Carbon is a chemical element with the symbol C, atomic number 6 and electron configuration [He] 2s^2 2p^2. Carbon is set as the sixth element of the periodic table. The hybridization of carbon consists of sp (for example, C\textsubscript{2}H\textsubscript{2}), sp\textsuperscript{2} (for example, graphite) or sp\textsuperscript{3} (for example, CH\textsubscript{4}).

Carbon nanotubes (CNTs) have a tubular structure made of carbon atoms, with diameter of nanometer range and length in micrometers. Since Iijima's landmark publication, the CNTs are widely used in many applications. The application of CNTs is typically governed by the CNTs structure (number of walls, diameter, length, chiral angle, etc.), which assign them various properties.

CNTs can be basically classified as, single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs). CNTs also exist in different shapes such as: toroidal, coiled and branched other than the straight. All these structures depend on the introduction of non-hexagonal defects in seamless hexagonal networks. The regular helical coils of CNT's are derived from a very definite packing of pentagons and heptagons in a perfect hexagonal lattice. Carbon nanotubes are generally produced by three main techniques, arc discharge, laser ablation and chemical vapour deposition (CVD). Compared with other techniques, catalytic CVD is considered to be an economically feasible process for large scale and pure CNTs production. The main advantages of CVD comprise easy control of the reaction and
production of high purity material, etc. Fe, Co, Ni are most commonly used metals due to high solubility of carbon in these metals and high carbon diffusion rate in these metals.

The catalyst–substrate interaction should be investigated with extreme consideration for the efficient CNT growth. The chemical bond formation between metal–substrate would affect the catalytic behavior of the metal. Thus substrate material, its surface morphology and textural properties significantly affect the yield and quality of the CNTs. Amorphous aluminum phosphate (AlPO₄) and mesoporous molecular sieves (MCM-41) were used as catalytic template. Various wt% of transition metals like Cobalt (1, 5, 10 and 20 %), Iron (1, 3, 5 and 10 %) and Nickel (1, 3, 5 and 10 %) were loaded on AlPO₄ by wet impregnation method. M-MCM-41 (M=Fe and Sn) molecular sieves with Si/M ratios (100) was synthesized by hydrothermal method. Various wt % Sn (1, 5, 10 and 20 %) was loaded over Fe-MCM-41 by wet impregnation method. The catalysts were characterized by XRD, XPS, Nitrogen sorption isotherms, TGA, SEM and HR-TEM. The effects of temperature and gas ratio of hydrogen to acetylene during the growth of CNTs by CVD were investigated. The synthesized carbon materials were purified by acid treatment and followed by air oxidation process. The CNTs were examined with XRD, TGA, SEM, TEM and Raman spectroscopy.

In order to adapt a new CNT synthesis strategy suitable for the mass production on industrial scale without giving up the quality of CNTs, electrophoretic deposition technique (EPD) was used for the preparation of catalyst layer. Preparation of catalyst layer over SS substrate by EPD
technique was carried out for the growth of CNTs via CVD. Various catalyst layers of cobalt, nickel and iron were studied. The effects of temperatures and gas ratio of hydrogen to acetylene for the growth of CNTs were investigated. The morphology and crystalline nature of the purified CNTs were examined with SEM, TEM and Raman spectroscopy. The catalytic activity increases depending on the metal used in the order Fe/SS > Co/SS > Ni/SS which is consistent with CNT yield.

Hybrid metal–insulator–semiconductor (MIS) and metal–insulator–metal (MIM) inorganic–organic memory using carbon nanotubes (CNTs) nanocomposites, have invited widespread attention for nonvolatile memory devices. The effect of CNTs content in electrical bistable switching of a polyvinyl alcohol (PVA)-CNT composite film was investigated. By varying the CNT content in the PVA films, the Si/Al/PVA-CNT/Al device performance parameters, including conductivity, turn-on voltage, and ON/OFF state current ratio, was tuned accordingly. The device exhibited the characteristic behavior of an insulator, write-once-read-many-times, rewritable and conductor effect by doping various weight percentage of CNT in PVA. The device with 3% CNT in PVA demonstrated significantly a lower turn-on voltage of -1V and a higher ON/OFF state current ratio of $10^7$.

MIM type memory devices (Si/PVA/CNT/PVA/Al) were fabricated with CNTs embedded in PVA. The effect of CNT content in the charge storage capacity of PVA-CNT composite film was investigated. The hysteresis obtained from the capacitance-voltage (CV) measurement resulted in a memory window of 1.9 V with 3% CNT loading with the gate voltage
sweep of +/- 6 V at 1MHz under room temperature. Si / HGO / CNT / HGO / Al, exhibited a large memory window 2.3V under 4V operation. These device exhibited long retention characteristics with small loss of charge. The reliability of the memory device was not degraded till $10^6$ P/E cycles.

CNT has attracted wide spread attention in the application based on their mechanical properties will be as reinforcements in composite materials. In order to enhance the advantages of nanotubes as reinforcing structures in high strength composites, the aggregates needs to be broken up and dispersed or cross-linked to prevent slippage. There are certain advantages that have been realized in using carbon nanotubes for structural polymer (e.g., epoxy) composites. Nanotube reinforcements will increase the toughness of the composites by absorbing energy during their highly flexible elastic behavior. In order to avoid the complicated functionalization process and defect on tubes, CNT are modified with AlPO₄ (AlPO₄@CNT) and SiO₂ (SiO₂@CNT). Amorphous AlPO₄ coated MWCNTs and amorphous silica coated MWCNTs were synthesized by sol-gel method. These materials were used as a filler material for the fabrication of nanocomposites.

The thermo-mechanical tests were conducted on neat epoxy, AlPO₄@CNT/Epoxy and SiO₂@CNT/Epoxy nanocomposites. AlPO₄@CNT /Epoxy exhibited excellent tensile strength, flexural strength, hardness and flame retardant capacity. Hence, AlPO₄@CNT filled epoxy nanocomposite with better thermal stability, mechanical strength and flame retardancy proved to best candidate for the fabrication of nano composites.