Abstract

The role of the catalyst in the growth of 1D carbon nanostructures is explored in this thesis. Four fundamental questions have been posed in seeking to understand the role of the catalyst and to determine if the vapour-liquid-solid (VLS) mechanism offers a comprehensive explanation for the growth of CNTs using various catalysts. i) Is the melting point of the catalyst a significant factor in determining whether CNTs grow? ii) Does the carbon solubility of the catalyst have a role to play? iii) Are metallic catalysts necessary to grow CNTs? iv) Is the catalyst really a catalyst or to ask that question in a different way, are any external catalysts necessary at all?

Several experiments were attempted using various catalysts to explain the growth mechanism of the 1D carbon nanostructures. Catalysts with a variety of melting points, carbon solubilities, metals and non-metals, etc were selected for the growth of CNTs.

Using a low melting point metal (Bi) as a catalyst, partially bismuth-filled carbon nanotubes were synthesized. Vertically aligned CNTs with uniform diameters were observed all over the substrate with iridium nano particles as a catalyst. Hanging networks of the CNTs between Si nano-pillars were also synthesized using silver nanoparticles as a catalyst.

Commercial grade SiO_2, TiO_2 and Al_2O_3 nano-powders were used as the catalyst for the growth of the CNTs. Similar morphologies of CNTs but with narrower inner diameters, large outer diameters and shorter lengths were grown using the above oxide nanoparticles as the catalyst.

Carbide catalysts like SiC and B_4C have been used as the catalysts for the growth of CNTs. Growth of CNTs was observed from the finer nanoparticles of SiC. Faceted stacked layers of graphene and CNT-hybrid carbon nanostructures were synthesized using B_4C nanopowder particles as the catalyst.

In the last part of the work, high quality CNTs were grown using Ni as the catalyst. The purified CNTs were used with amino-coumarin and its derivatives to form the photoactive layer in a photovoltaic cell in an attempt to utilize the CNTs to improve the performance of the photovoltaic cells.

Keywords: Carbon nanotubes, Growth mechanism, catalyst, atmospheric chemical vapour deposition, aligned growth, suspended CNTs