# Composites Reinforced with Carbon Nanotubes - A Review

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## Abstract

*This paper provides a general idea of carbon nanotube reinforced composites and its potential applications in various fields. It is evident from the history that composite materials have overcome the inability of conventional materials to cater the need of anticipated property requirements. The reinforcement of CNTs with the matrix material adds value and makes it as advanced multifunctional materials. The predominant properties and exciting functional characteristics of Nanocomposites provides a promising future in nanotechnology research. In this paper an attempt has been made to concise processing techniques, properties and testing methods of various nanocomposites like metal matrix CNT reinforced composites, Ceramic matrix CNT reinforced composites and Polymer CNT reinforced composites to the maximum possible extent. This article is intended to provide a crystal clear review of nanocomposites and a perspective including need for such materials to be produced with low cost and high quality.*

*Keywords:* Carbon nanotubes; Ceramics; Composites; Metals; Polymer.

## 1. INTRODUCTION

The researcher synthesized molecular carbon structures in the form of $C_{60}$ through arc discharge evaporation method which lead to invention of inimitable material called carbon nanotubes which has a needle like structure (Iijima, 1991). Whenever the particle size is reduced to size called 'critical size' the property of the particle changes to an incredible level. Kamigaito (1991) charted out the property changes depending up particle size which is listed in the table 2. The tiny size material exhibited many appealing and surprising properties which lead to the initiative of composite fabrication in the field of Engineering science and technology. Thostenon *et al.* (2001) clearly

elucidated the morphology of CNT,which can be explained by the orientation and magnitude of the chiral vector in a graphene sheet which is wrapped up to form single walled carbon nanotubes. The atomic structure in the Fig.1 indicates the existence of two configurations
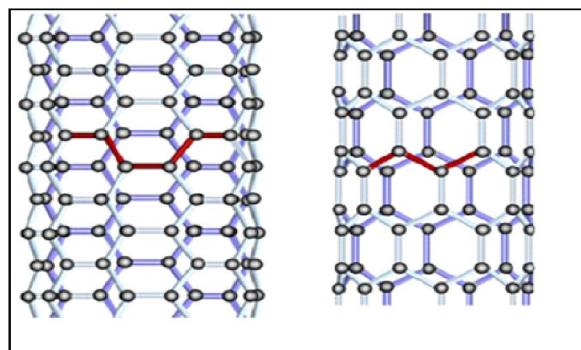


**Fig. 1: Atomic structure**

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**Table 1. Particle Size and Properties**

| Properties | Feature size (nm) at which changes might be expected |
|---|---|
| Catalytic activity | Less Than 5 |
| Making hard magnetic materials soft | Less Than 20 |
| Producing refractive index changes | Less Than 50 |
| Producing super paramagnetism and others electromagnetic phenomena | Less Than 100 |
| Producing strengthening and toughening | Less Than 100 |
| Modifying hardness and plasticity | Less Than 100 |

namely armchair and zigzag nanotubes.Experimental investigations over a decade reveal various remarkable improvements in physical and mechanical properties of carbon nanotubes. Collins *et al*. (2000) summarized these exceptional properties which are as follows. The elastic modulus of SWNTs is 1.2 TPa which is higher than that of diamond, the hardest material ever found. The tensile strength is about 2 GPa which is ten times higher than that of steel.
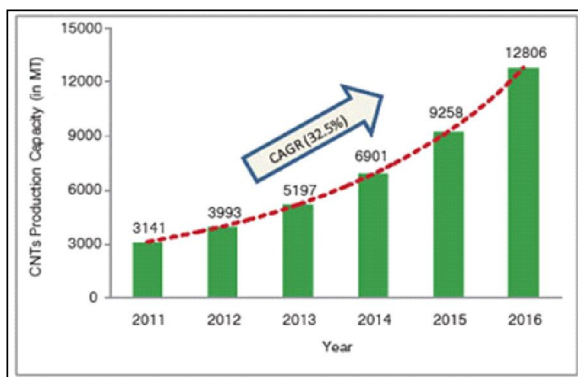


**Fig. 2:  Global CNTs market forecast.**

The density of SWNTs is one and half times more than aluminium. The electric current carrying capacity is estimated to be $1x10^9$ amp/cm$^2$ where as the conventional copper wire burns out at $1x10^6$ amp/cm$^2$. SWNTs are reported to sustain bending to large angles and re-straightening without damage which is distinctively different from the plastic deformation of metals.  The thermal conductivity of nanotubes is estimated to be 6000W/mK at room temperature which is relatively double the thermal conductivity of diamond. SWNT has a thermal stability up to 2800 °C in vacuum and 750 °C in atmospheric air. By comparison CNTs have very high aspect ratio which is the key factor to reinforce them into a composite. There is a definite improvement in overall properties of the fabricated composites. Ajayan *et al*. (1994) established that Mechanical, Electrical and Thermal properties are being enhanced through CNTs reinforcement.

Currently, carbon nanotubes account for a 28% market share of overall nano material's demand. Used across a wide range of industries including plastics and composites, electrical and electronics, and energy as well as a range of industrial sectors, CNTs have become an essential ingredient or reinforcement material for these industries, with its usage growing broadly in line with the global economy.  The fig. 2. unambiguously indicates the compound annual growth rate and fore cast for next five year which will kindle the specific interest along the researchers.

At this point it is important to brief about composites before going to nanocomposites. By definition, a composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level. Generally there exist several classifications of composites. Our interest is to

study only composites classification based on two criteria. They are based on type of matrix and geometry of reinforcement. Vaia *et al.* (2004) and Curtin *et al.* (2004) reported that exclusive properties like specific stiffness strength and large aspect ratio gave rise to the development of CNT reinforced composites for both structural and functional applications. The insolubility and weak dispersion of CNTs in common solvents and matrices have limited their applications. Therefore an effective method is used to modify the CNTs by polymers. The modification of CNTs can be done in two ways based on the bonding nature. The covalent modification of CNTs is the covalent chemical bonding of polymer chains to CNTs, which process dramatically improves the interfacial interactions between reinforcement and matrix materials. Once the cost of carbon nanotubes becomes comparable to that of carbon fiber (or even to that of the much cheaper reinforcing agent, carbon black), commodities such as nanotubes filled rubber tires could become reality (Sathish Kumar and Karthikeyan, 2012).
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## 2. CNT/POLYMER COMPOSITES

Polymer composite is the biggest application area for CNTs. These nanocomposites has a wide application in the field of automobile, aerospace, defence, sporting good, energy and infrastructure sectors. Due to their high strength, light weight, ease design and process flexibility, these polymer composites suits well for the above said sectors. Polymer /CNT composites can be processed by the following methods. The methods can be adopted according to the type of polymer used as the matrix phase. For thermosetting plastics and thermoplastics materials melt mixing, solution processing and in-situ polymerization suits well. Bulk mixing method can also be adopted for thermoplastics. Liu *et al.* (1998) sonicated SWNTs in a mixture of concentrated sulfuric acid and nitric acid which cuts the tubes into short segments with open ends. This helps in covalently attaching carboxylic acid groups. These short fibres can be interfaced easily with the polymer matrices.

According to Sen *et al.* (2004), the functionalization of CNTs by chemical method is a valuable approach to scale off the SWNTs bundles and improve the process ability. The improved chemical compatibility and the dispersion of the functionalized nanotubes within the polyurethane matrix enable a suggestive enhancement in the tangent modulus and tensile strength of the composite membrane fabricated by electro spinning process. Sinott *et al.* (2002) functionalized SWNTs by dissolving in solvents. Short tubes can be made soluble in water or organic solvents. Longer micrometer length nanotubes can be made soluble in inorganic solvents through ionic functionalization of COOH group. He also recognized that nanotubes walls can be modified by reactive elements such as fluorine. At room temperature range of 500 °C to 600 °C, fluorine chemically binds the nanotubes walls and produces severe modification. Frankland *et al.* (2002) used molecular dynamics simulation to show that the nanotubes/polymer interfacial shear strength can be enhanced by over a magnitude with the formation of cross links involving less than 1% of the nanotubes carbon atoms which is negligible. Gonjy *et al.* (2004) functionalized the nanotubes with amino acids by heating oxidized nanotubes with an excess triethylenetetramine.

The experiment exhibited that introduction of functional groups leads to covalent bonding of nanotubes surface with the epoxy resin. In the modification of Carbon nanotubes/polystyrene composites Hu *et al.* (2003) used polyatomic ion beam deposition. In the work of Coleman *et al.* (2006) and Khan *et al.* (2006) it is believed in polynanocomposites nanotubes could be an ideal reinforcement due to blend of remarkable properties including structural, mechanical, electrical and thermal properties .
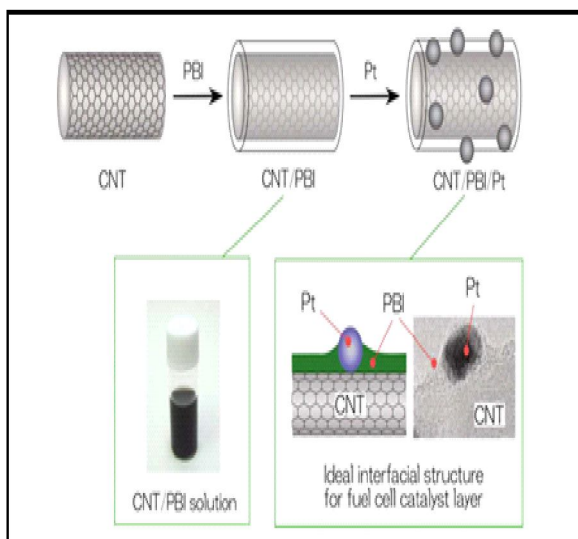
Recent improvements in processing of carbon nanotubes allow us to grow them upto several millimeters at length and this provides an opportunity for fabricating continuous nanotubes reinforced composites. Cao *et al.* (2005) and Suhr *et al.* (2007) reported that free standing arrays of millimeter long,

vertically aligned multiwall nanotubes exhibited super compressibility, outstanding fatigue resistance and visco elastic properties. One of the main reasons for passion towards carbon nanotubes as reinforcements for composites materials is their high elastic modulus and strength comparing to those of existing continuous fibers. It is highly desirable to produce some key properties of nanocomposites in contrast to the same properties in traditional composites. The presence of fiber ends induces stress concentrations in the matrix materials when composite is subjected to loading.

Chou *et al*. (1986) reported by recognizing fiber – bundle end shape and using bundle aspect ratio the associated singularities and nature of stress concentration have been studied. The addition of very small amount of CNTs in to a polymer matrix can lead to



**Fig. 3: Polybenzimidazole/CNT nanocomposites**

improvement of modulus and strength to a greater extend. Qian *et al.* (2000) reported that tensile modulus and tensile strength improved by 25% approximately by adding 1 wt% of MWNTs in to polystyrene by solution evaporation method. Biercuk *et al.* (2002) reported that by adding 2 wt % of SWNTs with epoxy

resin improves the Vickers hardness by 3.5 times approximately. Velasco-Santos *et al.* (2003) reported that by enhancing the dispersion of CNTs by using an insitu-polymerisation, the storage modulus of PMMA/MWNTs at 90 °C increased by 1135%. Schadler *et al.* (1998) reported that load transfer between the matrix and filler depends on the interfacial shear stress between matrix and reinforcement. The efficiency of properties improved depends upon thetype of CNTs fabrication methods and compatibility between CNT and host matrix. Zhang *et al*. (2011) prepared polybenzimidazole/functionalized carbon nanotube nanocomposites for the use as protective coatings.

Polymer nanocomposites have excellent electrical properties for applications. Ebbesen *et al.* (1996) compared the electrical conductivity with metals the individual CNTs ranges from 107-s/m to 108s/m when compared with metals. The electric conductivity of polymer nanocomposites depends up on the many factors like the amount of CNTs added in wt % to the matrix, the type of CNTs and finally the aspect ratio. Another factor which significantly affects the electrical conductivity is the chemical functionalization of CNTs. Several studies reported that fiber dominated in-plane properties are not significantly affected by the introduction of CNTs (up to 2 wt%) (Gojny *et al.* 2004; Wichmann *et al.* 2005; Qiu *et al.* 2007 and Green *et al.* 2009). However, matrix dominated properties, particularly the inter-laminar shear strength (ILSS) are improved by about 8-30% as assessed by using short beam test. Hsiao *et al.* (2007) has reported 31.2% improvement in ILSS by adding 1 wt % of MWNTs and 45% improvement in ILSS by adding 5 wt% of MWNTs with graphite epoxy composites.

Gojny *et al.* (2003) showed that there is a considerable improvement of ILSS from 15.7% to 19.8% by addition of 0.1 wt to 0.3 wt% respectively DWCNT with glass/epoxy composites. Wichmann *et al.* (2006) reported 16% of ILSS improvement by addition of 0.3 wt% DWCNT with glass/epoxy composites. Zhou *et al.* (2006) examined carbon /Epoxy with 0.1-1% MWNTs by double cantilever beam method and finds

there is 60% improvement in fracture toughness in mode-I and 75% mode-II.

The effective utilization of CNTs for fabrication nanocomposites strongly depends on the uniform dispersion throughout the matrix without destroying their integrity. It is very clear from the studies that CNTs have strong tendency to form clusters due to their large surface area. These aggregates persist unless high shear force is applied. The biggest challenge is to obtain uniform dispersion. Some of the methods in which uniform dispersion is obtained are discussed in the following sections. They are solution blending, melt mixing, surfactant assisted mixing and insitu polymerization.

Solution blending is the most common method for preparing CNT/Polymer nanocomposites. The major advantage of solution blending is rigorous mixing of CNTs with polymer in a solvent which improves nanotubes dispersion and avoids aggregation. There are three basic steps involved in solution blending. First the nanotubes is being dispersed in a suitable solvent. This is the major stage in which the properties are dependent of uniform dispersion. Second it is mixed with the polymer either in atmospheric temperature or in elevated temperature. Finally nanocomposites are recovered by precipitation.

Badaire *et al*. (2004) reported that the dispersion of nanotubes can be achieved by shear mixing, magnetic stirring reflux or most commonly ultrasonication. Sonication can be given in two forms, mild sonication in a bath (or) high power sonication. Agitating induced by sonication leads to uniform dispersion. In solvent blending slow preparation step is often lead to CNT aggregation. To overcome this problem ,CNT/polymer suspension can be kept on rotating substrate or can be dropped on a hot substrate to expedite the evaporation step . Du *et al*. (2005) developed another method which is coagulation that involves pouring of a CNT/polymer suspension in to an excess of non solvent. This lead to entrapment of SWNTs by precipitating polymer chains which intern

prevents the SWNTs from bundling. Haggenmueller *et al*. (2006) reported that the above method is very successful in case of PMMA and polyethylene (PE) nanocomposites.

For industrial applications, melt blending is the most preferred technique due to its simplicity in process and low processing cost. Normally melt blending involves the melting of polymer pellets to form a viscous liquid and application of high shear forces to disperse the nanotubes. Poetschke *et al*. (2003) elucidated that MWNTS/polycarbonate can be successfully fabricated through melt blending. Even though very high temperature in melt blending enhances the dispersion of CNTs they in turn degrade the polymer intrinsic properties. To overcome these difficulties Haggermell *et al*. (2006) combined the solution and melt by subjecting a solvent cast SWNTS/ polymer film to several stages of melt pressing.

Insitu polymerization is one of the superior methods in processing of polymer nanocomposites. The main benefit of the method is that it enables grafting of polymer macromolecules on the wall of CNTs. Philip *et al*. (2010) reported that a method to quickly produce macroscopic CNT composites with a high volume fraction of millimeter long, well aligned CNTs. Shear pressing is the method used to process tall vertically aligned CNTs arrays in to dense aligned CNT performs, which are subsequently processed into composites exhibited a high tensile strength up to 400 MPa. Due to the higher intrinsic electrical conductivity polymer nanocomposites are widely used to shield electromagnetic interference and as electrostatic discharge components. Higher mechanical strength of these nanocomposites is an advantageous factor while manufacturing aircraft components and sporting goods.

## 3. CNT /METAL MATRIX COMPOSITES

The development of metal matrix composites is the most challenging processes. The matrix phase is a metal and reinforcement is CNTs. Normally Aluminium, Tungsten, silver, Copper and magnesium are used as a

metal matrix. The purpose of this review is to elaborate various aspects such as microstructure, behavior, processing rout and dispersion ratio of CNTs with metals. The important requirement during metal matrix composite fabrication is matrix reinforcement interfacial reaction and chemical stability of the reinforcement. Some of the other factors are (i) homogeneity in CNT dispersion (ii) chemical and structural stability (iii) strength of bond between CNT and matrix while processing MMCs.

Some of the processing techniques are briefly explained in the following. They are powder metallurgy ,melting and solidification, thermal spraying, electrochemical method, molecular level mixing, sputtering techniques, sandwich processing, Torsion/ friction welding, vapour deposition, nanoscale dispersion, plasma spraying and high velocity oxy fuel spray forming. Mechanical alloying and sintering is used to fabricate various MMCs like Al-CNT, W-Cu-CNT, Cu-CNT, Mg-CNT and Ag-CNT. He *et al.* (2007) have grown CNT by chemical vapour deposition process on Al powders which were then compacted and sintered at 640 °C to obtain Al 5 wt% CNT composite of high relative density and homogenous dispersion of CNTs. Yang *et al.* (2004) achieved uniform dispersion of CNT

in Mg matrix by mechanical mixing of the powders in an alcohol and acid mixture followed by sintering at 550 °C. Carreio Morelli *et al.* (2004) fabricated by hot pressing have shown improve hardness, compressive strength and bend strength. Similar fabrication is done by Pang *et al.* (2007) and obtained similar results.

Kim *et al.* (2004) were the first to report spark plasma sintering of copper CNT composites which were fabricated at a temperature of 1023 K and pressure of 40 Mpa with better dispersion of CNTs. One of the most interesting alloys are shape memory alloys called smart materials. When orientations of CNTs are controlled properly, a composite material may be built with tailored local properties that can be used in sensors, actuators and smart devices. However, the grand challenge is the lack of manufacturing method that can fabricate locally tailored composite with varying CNT content and alignment, especially in metal matrix composites. Kim's group is working on a manufacturing concept using semisolid flow, to address this challenge. This group illustrated the process in Fig. 4. The central hypotheses of the task are that: 1) CNT content can be varied locally in a metal composite by controlling the deposition of CNT-treated metal powders for semisolid processing and 2) alignment of CNTs can be achieved by the
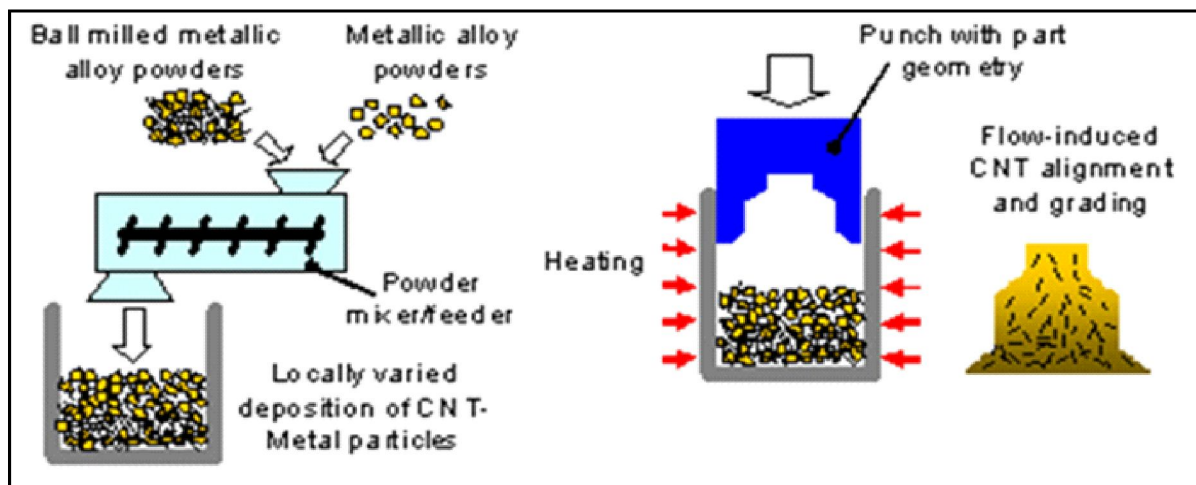


**Fig. 4: CNT/MMC for Smart Materials**

velocity gradient induced by the flow of the matrix phase in the semisolid temperature regime.

These alloys have dependent properties, Majkic *et al.* (2006) confirmed the property improvement of Ni-Ti based SMA by conducting experiments. The another route is to melt and solidify to form metal matrix composites. Bian *et al.* (2002) were the first to synthesize CNT reinforced Zr- based metallic glass by casting. In this composite due to crystallinity, the hardness is being enhanced. However in this method due to melting, the suspended CNTS have the tendency to form clusters in the presence of forces due to surface tension.

The most widely used processing technique is vapor deposition. This route was the key interest to all the researchers since it provides tremendous possibilities in ease of fabrication methods and properties. Both physical and chemical vapour deposition are used to fabricate MM-CNTs. Nanoscale dispersion is one of the successful method in achieving homogeneity and good reinforcement. Kwon *et al.* (2009) used nanoscale dispersion to produce precursor Al powder on which nanotubes were dispersed uniformly. Even though there is some lag in two common factors in fabrication of MM-CNT the homogeneity and interfacial reaction there is a remarkable improvement in properties which was found by various research groups.

Noguchi *et al.* (2004) added 1.6 volume % of CNT which has improved compressive yield strength to a greater extent approximately 350%. He *et al.* (2007) have reported 333% increase in hardness and tensile strength to 184% with 6.5% volume % CNT addition. Dehong Lu *et al.* (2013) studied the wear performance of Mg-CNT composites fabricated by friction stir processing. The experimental investigations revealed that when the load is higher than 1.95MPa, the wear of (0.1% $Al_2O_3$+ 0.2% CNTs)/AZ31 composite is considerably lower, the friction coefficient of composite is obviously lower than those of other composites. A material with low coefficient of thermal expansion is mostly preferred for high temperature applications. To justify the improvement in this nature some of the researchers have experimented to reduce the coefficient of thermal expansion. Tang *et al.* (2004) reported on addition of 15 volume % of CNT with Al matrix the coefficient of thermal expansion reduces by 63%. Deng *et al.* (2007) have obtained 12% decrease in coefficient of thermal expansion with the addition of 1.28 volume percentage. Wang *et al.* (2003) have reported that Si coating on CNT increasing their oxidation at the temperature range of 570 °C to 675 °C. Thermal resistance finds vital role in the effective functioning of microprocessors as they dissipate heat faster. Ngo *et al.* (2004) and Chai *et al.* (2007) have shown decrease in thermal resistance by 62% approximately by filling the voids of CNT arrays with copper. Few researchers tested MMCs to review the tribological properties which are very significant for components used in moving parts. The decrease in the coefficient of friction has been attributed to the lubricating nature of the MWNTs caused by the easy sliding of their walls, which are attached by weak van der waals forces. Deng *et al.* (2004) have reported a maximum of 83% decrease in the wear volume for electro less plated Ni-P-CNT composite coating with a 2 volume % CNT content, whereas the coefficient of friction reduced was reduced by 60%. Tu *et al.* (2004) have reported that on addition of 16 Volume % of CNT there is 91% reduction in Coefficient of friction and 140% reduction of wear rate.

The most inevitable damage to the performance of any material is corrosion. Praveen *et al.* (2007) have reported that the service life of Zn-CNT composites is doubled by Zn coating. Yang *et al.* (2004) have reported increase in pitting potential by 24% with 5 wt % of CNT addition. Chen *et al.* (2004) reported the effect of CNT content on the hydrogen storage capacity of Mg-CNT composites. At higher temperature, composite with 5 wt% CNT show better hydrogen storage capacity.

The potential application of CNT reinforced metal matrix composites are briefly discussed in the following section. The requirement of good wear resistant, good thermal conductivity, low density with

high strength in aircraft brakes and landing gears lead to the development of CNT/MMCs in aerospace industry. High elastic modulus, Large surface area, high current density, reduced response times, increased Hydrogen adsorption- desorption rate are the desired properties in MEMS and sensors industries. In sports industry light weight bicycles, tennis and badminton rackets are made of CNT reinforced metal matrix composites. In automobile industry to fabricate brake shoes, cylinder liners, piston rings and gears Polymer/CNT composites were used.

## 4. CNT/CERAMIC MATRIX COMPOSITES

Ceramic materials are non metallic inorganic compounds primarily compounds of oxygen but also compounds of carbon, nitrogen, born and silicon. Ceramics are classified in to two types based on their engineering applications. They are traditional ceramics and nontraditional ceramics. Some of the interesting individual properties of like high temperature stability, high hardness, brittleness, high mechanical strength, low elongation under application of stress and low thermal conductivity make them an ideal matrix material in fabricating CNT reinforced ceramic matrix composites. As stated above ceramics have already excellent individual characteristics and reinforcement of CNT will provide the highest possible characteristics for different applications. The higher thermal conductance of CNTs suggests that their incorporation even at low volume fraction might provide the thermal transport needed to reduce material operating temperatures and increase
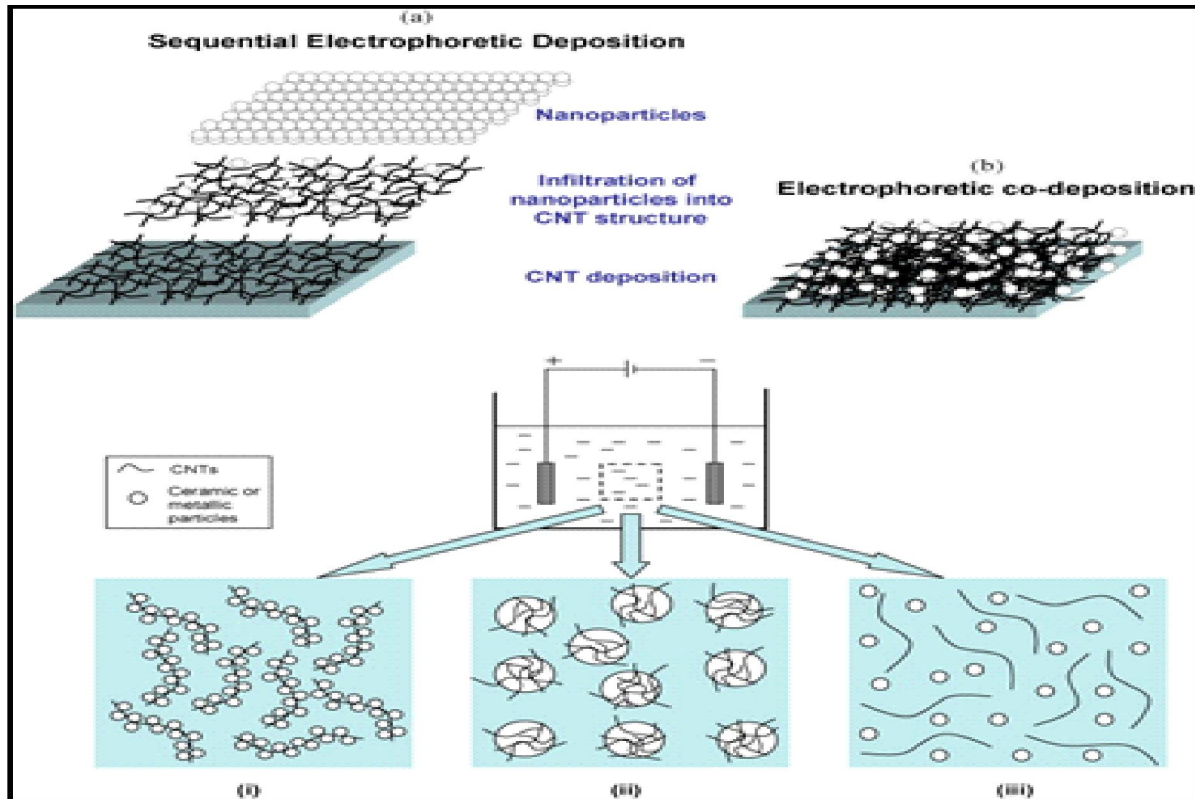


**Fig. 5: Fabrication of CNT/ Ceramic Nanocomposites by EPD**

thermal shock resistance. Control of electrical resistance through the use of CNT additives is an attractive alternative to other composites systems. Toughening in CMCs is typically achieved by weak fiber/matrix interface that allows debonding and sliding of fibers within the matrix.

Zhang *et al.* (2002) reported fracture toughness improves by thrice compared to other reinforcement used in fabrication of ceramic matrix composites. Peigney *et al.* (1998) have developed CVD technique to synthesize CNT, insitu in the presence of ceramic powder destined to form matrix. Powder processing methods are very commonly applied in ceramic systems and were the first technique considered during the early development stages of CNT/Ceramic composites. Seeger *et al.* (2003) prepared a 2.5 wt% MWNTs/$SiO_2$ gel by mixing MWNTs, acidified water (Catalyst) and tetraehtoxysilane before sintering at 1150 °C in argon which resulted in heterogeneous microstructure. Seeger *et al.* (2001) confirmed uniformity in dispersion can be obtained by another method using Nd:YAG laser to heat $SiO_2$/CNT mixture rapidly, producing an amorphous silica matrix without crystallization and containing 2.5 wt % MWNTs. Hwang *et al.* (2001) have developed CNT/$SiO_2$ composite rods as reinforcing elements for CMCs. In principle the approach provides a mean of modifying the wettability and /or adhesion between CNTs and chosen ceramic matrix even after high temperature consolidation.

Electro deposition is another conventional ceramic processing method that allows the application of varying thickness to complex 3D shapes including interior of porous substrates. Spark plasma sintering is another method allows ceramic powder to be sintered at lower temperature at shorter period of time which controls chemical reaction, densification and grain growth. The control of these factors helps to minimize grain growth and offers higher productivity and cost effectiveness.

The Fig. 5 shows the Different strategies to fabricate CNT/ceramic nanocomposites by EPD:

(a) schematic diagrams showing sequential deposition of CNTs and nanoparticles to form layered heterostructures and electrophoretic co-deposition; (b) schematic diagram showing different alternatives to produce CNT/particulate composites by electrophoretic co-deposition: (i) self-assembly of nanoparticles coating individual CNTs, (ii) heterocoagulation of CNTs onto individual (larger) particles, and (iii) simultaneous deposition of CNTs and ceramic (or metallic) particles exhibiting the same charge polarity in suspension.

Balazsi *et al.*(2005) reported that there is an improvement in mechanical properties at lower temperature by using spark plasma sintering. Tapaszto *et al.* (2011) compared SPS with the conventional hot isostatic pressing method for $Si_3N_4$ / carbon nanostructure composite fabrication. The experiment revealed that the samples prepared with SPS method showed an increase of elastic modulus by 10-20% for all type of carbon addition as compared to the samples prepared by hot isostatic pressing method. Seung *et al.* (2005) fabricated CNT/alumina nano composites by molecular level mixing process and insitu SPS. The process showed homogeneity in dispersion of CNTs with in grains or at grain boundaries of the alumina matrix. He concluded that CNT/alumina nanocomposites thus fabricated showed an enhanced hardness and toughness compared to monolithic materials, which is based on the load sharing and bridging mechanisms of CNTs in matrix material. Lim *et al.* (2005) studied the tribological behavior of alumina/ CNT composite. In his study alumina/CNT composite with a different volume fraction were fabricated to investigate the effect of dispersion, wear and friction behavior. Ball on reciprocating wear tester is used to measure wear and friction at room temperature to measure wear friction. He concluded that alumina CNT composite with 0 to 12 wt % decreases the wear loss significantly. Chen *et al.* (2011) investigated the fracture of CNT reinforced CMC. It was concluded that for composites with hard matrix ,there exists a critical interface strength below the CNT is always pull out and the fracture toughness can be effectively improved by increasing the interface length.

## 5. CONCLUSION

The fundamental characteristics of CNTs based on the studies and experiment has declared that composite reinforcement can be made on such a promising material to obtain better results. Deviations from the expected results of processing and properties must be taken for future score. Even though the quality of CNT/Polymer nanocomposites depends upon many factors including type of CNTs, purity, hilarity, aspect ratio, defect density, percentage of loading , alignment, dispersion and interfacial adhesion between the reinforcement phase and matrix phase still the above studies indicates a remarkable property enhancements in the composites. Carbon nanotubes containing MMCs are being developed and projected for different applications ranging from structural to functional applications. It is evident that conventional fabrication techniques such as powder metallurgy, mechanical alloying and sintering, extrusion, electro deposition and hot pressing are some of the novel techniques in composite fabrication. The uniform dispersion still a critical issue has been largely reduced by using different dispersion techniques like molecular level mixing, nanoscale dispersion and high energy level ball milling. But these techniques are only at laboratory level and not in large scale production. There is a huge scope for further work in this field. The challenge remains to obtain homogeneous dispersion of ultrafine CNTs in the microstructure when produced in larger scale Since the properties of nano structured composites are highly structure/size dependent, there should be basic understanding of properties which will enable the nanoscale design of advanced multifunctional materials for engineering applications. In larger scale production of these composites, we should take cost as one of the premium factor .since in all the enterprise cost is given prime importance. Once the cost of carbon nanotubes becomes comparable to that of carbon fibers (or even to that of the much cheaper reinforcing agent, carbon black), commodities such as nanotubes filled rubber tires could become reality. The incorporation of CNTs produced from waste plastic and tyres will lead to the development of green tires which will reduce the environmental degradation at very low cost and high quality.

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