes are considered to be among the technologically most promising nano-scale materials due to their extraordinary electronic and mechanical properties with potential applications in various fields of science and microelectronics industries. Many different techniques have been used to study growth of these new materials. such as laser ablation, chemical vapor deposition, plasma-enhanced chemical vapor deposition and pyrolysis.

Chemical vapor deposition (CVD) methods are the most promising for obtaining controlled growth of individual nanotubes on patterned substrates. Thermal chemical vapor deposition was the subjectof the our previous study [1] where the temperature and particle size dependence of multi wall carbon nanotubes (CNT) was investigated. However, a way of controlling length, diameter and chirality of nanotubes has not been easy to demonstrate with such an approach. In the present study, free standing carbon nanotubes were successfully synthesized using plasma chemical vapor deposition (PCVD). Features like: growth of tubes at lower temperatures, easy vertical alignment and high yield of CNTs represents some of the main advantages of this method over the other ones. The plasma method generates a glow discharge in a chamber using a direct current (dc) applied between two electrodes. CNTs were grown on 10nm Ni coated Si substrates at 700^0C with a gas mixture of NH_3 and C_2H_2. The growth time of CNTs was maintained for 15minutes. Free-standing tubes with diameters on the order of 50nm were produced The same conditions were used when the catalyst was replaced with Fe with somewhat different results. SEM, TEM and HRTEM were used for sample analysis.

In the plasma process the effects of reactant gases and catalyst type and thickness is important in controlling the nanotube diameter, length and density and their alignment is controlled by uniformity and direction of the electric field. Parametric studies will be presented.

[1] O.A. Nerushev et al., J.Appl. Phys. In press