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Characterization of ZnO - Biopolymer Nano Composites

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ABSTRACT

In this work ZnO nano clusters were grown in biopolymer background. Attempt has made to control the nano-cluster size by the in situ chemical sol-gel process. The dc volt-ampere characteristics of the developed ZnO nano composites which were prepared under different conditions were measured. XRD and optical absorption of the material were also studied to get information on grain size. The work indicated a possible new characterization technique by the use of the dc I-V characteristic which perhaps contains information about cluster size of the nano composites.

Keywords: Nano composites, Spectrophotometry, Electrical conduction.
PACS: 81.07.Bc; 07.60.Rd; 73.61.-r; 81.16.-c

INTRODUCTION

Nano composites (NC) draw attention for their novel properties. ZnO is an eco-friendly material moreover non toxic for human bodies. ZnO NC may be useful in bio-medical applications. ZnO nano clusters are large band gap semiconductor and they can be produced by various ways. The material is an important in development of solar cells due to their small cluster size (~50nm). Production of NC's via bottom up sol-gel route is cheaper than top down route. In this work ZnO NC were synthesized following low temperature (~100^{O}C) sol-gel route. The process uses zinc acetate as main reagent and gum *Acacia* as a capping agent. It is important to study the properties and cluster size of a NC sample for better application. The objective of the work aiming at a new characterization technique from the study of dc electrical character the later is legitimate as a quick and easy method compared to other micrographic techniques.

MATERIALS AND METHODS

Sample Preparation

In-si-tu production of ZnO NC was made from zinc acetate, analytical grade, M.W. 219.50 (product of CDH, India) and gum Arabica (E. Merck Ltd, India) as starting materials. The later is a high potential biopolymer [1]. 100ml M/10 solution of $Zn(CH_3COO)_2$ in distilled water was drop wise mixed with hot (~100°C) diluted aqueous solution of Acacia while the Acacia solution was vigorously stirred with magnetic stirrer. It was then refluxed for 10 hours. Rates of drops were set at 2 second interval and 4 second interval for two samples (sample 2 and sample 3) respectively. Also a sample (sample 4) with 10ml M/10 Zn $(CH_3COO)_2$ at 10 second drop interval was prepared through same process. Another sample (sample 1) was made with 100ml M/10 $Zn(CH_3COO)_2$ solution mixed at a time with Acacia and refluxed for 10 hours.

Measurements

DC I-V characteristics of the developed nano-composites were measured at 20mV voltage steps (0 to 2V) using PC interfaced Keithley 2400 source meter. Optical absorbance of sample 1 was measured with Systronics 2201 UVVIS spectrophotometer. XRD of ZnO specimens were measured with Rigaku Miniflex, Japan using Cu Kα line.

RESULTS AND DISCUSSION

From I-V measurement of sample 1(Fig. 1 A) and sample 2 (Fig. 1, graph B) it is observed the typical characteristics of NC which also appear in Fig.2. I.l/A (where I=measured current, l=sample thickness, A= area of contact) is plotted in vertical axis.

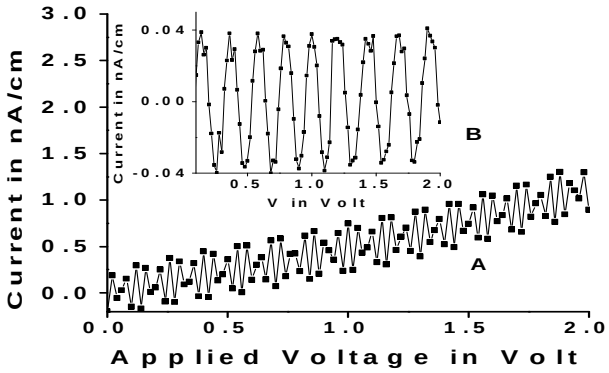

Figure 1. DC I-V characteristics of bulk sample 1 and sample 2 (inset)

The average slopes of two graphs of Fig.2 are 0.004e-9ohm-1cm-1 and 0.55e-9ohm-1cm-1 respectively. The results of same measurement on sample 3 and 4 are shown in Fig.2 (graph A and graph B respectively) having average slopes 0.003e-9ohm-1cm-1 and 0.007e-9ohm-1cm-1 respectively. It is the hall mark for NC dimension in the nano-complexs.

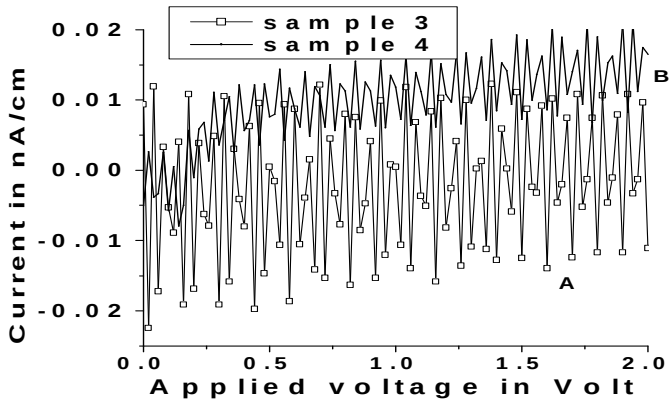

Figure 2. DC characteristics of sample 3 and sample 4

General nature of graphs (Fig.1 and Fig.2) indicates that samples contain nano clusters with different sizes. It is apparent that the average NC sizes in the developed nano-composites are of decreasing magnitude as we pass from sample 1 to sample 4. The results summarized by Fig.1 and Fig.2 show a clear evidence of reduction in average NC sizes by decrease in amplitude of coulomb blockade in the respective dc I-V characteristics.

Graph A in Fig.3 shows the XRD pattern of sample1 and compared with ordinary ZnO powder (graph B) with a clear distinction.

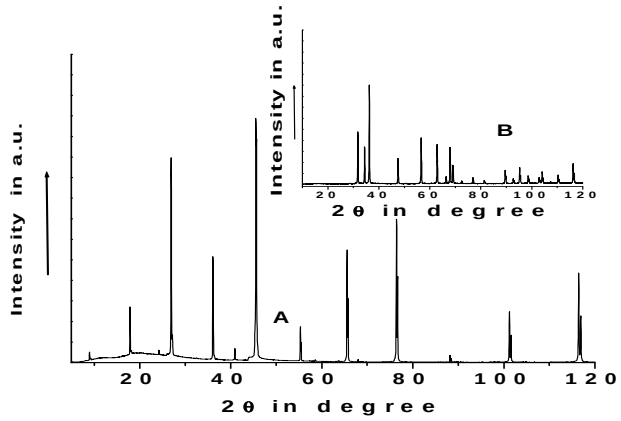

Figure 3. XRD pattern of sample 1 and bulk ZnO (inset)

Using Scherrer formula [2], the estimated average grain size of the ordinary ZnO is 98.39nm whereas ZnO NC has average grain size 42.22nm. Figure 4 shows the optical absorption spectra of sample 1. ZnO has bulk band gap 3.2eV [3] corresponding to 388.4 nm wavelength. A peak appears at 381nm corresponding to blue shifted band gap 3.26eV due to quantum size effect [4, 5].

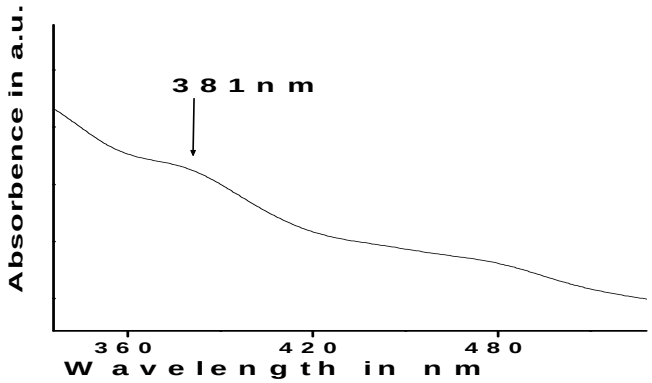

Figure 4. Optical absorption spectra of sample 1.

CONCLUSION

Gum Acacia capped ZnO NC have been prepared successfully. The dc I-V characteristics bear the signature of different NC with probable variation of grain size.

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