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STUDY OF ELECTRICAL BEHAVIOUR OF GRAPHENE-SILICON DIOXIDE NANOSTRUCTURE COMPOSITE

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Abstract –

Quite recently a new carbon nanostructure, called graphite, has emerged, taking the attention of the scientific community because of its promising use in spintronics. Besides, many efforts have been dedicated to study the electronic properties of graphene, because creating a gap could allow the use of graphene in field effect transistors. In graphene, the presence of different types of boundary shapes, called edges, modifies the electronic structure of the material.

This paper reviews recent advances in the modification of graphene –SiO_2 (CSO) nanocomposites. The modification of graphene/graphene oxide and the utilization of these materials in the fabrication of nanocomposites with different materials matrixes have been explored. Graphene was synthesised by Hummer method, which was added at various composition with AR grade SiO_2. In looking for above mentioned applications we have decided to prepare nanocomposite of graphene-silicon dioxide (CSO) in the various proportions viz. 1:2, 1:3, 2:1 and 3:1. These composites were studied using its electrical conductivity measurements on four probe method from room temperature to 523 ^oK. The ln σ vs. 1/T (K) showed stable electrical conductivity behaviour. This is most suitable for thermal management systems. Similarly the AC conductivity measurements were carried out at room temperature which shows linear behaviour which is suitable for microelectronic devices.

Keywords - Graphene, Silicon dioxide, nanocomposites, electrical conductivity, TEM, SEM, etc.

INTRODUCTION

Graphene is generally described as a one-atom-thick planar sheet of sp2-bonded carbon atoms that are densely packed in a honeycomb crystal lattice. The carbon-carbon bond length in graphene is approximately 0.142 nm. Graphene is the basic structural element of some carbon allotropes including graphite, carbon nanotubes and fullerenes. Graphene exhibits unique properties, such as very high strength and very high conductivity

The unique electrical and mechanical properties of graphene have led to interest in its use in a variety of applications. For example, electrochemical energy storage has received great attention for potential applications in electric vehicles and renewable energy systems from intermittent wind and solar sources. One such energy storage application is Lithium ion (Li-ion) batteries. This inexpensive material possesses good thermal and electrical conductivity, good mechanical strength, and more surface area than expensive carbon nanotubes (CNTs), Graphene sheets have a unique ability to promote fast electron kinetics for a wide rangeof electroactive species. In addition, functionalized graphene has made the realisation of composite electrodes possible. It has been also demonstrated that graphene, with zero band gap and high carrier mobilities and concentrations shows nearly ballistic transport at room temperature.[1)] The properties of graphene can be extended by integrating it with other nanomaterials to form unique hybrid materials. One approach is to make composite of graphene and SiO_2 , a conducting material and insulating material nanocomposite.

In this paper, we report on the sysnthesis of graphene and silicon di oxide by using the Hummers-Offeman method. The prepared samples were characterised by X-ray diffraction (XRD) and Four probe method for electrical conductivity of nanocomposites.

2. EXPERIMENTAL

2.1 Preparation of Graphene-SiO_2 composite

For the synthesis of graphene, graphene oxide (GO) was prepared first, and then graphene was obtained after reduction of the graphene oxide using reduction agent. Graphite was selected as the starting material. Graphene oxide was prepared from graphite according to a modification of the HUMMER-OFFEMAN method.The graphite powder (3g) was dispersed in cold concentrated sulphuric acid (69ml, 98%, and dry ice bath) and potassium permanganate (KMNO4, 9g) gradually added with continuous vigorous stirring and cooling to prevent the temperature from exceeding 293K. The dry ice bath was removed and replaced by a water bath and the

mixture was heated to 308 K for 0.5 h with gas release under continuous stirring, followed by slow addition of deionized water (4 ml), which produced a rapid increase in solution temperature up to a maximum of 371 K. The reaction was maintained for 40 min in order to increase the oxidation degree of the graphite oxide product and then the resultant bright-yellow suspension was terminated by addition of more distilled water (140 mL) followed by hydrogen peroxide solution (H_2O_2, 30 %, 30 mL). The solid product was separated by centrifugation at 3000 rpm and washed initially with 5% HCl until sulphate ions were no longer detectable with barium chloride. Solid product was then washed three times with acetone and air dried overnight at 338 K. After sonication for 30 min, the graphite oxide was transformed to graphene oxide.

The reduction of graphene oxide was performed as follows: Twenty-five milligrams of the graphene oxide powder was placed in a cup and 200 mL de-ionized water was then added. Ten minutes of magnetic stirring at 200 rpm yielded an in homogeneous brown suspension. The resulting suspensions were further treated with a reduction agent, hydrazine solution (1:5, volume ratio of hydrazine to de-ionized water) (i.e) Sodium Boro Hydrate, gradually added with continuous vigorous stirring and it was filtered through a What-man filter paper. The solid obtained was collected and in vaccum at 353K for 8 hrs, the sample was reduced from graphene oxide to just graphene. The preparation procedure is shown in Fig 1.

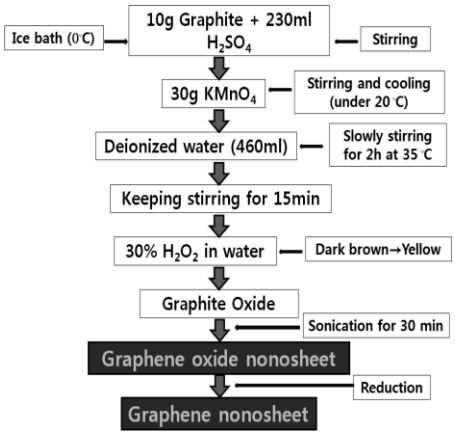


Fig.1 Synthesis of Graphene

2.2 Synthesis of graphene-SiO_2 composite

Silicon powder was crushed finely. The nanocomposites of graphene and Silicon di Oxides were made by mixing graphene and SiO_2 in different proportion and five samples prepared. The Total weight of each sample was 1gm. First sample was pure SiO_2. Second sample was composite of proportion 70% SiO_2 and 30% graphene. Third sample was of proportion 50% graphene and 50% SiO_2. Fourth sample was 70% graphene and 30 % SiO_2 And the fifth sample was 100% Graphene. After this pallets of each sample were made readyand silver pasting was done on them.

2.3 Characterization

XRD measurement was performed for graphene sample at room temperature. Electrical properties of composites were measured by four probe method. The ac conductivity of the samples were recorded for the frequency range 1K to 10k for various temperature ranges. The graphs were plotted for determining electrical conductivity of the samples.

3. Result and discussion

XRD Analysis: After the synthesis graphene of was done the sample was inspected by using XRD techniques. From the graph it was observed that the particle size is in nano range. The XRD pattern of graphene shows the broadened peaks which indicate the nature of nanoparticle particles. Fig. of XRD shows intensive peak at peak 10 at the angle of 26.68 degree which has maximum intensity. The presence of Peak 1 shows two graphene atoms are well away from each other; this may be because of presence of graphene Oxide in the sample or due to excess of Sodium Boro Hydrate in the sample. This means there were some defected graphene. This is probably due to the existence of the amount of hydroxyl, carboxyl, carbonyl, and epoxide functional groups attached onto the basal or edge plane. The reduction of the $NaBH_4$ yields a deoxygenated sp^2 carbon from epoxides and hydroxyls.
From the data provided in XRD the particle size was found to be between 8 to 20 nm by using the Scherer equation.

Electrical Properties: Recently, graphene based carbon materials are used as transparent and conductive materials. The electrical conductivities of graphene composites are evaluated at room temperature based on the four probe method.

According to the results above, the increasing conductivity is effects of reducing the average inter sheet distance. The temperature variation electrical conductivity was studied for different composite samples and it was found that resistance of the graphene sheet was decreased. The material is found to be stable in terms of electrical conductivity with respect to the frequency. It does not change its electrical conductivity over a wide range of frequencies. The conductivity of the composite was independent of frequency. The measurement was carried out at room temperature over the range of frequencies from 1 kHz to 10 kHz. The plots of the electrical conductivity were produced for all samples. This property of material of having stable conductivity makes it very useful in fabricating electronic devices. It is also found that this material has negligible hopping which makes it act as better capacitor. It improves its dielectric properties.

In conclusion, graphene was successfully prepared from the graphite powder by chemical oxidation method. From the result, it was found that the material has stable conductivity for wide frequency range and the peak 1 in XRD need further study. In summary, the graphene and its composite mentioned above have led to the exploration of numerous application such as transistors, chemical and biosensors, energy storage devices, nanoelectro-mechanical systems and others. Carbon based nanotechnology has been grown very fast in last decade. Research in this area will assist the development of next generation graphene based composites and devices.

Future Study: The peak1 in XRD having d value 7.17 indicate the two graphene carbon atoms are well away from each other and it needs much more study to illustrate the peak1 point

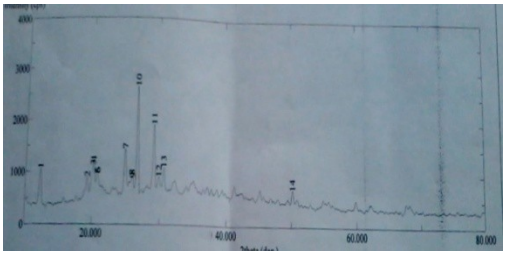
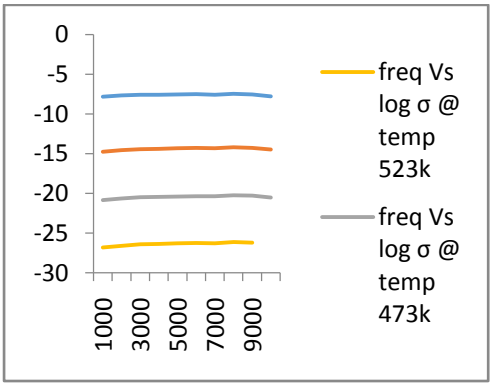


Fig.2: XRD of Graphene

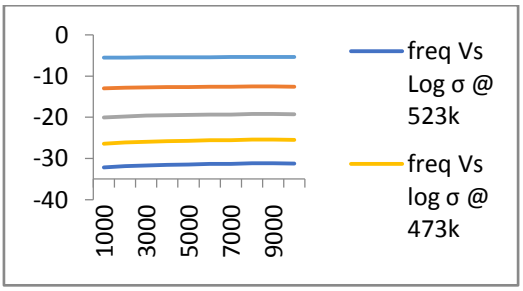
- **PAY -01 (SiO_2 100%)**

Fig.3.a. Frequency Vs Log σ



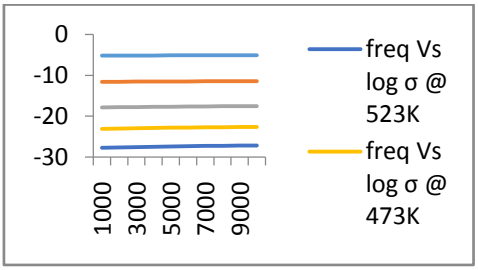
- **PAY-02 (70% sio_2+30% Graphene):**

Fig.2.b. Frequency Vs Log σ



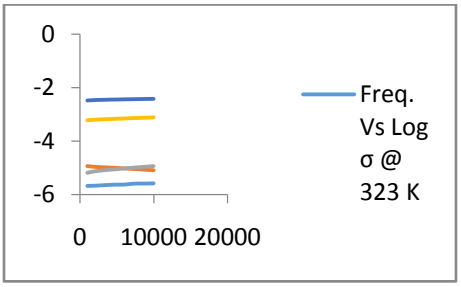
- **PAY-03 (50% sio_2+50% Graphene):**

Fig.2.c. Frequency Vs Log σ



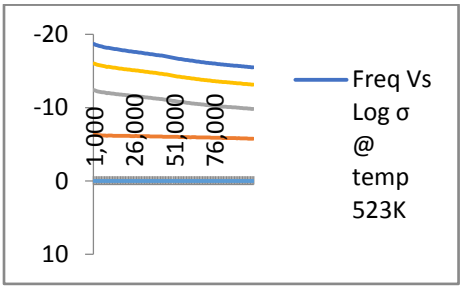
- **PAY-04 (30% sio_2+70% Graphene):**

Fig.2.d. Frequency Vs Log σ



❖ **PAY-05 (0% sio_2+100% Graphene):**

Fig3.e. Frequency Vs Log σ



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