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Testing the Conductivity of the Carbon Nanotube Doped Coal.

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Abstract

Carbon, has always been a fascinating material to researchers. Carbon is generally of semiconducting nature. But non-porous or graphitic carbons have significant amount of conductivity and can be utilized to develop a new material for electronic devices. In this paper, we have made an attempt to experiment on coal carbon and determine its conductivity/resistivity. We have proceeded to study the conductivity of coal sample found from Barapukuria coal mine. Also by adding small amount of nanotubes and sequentially increasing the weight ratio, we have proceeded to increase the conductivity of our prepared samples. What we found that adding only 3% of MWNTs increased the amount of flow of current (for the same of voltage applied to carbon samples without adding NT) by about 5 times. We have found that conductivity increase from 3.404×10^{-12} Ωm to 0.028 Ωm by adding 60mg of carbon nano tube.

Keywords: *Carbon nanotue(CNT), Single wall (SW), Multi wall (MW)*

I. Introduction

Nanotechnology is one of the main features of modern science.It conducted at the nanoscale which is about 1 to 100nm. Carbon nanotube (CNT) is a tube-shaped material, made of carbon, having a diameter measuring on the nanometer scale. A nanometer is one-billionth of a meter, or about 10,000 times smaller than a human hair. CNT are unique because the bonding between the atoms is very strong and the tubes can have extreme aspect ratios. These cylindrical CNTs have unusual properties which are very significant in nanotechnology, electronics, optics and other fields of material science and technology.CNT can be formed from one atom thick sheets of carbon called graphene. These sheets are rolled at specisic and discrete angle to make CNT. They can be categorized as single walled nanotubes (SWNTs) and multiwalled (MWNTs) (shown in figure 1). Carbon nanotubes are the strongest and stiffest materials yet discovered in terms of tensile strength and elastic modulus respectively. A multi-walled carbon nanotube have a tensile strength of 63 gigapascals (9,100,000 psi) *(*M..F. Lourie *et al.,*2000).CNT can be metallic and semiconductor depending on their structure. *Metallic CNT can carry an electric current* density of 4×10^9 A/cm^2, which is more than 1,000 times greater than copper (H. Seunghun *et al.,2007)*

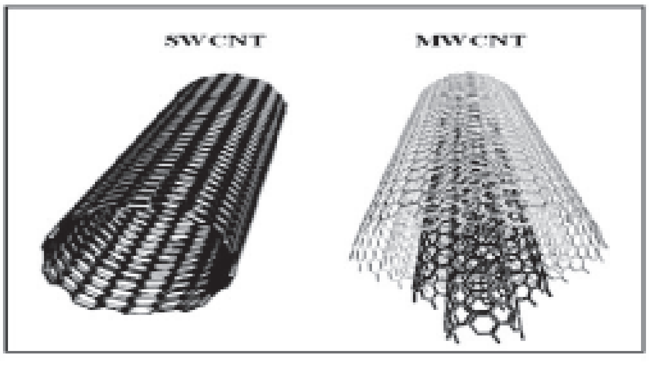

Figure 1: Carbon Nanotube

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Carbon nanotubes (CNTs) have recently emerged as the wonder materials of the new century and are being considered for a whole host of applications ranging from large scale structures in automobiles to nanometer scale electronics.

New research from the University of Pennsylvania indicates that CNTs may be the best heat-conducting material man has ever known. Ultra-small SWNTs have even been shown to exhibit superconductivity below 20°K. (Z. K. Tang *et al.*,2001) Research suggests that these exotic strands, already heralded for their unparalleled strength and unique ability to adopt the electrical properties of either semiconductors or perfect metals, may someday also find applications as miniature heat conduits in a host of devices and materials. The strong in-plane graphitic C-C bonds make them exceptionally strong and stiff against axial strains. The almost zero in-plane thermal expansion but large inter-plane expansion of SWNTs implies strong in-plane coupling and high flexibility against non axial strains. Many applications of CNTs, such as in nano scale molecular electronics, sensing and actuating devices, or as reinforcing additive fibers in functional composite materials, have been proposed. CNT paper electrodes are used in advanced supercapacitors.(G. Xu *et al.*,2011).Wearable and stretchable devices can be fabricated from thin films of aligned single-walled carbon nanotubes.(T. Yamada *et al.*,2011)

II. Experiment

The coal samples that we have used here have been taken from Barapukuria coalfield situated in an area of shallow basement in the northwestern zone of Bangladesh. Here we have coal samples collected from GDH:46 boreholes at 954feet depth. The samples were collected in the form of cylindrical shape. we have carried out experiments in the Solid state Laboratory of BUET .

Powder from each sample was measured to be exactly 0.7gms. An electronic weighing machine was used for this purpose.

After preparing the tablets from the samples, we continued with the conductivity experiment. For that, we coated each circular surface with a conducting silver coating (as thin as possible).Each voltage level gives an output current which is measured by the Keithley 614 electrometer. (shown in figure 2(a) &2(b).

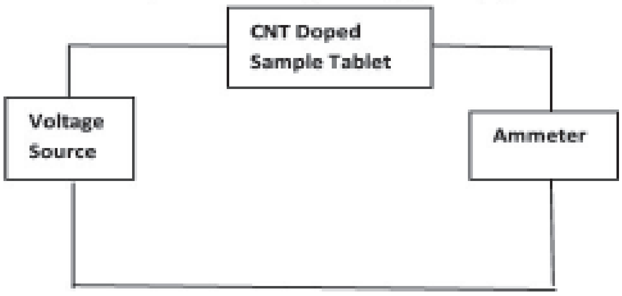

Figure 2(a): Experimental Layout

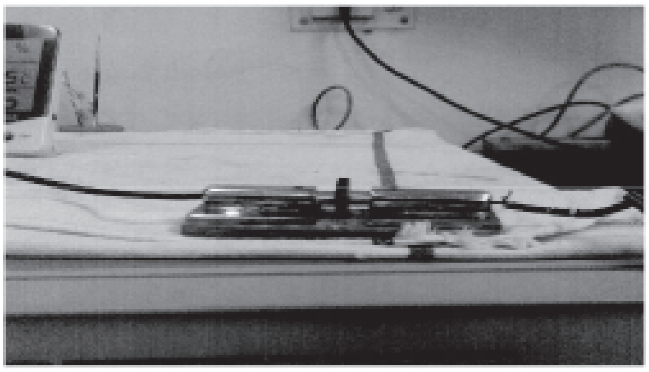

Figure 2(b): Testing the conductivity of the samples

III. Calculation

Sample thickness, d= 3.3 mm (GDH:954 ft Diameter, D = 15.5mm; radius, r = 7.75mm.So, surface area $A = \pi r^2 = 3.14 \times (7.75)^2 = 188.7$ mm^2 . Resistivity can be expressed by,

$$\rho = RA/d \qquad (1)$$

R is found from the I-V characteristics using Ohm's law: V= IR

Then the calculated values are placed in the above eq 1. Thus ρ is calculated. Such as for

GDH 954feet sample and applied voltage increases up to 150V but the current remain very low as shown in figure 3.we have the resistance value R = 187 MΩ. So, Conductivity ρ = 187 $\times10^{6}\times$188.7mm/ 3.3mm = 3.404×10^{-12} Ωm . The average value of ρ was calculated for every samples and thus ρ_{av} was determined. Here it is found that the conductivity is very low for the coal sample . It almost works as an insulator. Later when we add carbon nano tube the conductivity improved significantly.

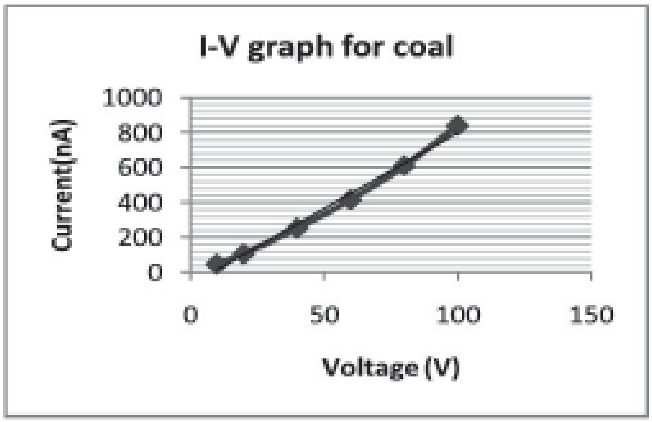

Figure 3 : I-V graph for coal sample

We mixed different weight of CNT (20mg - 60mg) with coal powder to prepare the sample tablets. Every time the tablet weight remain same (0.7g). After adding nanotubes different samples had considerably different thicknesses though total weight was same and all samples were subjected to same amount of pressure (8000 PSI). The sample Diameter:15.5 mm,Radius, r = 7.75 mm The different sample thicknesses are: d = 3.2mm (20mg NT), d = 3.5mm (40mg NT), d = 3.5mm (60mg NT), d= 3.6 mm (80mg NT); in case of 80mg, the thickness was uneven and the sample was too brittle, so we had to discard it.

For 20mg of CNT as the voltage increases from 5V to 90V the current increases from 90nA to 1753nA (shown in figure 4). Here the average conductivity is around 1.88×10^{-8} Ωm

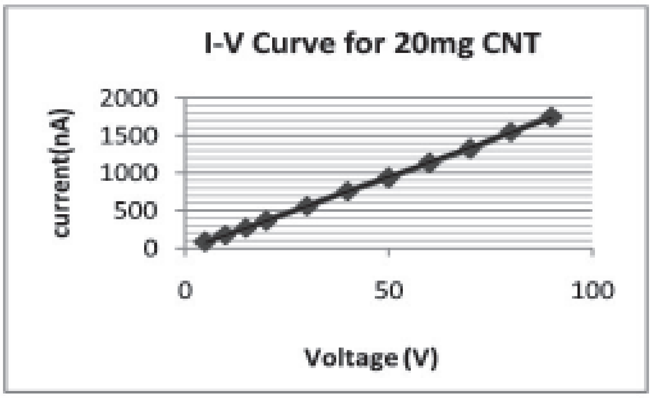

Figure 4: I-V graph for sample containing 20mg CNT

For 40mg of CNT as the voltage increases from 1 V to 50 V current increase from 0.1mA to 4.7mA .(shown in figure 5). Now the average conductivity becomes 1.0×10^{-4} Ωm.

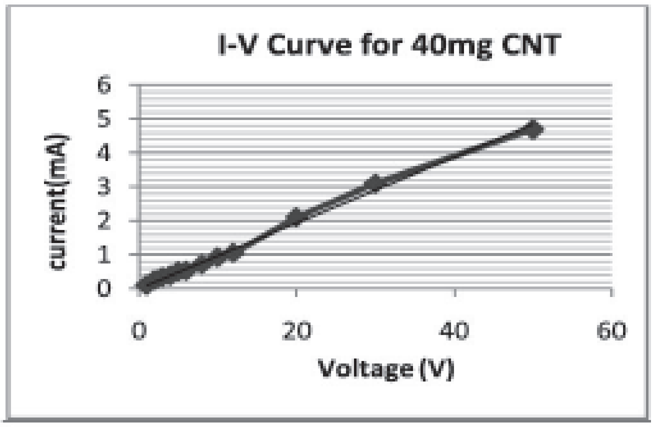

Figure 5: I-V graph for sample containing 40mg CNT

For 60mg of CNT as the voltage increases 1V to 20V the current increases from 19mA to 480mA.(shown in figure 6). At 20V the samples get burnt as the current become too high. Here the conductivity is around 0.028 Ωm.

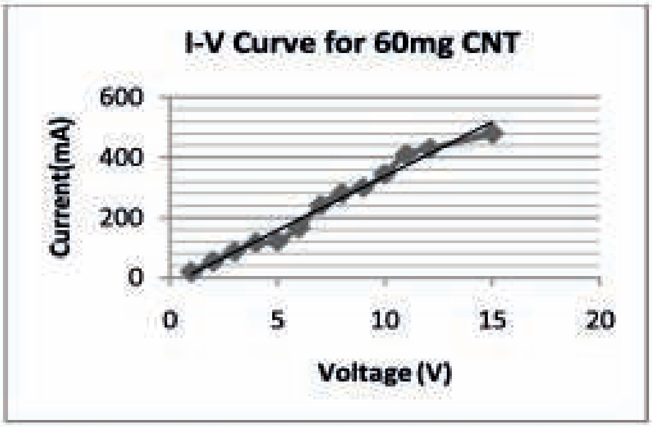

Figure 6 : I-V graph for sample containing 60mg CNT

IV. Conclusions

CNTs are so far the most promising of all other materials that can be used in nanotechnology. It can be used in IC fabrication as discrete circuit components. Scientists all over the world have explored the enormous possibility of replacing Si with carbon.

In this study one of the main features of CNT which is conductivity was tested. By mixing small amount of CNT with coal powder conductivity can be increased hugely. It was seen that only applying 20mg of CNT with coal powder conductivity of the sample tablet became 1.88×10^{-8} Ωm. By applying 40mg to 60 mg CNT conductivity was increased from1×10^{-4} Ωm to 0.028 Ωm. If higher voltage was applied current became too high to burn the sample tablet. If more CNT is applied the tablet became too brittle to conduct the experiment. CNT work as superconductor which promises larger and significant use in electronics.

Acknowledgments

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