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Carbon Nanotubes be the Building Block of Smart Materials Based on Nanotechnology

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Abstract—*The present paper reports, Carbon nanotubes be the building block of smart materials based on nano technology and nano science. Nanotechnology has developed by leaps and bounds due to a potential high impacts of its applications in the worlds today. Single wall carbon nanotubes have extraordinary mechanical and electrical properties in many cases. Nano technology uses carbon nanotube as a nanomaterial's for fabrication of different kinds of nano machines and smart materials. Carbon nanotubes are used for the development of polymer composite materials, this is the main aim of my work. Carbon nanotubes can be used to form polymer hybrid materials that have very good elastic properties, piezo resistive sensing and electro chemical actuation for particular interests are smart nanocomposite materials those are strong and self sensing for structural health monitoring or self actuating to improve the performance and efficiency of structure and devices. Nano scale research is broad, challenging, inter disciplinary under graduate through Ph.D. levels students and faculties have combined effect and efforts to attach the special problems related to building nano scale smart materials. This paper reports on overview of the work being performed to fabricate polymer nano materials starting from nanotubes synthesis through to device fabrication and testing. Nanotube synthesis is performed using an easy tube nanofurnance. The material produced indicates that carbon nanotube hybrid smart materials may become a new class of smart material with unique properties and applications. But much work still need to be done to realize their full potencial.*

Keywords*:Carbonnanotubes,Smartstructures,Piezoresistive Nanocomposite,Electrochemical.*

1. INTRODUCTION

Nanotechnology & Carbon Nanotube – with huge investigation from the government and private sector, nanotechnology has developed at a great pace during the last two decades, and so has the commercialization of nanotechnology. A key challange to sustain this development trend is to provide needed researchers and skilled workers with interdisciplinary backgrounds. Although many courses and programs have been developed for universities and research centers in this field to train future engineers and scientists, limited efforts have been made to train technologist and technicians. Nanotechnology and nanoscience got started in the early 1980s with two major developments : the birth of cluster science and invention of scanning tunneling microscop (STM) [1].

This development led to discovering of fullerenes in 1985 and carbon nanotubes a few year later. Carbon nanotubes have recent received extensive attention due to their nanoscale dimension and outstanding material properties. Such as ballistic electronic conduction, immunity from electron migration effects at high current densities, transparent conduction & fabrication of smart materials [2].

As nanotube is fabricated it bends automatically due to its nanoshape. Bending of nanotube provides buckling and this buckling is usual way for nanotube to reduce its strain. After that nanotube is ready for its varius purposes [3].

Single walled carbon nanotubes (SWCNT) have extra ordinary mechanical and electrical properties which in many cases exceed those of any other materials [4]. These superior properties include ITPA elastic modulus 50 GPA strength electrochemical actuation and high thermal and electrical conductivities. These properties generally super pass the properties of multi walled carbon Nanotubes (MWCNT). Which are a concentric arrangement of SWEN. Potential applications of CNT include high strength composite, Electrochemical and piezoresistive sensors and electrochemical actuators. The electrochemical actuation property of CNTs may provide higher actuation performance than piezoelectric materials and also higher performance when comported to other nanotubes made of elements like, Vanadium, Silicon, boron and titanium. The CNTs actuate electrochemical charge injection expansion in an electrolyte. Mats of carbon nanotubes can be performed using Vander wools attraction and actuated in an electrolyte, but the strength and actuation performance are far below the predicted performance using model material. Fibers spum from CNT shown great mechanical properties [5].

The actuation and sensing properties will depend on how effective ion exchange is to the nanotubes in the interior of the fiber. Another approach is to cost the carbon nanotubes in a conductive polymer to attempt to gain good ion exchange and good shear load transfer. The conductive polymer provides strength and when hydrated allows actuation and is discussed in the paper. Over all the CNT mat/ Fiber conductive polymer materials are predicted to open up an enabling new type of smart material that improves the new way, by generate and measure the motion in devices from the macroscale to nano scale.

The CNT based smart material is a structural material because it is a load bearing a functional material of its electromechanical properties. This paper also reports the description of effort to make carbon nanotube polymer composite materials for reinforcement sensing and actuation from nanotube synthesis all the way to device fabrication.

2. SYNTHESIS OF NANOTUBES

An current there are three methods for fabrication of single walled carbon nanotube (SWCNT). These are (I) laser ablation (II) Electric are discharge and (III) Chemical Vapour Deposition (CVD) an all the three methods CVD method is continuous process and currently is the best known techniques for high yield-low impurity production of CNT [6]. When CVD supplemented with plasma generating and controlling facility has the capability to control the size shape and alignment of nanotube. It is a gas phase technique that uses carbon nanotube, carbon sources feed gases such that as benzene, methane, acetylene and carbon monoxide. The main principle is that to decompose and cracking the carbon source gas molecule at high temperature over the catalyst, which is on the substrate. The selection and preparation of substrate (Catalyst) are important aspect related to nanotube yield and the ability to purify the nanotubes. The CVD nano furnace is used for the synthesis of carbon nanotube as demonstrated in Fig. –I. This furnace uses the thermally driven CVD process and consists of two main units the control unit and the prosaic unit [7]. The control unit is demonstrated in Fig. -2. This is computer controller to operate the furnace. The process unit is composited of (i) a gas cabinet (ii) Furnace (iii) a loader. The process uses four gases: Methane, Ethylene, Hydrogen and argon. These are involved in the production of nanotubes. Nitrogen the fifth gas is used for operating the gas value in the furnace. Methane and ethylene are the carbon source gases. Argon is used for creating the inert atmosphere [8]. The furnace and sample on the loader in the quartz tube are show in fig-3. Hydrogen is used for moderating the chemical reaction of hydrocarbon decomposition safety is created by using a nano furnace and combustible gases. Mass flow controller control the flow rate of gases. The gases enter the furnace in the quartz tube and heated at 900ºC to 1000ºC. The gas pressure be near to atmospheric pressure in nature and substrate. The hydrocarbons decomposes in the quartz tube over a catalyst & mounted on a substrate. A quartz boat or molybdenum boat are used with a powered support and catalysed for bulk nanotube growth for high purity nanotubes, the catalysed substrate deposited on a silicon oxide water. The catalysed was deposited at the centre of substrate and spin to control the thickness of layer of the substrate and catalyst. The substrate was inserted inside the quartz tube automatically using the loader that is quartz loader tray driven by computer the three steps for production of high purity SWCNT are as (I) Maximum ramp (II) deposition and (III) cooling [9]

An the maximum ramp step the temperature of the furnace raised from ambient to 900ºC in 12 minutes. Argon is flowed continuously. Once the temperature reaches 900ºC it is maintained for 10 Minutes.

This is the deposition stage. Nanotube production occurs in the deposition state. The next cycle is cooling cycle. After the nanotubes are produced they must be cooled to ambient conditions [10].

3. SEM CHARACTERIZATION OF NANOTUBE

SEM (Scanning Election Microscopy) Characterization can be done for SWCNT. A shortly hot-field emission tip is employed as the electron source and has a ultimate resolution of 1.2 to 1.5 nm. A big specimen chamber housing a motorized stage with an internal ECO camera allows for chamber pressure between 1 to 20 Torr. Gasius detection systems are used in imaging of the samples [10].Growth of SWCN using a catalyst on silicon wafer is demonstrated in Fig. -4. Growth of SWCN between catalyst particle is shown in Fig. -5.Ribbon like structure of SWCNT is demonstrated in fig.6. Sheet like structure of SWCN is demonstrated in Fig. -7. [11].

Polymer nano composite application of nanoyubes:- When loading the resin with different weight presence of nanotubes then polymer nano composite is obtained. The dispersion and bonding of the nanotubes matrix then polymer nano composites are obtained. To improve the dispersion and interfacial bonding between resin and nanotubes. The nanotubes are first dispersed in a monometer using nigh speed dremel tool. The nanotubes can be coated with acrylic acid or another material in a plasma polymerization process. Another approach is to disperse the purified nanotubes in a surfactant and without coating. Nanocomposites are then made by mixing the carbon nanotubes in Epon 868 resin with a high speed dremel tool at elevated temperature and then curing with Epicure 3234. Fiber pullout of Matrix is shown in Fig-8, Single fiber pullout of nanotube is demonstrated in Fig. -9. Fiber end showing amorphous carbon coating image is demonstrated in Fig. -10. [10].

Piezoresistive Sensor application of Carbon nanotubes:-

Since electrical resistance changing with strain is called piezo resistive sensor of nanotubes. When monitoring load and strain in composite structures, then its piezoresistive response is used. A CNT piezo resistive load sensor and strain sensor are shown in Figure – 11. The response of load sensor depends on the contact resistance between the composite and the electrodes. The response with copper foil electrode in contact with composite is shown in figure -11 also. A transverse load applied on the sensor and resistance was measured using Multimeter. The initial part of the curve can be mostly removed by using a conductive epoxy to bond the electrode to composite [13].

4. ELECTROCHEMICAL ACTUATOR APPLICATION OF NANOTUBE

Nanotubes and nanofibers are composed by different methods. Nanofibers and sensors are also fabricated by different methods. In one approach SWCNT are dispersed in N-N Dimethyl formamide using a high speed rotatory tool and then aligned in a rectangular mold made of Teflon. A shear wiping action is used to try to align the nanotubes. The solvent is applied and evaporated by layer and by layer. This slow process produces a some what align the nanotubes. A thin layer of conductive epoxy is places on one side of paper and a wire is bonded to one end. This actuator is placed in an electrolyte and driven by a function generator with low voltage actuation on the order of volts. This actuation vibrates in the electrolyte at a small amplitudes upto 1mm at frequency upto 15 Hz. The possible applications include actuation of any thing operates in a liquid environment. The actuator can also act as a flow sensor by being connected to an oscilloscope. In the first time CNF (Carbon Nano Fiber) was developed for electrochemical actuation [14]. A CNF material is shown in Fig. -12.

Raman Spectroscopy characterization of nanotube- when a qualitative and quantitative analysis of nanotubes is done by a technique, then this technique is called raman technique. When a beam of light traverses a dust free, transparent sample of a chemical compound , a small fraction of the light emerges in directions other than that of the incident beam. Most of this scattered light is of unchanged wavelength. A small part has wavelength different that of the incident light, its presence is a result of the Raman effect. Raman lines is characteristics of particular molecular species and its intensity is proportional to the number of scattering molecules in the path of light. In this analysis only wave number is considered for calculation of diameter. To estimate the electronic properties of nanotubes that is the nanotubes are metallic or non metallic or semiconducting. The wave number of interest must be lie between 1400 to 1700 per cm. One of the CNT. Raman speetra is demonstrated sin Fig-13. [15].

5. FUTURE DIRECTION:-

As it stands now, the majority of commercial nanoparticle application in medicines, industry and in other purposes geard toward new development. There are some developments in the direction remotely controlling the function of nanoprobe and other kind of strange nano particles. The major trend in further development of nano materials is to make them multifunctional and controlled by external signal or by local environment. Thus essentially turning them into nano devices. If nanotechnology produces some difficulties then we have to consider other kind of new technology that may be pico or femto technology. This technology may be superior than nano technology and may be provide great advantages with respect to nano technology.

6. CONCLUSIONS

The new materials developed by use of carbon nanotube are strong and smart. Dispersion and adhesion of nanotubes to the matrix material that still need to overcome to commercialization and application. Improved processing and characterization technique at reduced cost that may be generate many applications for multifunctional nano composite smart materials.

7. FIGURES

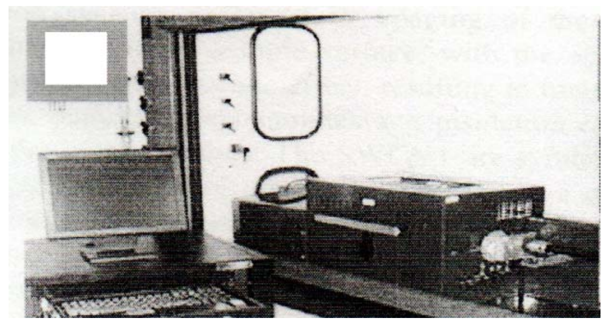

Fig. No.-1. The CVD nanofurnace

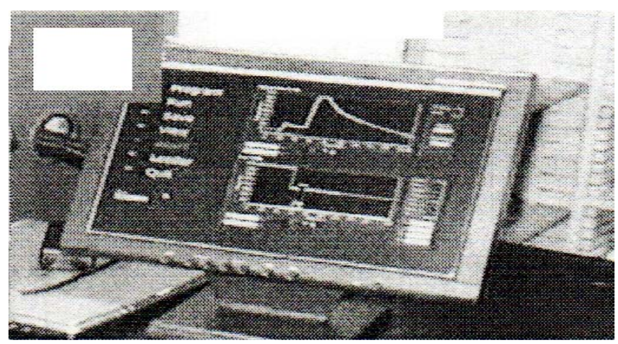

Fig. No.-2 The Control Unit

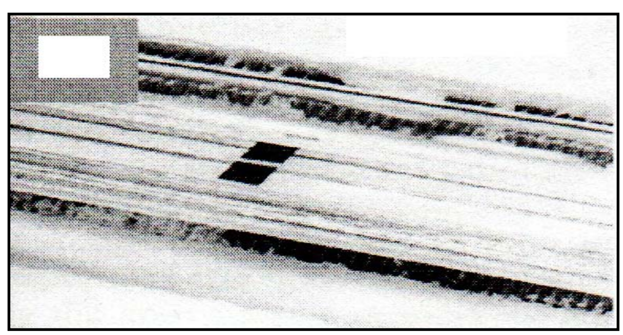

Fig. No.-3 The furnace and sample on the loader

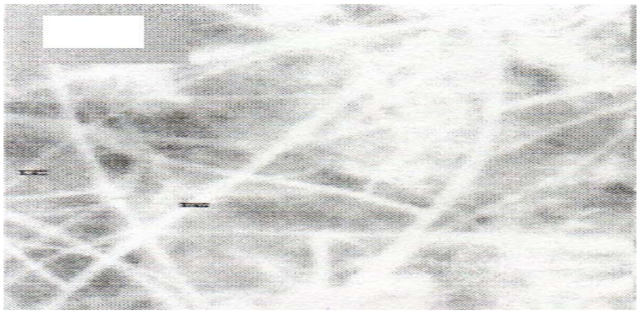

Fig. No.-4 Growth of SWCN using a catalyst on silicon wafer

Fig. No.-5. Growth of SWCN between catalyst particles

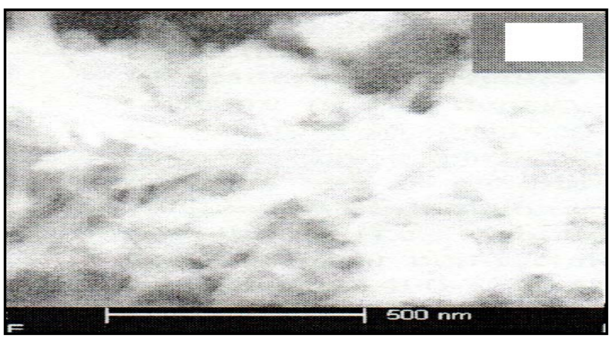

Fig. No.-6. Ribbon like structure of SWCN

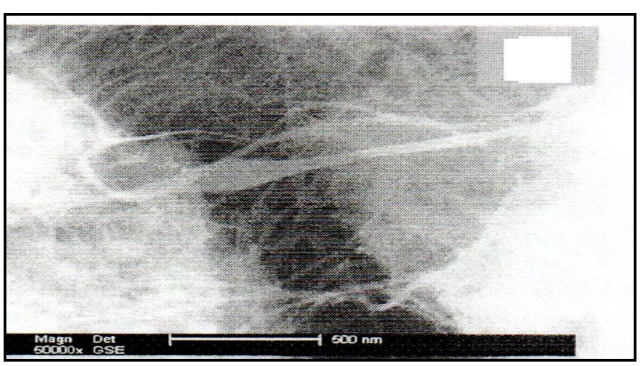

Fig. No.-7. Sheet like structure of SWCN

Fig. No.-8. Fiber pull out of Matrix

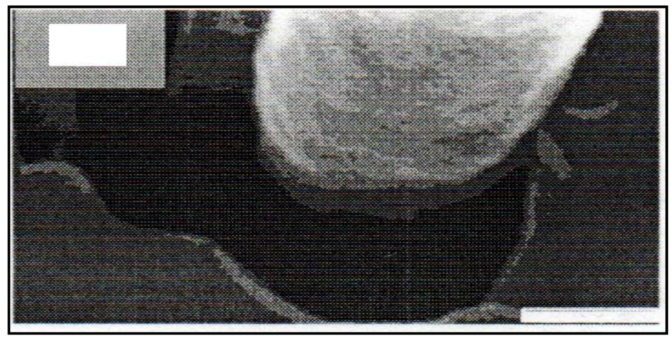

Fig. No.-9. Single fiber pullout of matrix

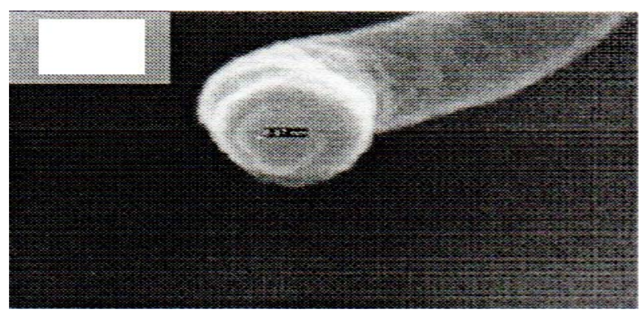

Fig. No.-10. A morphous carbon coating image

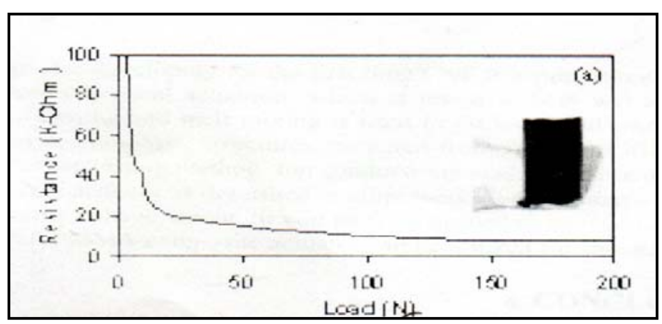

Fig. No.-11.The responsewith copper foil electrode in contact with composite

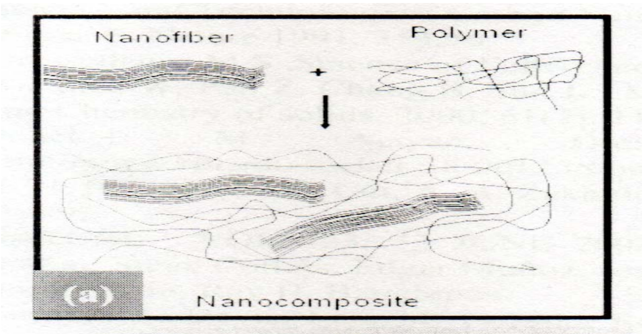

Fig. No.-12. The CNF in polymer matrix

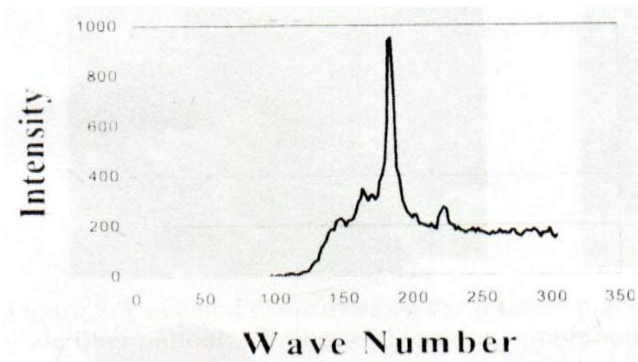

Fig. No.-13. CNT Raman spectra.

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