EXTENSIVE OVERVIEW OF CARBON NANO TUBES

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Abstract : ***In all manufacturing industries, tool cost accounts for about 50-55%. So, greater emphasis is given to cutting tool cost and inventing newer tool coatings which significantly increases Tool life. Carbon is abundant and unique element in periodic table. Not only in Nano form it is also used in cutting tool industry as CBN, industrial diamond .CBN is artificial diamond and has very high hardness, next only to natural diamond. Research is going on how to use carbon Nano coatings. Various synthesis techniques as PVD, CVD, CCVD, Laser Ablation etc. are available to deposit carbon Nano coatings on substrate. The challenge is yet to develop a mechanism for large scale production of Nano tubes. Further the quality of Nano tube obtained is also important. Single walled Nano Tubes (SWCNT) is far more superior to MWCNT as far as their mechanical properties are concerned. But they are purest form of Carbon Nano Tubes and are difficult to obtain. Carbon Nano tubes are coiled grapheme tubes which possess a very high aspect (L/D) ratio. These carbon molecules are tiny tubes with diameters down to 0.4 nm, while their lengths can grow up to a million times their diameter. They are very light in weight and their toughness is very high. The carbon nanotube reinforcement of metallic binders for the improvement of quality and efficiency of diamond cutting wheels is being tested .Advantage of superior mechanical properties of the carbon nanotubes, can be taken by using them as fillers in epoxy resins.***

Index Terms - Carbon Nano Tube; Aspect Ratio; Diamond ;Tool Coating; MWCNT,SWCNT.

I.INTRODUCTION

One of most advanced manufacturing technology which is often labeled as technology of future is Nanotechnology. It is often referred as "Extreme Technology".It combines miniaturization with precision. Nanotechnology covers the molecules having at least one dimension of about 1–100 nm [1]. Carbon Nano Tubes are first discovered by Ijima[2] and since then their discovery has contributed a lot in Physics, Chemistry and Material Sciences[3].Carbon Nano tube are rolled up Graphene tubes which can be found as either Single walled Carbon Nano Tubes SWCNT or Multi walled Carbon Nano Tubes MWCNT. Single wall carbon nanotubes (SWCNTs) have well defined atomic structure, have high length to diameter ratio, and higher chemical stability.[4]
However, synthesis of SWCNT is big challenge because of greater control needed while yielding them. However, MWCNT are easier to synthesize but they are inferior to SWCNT as far their physical properties are concerned.

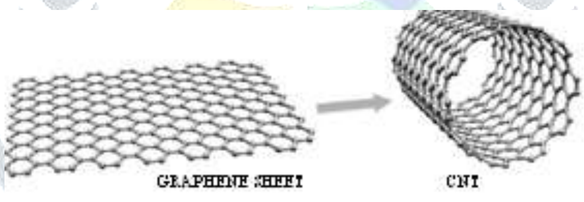

Figure 1. Graphene sheet rolled to form CNT

II. SYNTHESIS OF CNT

There are different techniques to synthesize SWCNT and MWCNT. Previously very high temperature synthesis techniques as arc discharge method, laser ablation were used for their synthesis, but nowadays low temperature synthesis techniques as chemical vapor deposition (CVD) techniques (<800) are abundantly used, as the latter process can be controlled better.[5]
Any above-mentioned process prepares whatever types of CNTs, a number of impurities are present in the CNTs. The extent of impurity will always depend upon the process of synthesis. Impurities present generally are carbonaceous particles such as Nano crystalline graphite, amorphous carbon, fullerenes and different metals (typically Fe, Co, Mo or Ni) can be introduced as catalysts during the synthesis. Therefore one of fundamental challenge is to purify the CNTs.[6]

A. PVD TECHNIQUES:

These techniques involves deposition of carbon at very high temperatures.

AA. ARC DISCHARGE

Arc discharge processes use higher temperatures (above 1700 °C) for CNT synthesis, as a result CNTs with fewer structural defects are formed in comparison with other techniques. Different catalytic precursors are used for the arc discharge deposition of CNT[7-8]. Usually the MWNTs are produced when no catalyst is used. On the other hand, the SWNTs are obtained when the transition metal catalyst is used.

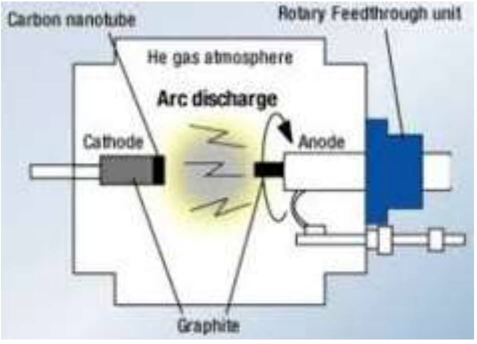

Figure 2.Arc Discharge Method

source: www.intechopen.com

AB. PULSE LASER DEPOSITION

Pulse Laser deposition (PLD) is depend ant upon the laser properties as energy fluence, peak power, repetition rate and oscillation wavelength, the structural and chemical structure of Target work piece, the chamber pressure, flow and pressure of the buffer gas, the substrate and ambient temperature and the distance between the target and the substrate. Accelerated electrons are discharged from cathode in short pulses ranging from milli to micro seconds.[9]

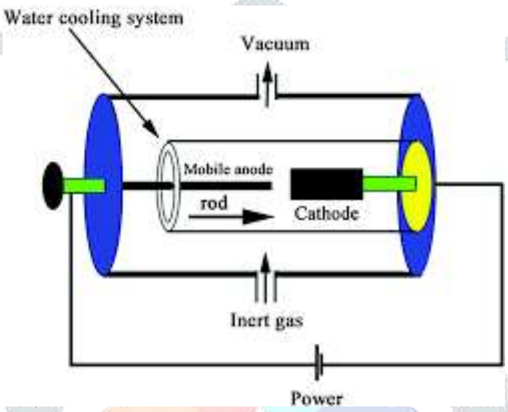

Figure 3: Pulse Laser Method

Source:pubs.rsc.org

B. CVD TECHNIQUES

In 1996 a CVD method was invented for nanotube synthesis; 50 nm thick film of nanotubes that were highly aligned perpendicular to the surface [10]. This method is capable of controlling growth direction on a substrate. In this process, a mixture of hydrocarbon gas, acetylene, methane or ethylene and nitrogen is introduced into the reaction chamber. During the reaction, nanotubes are formed on the substrate by the decomposition of the hydrocarbon at temperatures 700–900 ◦C and atmospheric pressure [11]. Here the process is occurring at comparatively low temperatures.

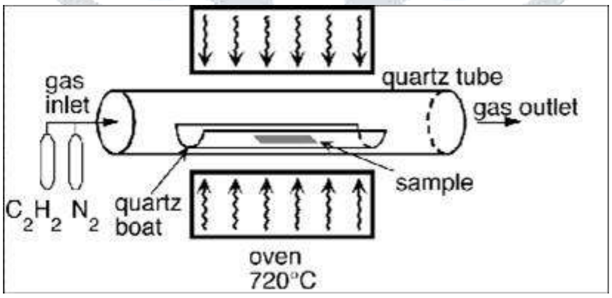

Figure4: CVD Techniques

Source:sites.google.com

III. PURIFICATION OF CNTs

Different post-growth treatments have been developed to purify the tubes and to eliminate the defects in the tubes. An ultrasonic bath method is used to free many tubes from the particles that are originally stuck together [12].

The smaller the particles the more difficult is the elimination. Impurities in MWNTs can be treated by oxidative treatment by a liquid phase treatment in acidic environment. For SWNTs, methods are more complicated as cross-flow filtration.

IV. PROPERTIES OF CNTs

A. PHYSICAL PROPERTIES

The thermal vibrations of nanotubes can be used to find The Young's modulus of elasticity ; a very high average value of 1.8 TPa was found by Wong et al. used a scanning force microscope [13-14]. The density of bundled nanotubes is 1.33–1.40 g/cm3, as compared with Aluminium, possessing a density of 2.7 g/cm3 [15].

B. ELECTRICAL PROPERTIES

Carbon nano tubes are good conductors of electricity. Field emission is another good property of CNTs; they emit electrons from their tips, when they are placed in an electrical field[16].

C. THERMAL PROPERTIES

They possess good thermal properties and displays stability in vacuum up to 2800 ◦C, and in air up to 750 ◦C. is 6000W/mK at room temperature which is comparable with nearly pure diamond, which has 3320W/mK [17].

V. APPLICATION OF CNTs

A. GENETIC ENGINEERING

The nanotubes conduct water at a rate similar to that of certain channels in the kidneys. Due to these unusual transport properties of carbon nanotubes might be used in biomedical applications, such as *highly targeted drug delivery*. A carbon nanotube-tipped atomic force microscope can be used for tracing a strand of DNA and identify chemical markers, used for gene identification.[18]

B. AEROSPACE AND AUTOMOTIVE INDUSTRY

CNT have very high (L/D) or aspect ratio and has high strength combined with the low density which can be used for the developing of a space elevator. Although this sounds a fancy but scientists are researching on this[19-20].

C. ELECTRONICS AND CHIP MANUFACTURING

Essential devices like field-effect transistors (FET) have been developed using CNTs which have been termed as carbon nanotube FET (CNT-FET).The carbon nanotube-based devices operated at very low temperatures, with electrical characteristics remarkably similar to silicon devices[21].

VI. CONCLUSIONS AND FUTURE SCOPE

CNTs are very promising materials of future engineering. They can be produced by high temperature processes as PVD or low temperature processes as CVD. Their mechanical properties are very promising strength comparable to diamond. Some researchers are using them in Biomedicine and genetics. Also because of good semiconducting properties they are used for developing microchips. Their future usage includes developing Bullet-proof vests, Space elevators, Gene identifiers etc.

Ijima et al. has discovered revolutionary material as CNTs, for which he rightly got Nobel Prize in Physics in 1991.

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