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Low-Pass Filter Characteristics Of Zns:Cu Quantum Dots Embedded In Polyvinyl Alcohol (PVA)

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Abstract:

Zinc Sulphide (ZnS) is a group II-VI semiconductor having a large band gap of 3.54 eV for cubic and 3.91 eV for hexagonal structures which can be further increased by reducing the size. The physical and electrical properties of these nanocomposites changes significantly when doped with other suitable materials. In this paper we report synthesis, characterization and Low-Pass filter characteristics of ZnS:Cu nanoparticles embedded in PVA matrix.

Chemical route is used to prepare ZnS:Cu nanocrystals embedded in Polyvinyl Alcohol (PVA). The UV-Vis spectroscopy of the prepared sample shows an absorption peak at 301 nm. PL spectra show an emission peak at 400 nm. The gain vs frequency curve of the samples is identical to the characteristics curve of a Low Pass filter. The frequency response of the prepared samples shows their possible applications as Law Pass Filter.

Keywords: *ZnS: Cu nanoparticles, low pass filter, frequency response.*

Introduction

Zinc Sulphide (ZnS), a group II-VI inorganic compound semiconductor material, has attracted considerable research interest due to its extensive usage in thin film electroluminescent devices, Infrared windows, Flat panel displays, Sensors and Lasers. ZnS quantum dots as High pass filter were reported by S.S Nath et al. [1] in 2008. CdS and CdS:Cu quantum dots as low pass filter is reported recently by Kakati J et al. [2]. In this paper, we have synthesized both ZnS and ZnS:Cu nanocomposites and compared their frequency response. The frequency response of the Copper (Cu^{2+}) doped samples shows higher gain as compared to the undoped samples.

Synthesis

Synthesis of ZnS quantum dots is carried out using chemical method. Zinc Chloride ($ZnCl_2$, 99.99%) Sodium Sulphide (Na_2S, 99.99%) and Copper Chloride ($CuCl_2$, 99.99%) were purchased from Sigma and used without further purification. Double Distilled water is used for the experiments. PVA is used as capping agent.

Characterization

For UV-Vis, PL and HRTEM characterization liquid samples are used. For XRD, AFM and SEM & EDX characterization we have prepared thin films from the samples. From the optical absorption spectra (Fig. 1), band gaps of the as-synthesized samples are estimated using Tauc's method and found to be higher than the bulk band gap. From the photoluminescence spectra (fig.2), it is clear that the luminescence intensity of the doped samples is higher than that of the undoped samples.

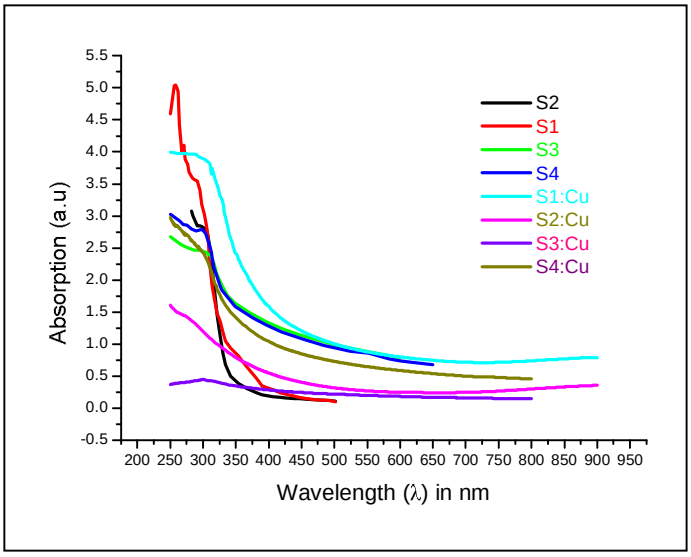

Figure 1: UV-Vis of the prepared samples

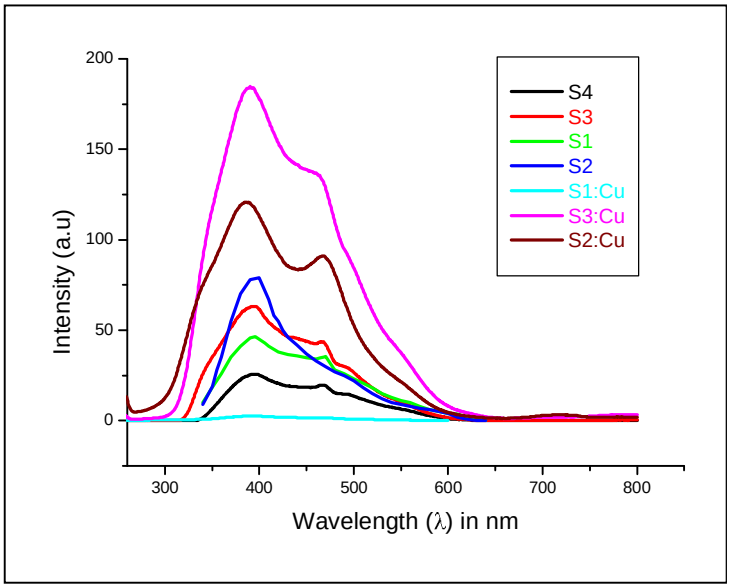

Figure 2: Photoluminescence spectra of the samples

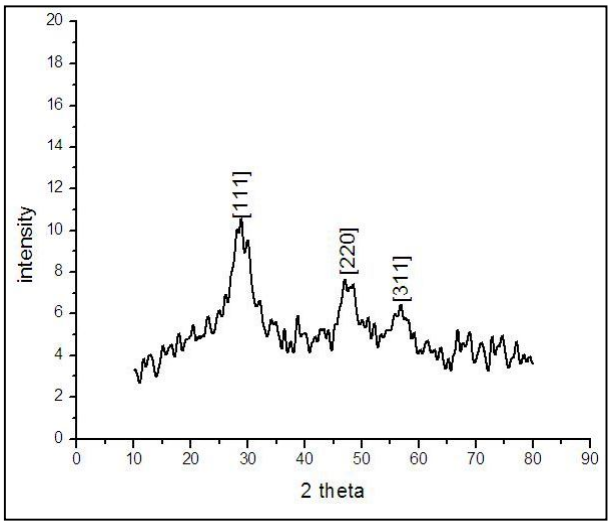

Figure 3: (a) XRD pattern of sample S3

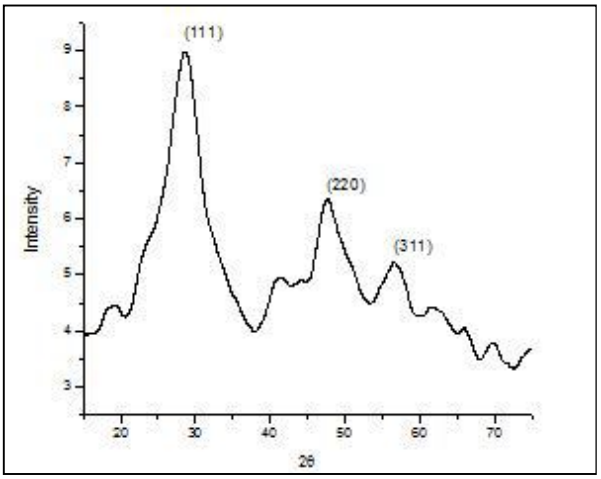

Figure: 3(b) XRD pattern of Sample S3:Cu

From XRD (Fig.3), the size of the particles are calculated from Debye Scherer formula and found to be ~ 6 nm and ~ 8 nm for S3 and S3:Cu respectively.

HRTEM image of the undoped ZnS sample shown in fig. 4(a) indicates the nanocrystalline nature of the sample with distinct grain boundaries having average crystallite size of ~ 8 nm. Fig. 4(b) & 4(c) show the SAED and EDX images of the sample, respectively. The AFM images of sample S7:Cu confirms the nanoformation.

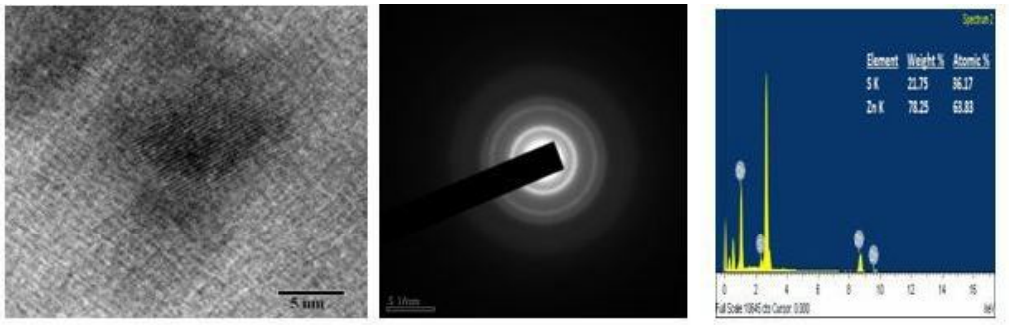

Figure 4(a): HRTEM of sample S3 *Figure 4(b): SAED image* *Figure 4(c):EDX of sample s3*

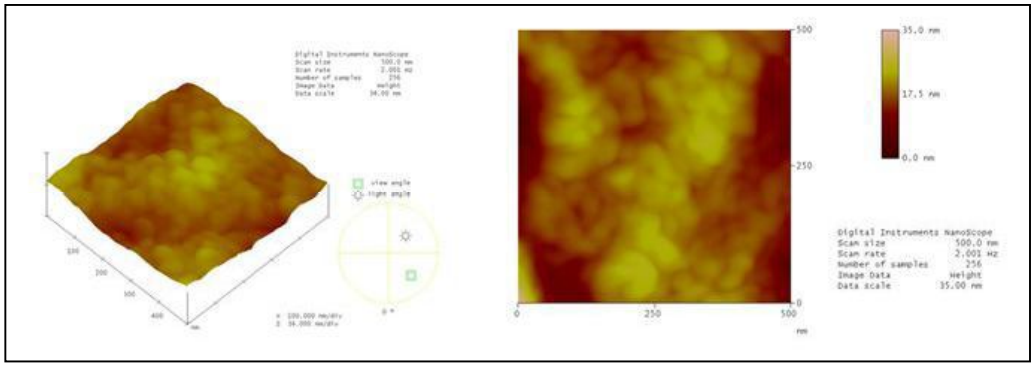

Figure 5: AFM images of sample S3:Cu

Application as Low Pass Filter

The Low pass filter characteristic is obtained by applying a sinusoidal signal of fixed amplitude from a signal generator across the sample and taking the corresponding output at the oscilloscope. From our investigation it is found that the amplitude of the output signal decreases with the increase in input frequency. The frequency response of the undoped and doped samples is shown in Fig 6 and Fig 7 respectively. The gain vs frequency curves of the samples show low pass filter behavior of the sample. It can be noted that the gain of the doped samples is greater than that of the undoped samples.

Conclusion

We have successfully fabricated ZnS and ZnS:Cu Quantum Dots embedded in PVA. The as synthesized nanocomposite shows Low pass filter characteristics. So far our knowledge goes this is the first report of Low pass filter characteristics of ZnS and

ZnS:Cu Quantum Dots. The findings of the present work call for further experimental as well as theoretical works on the problem.

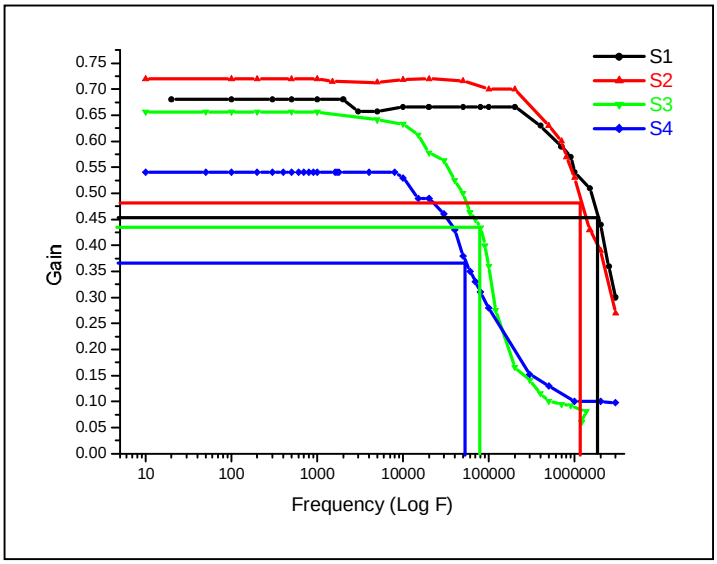

Figure 6: Freq vs. Gain curve of the undoped samples

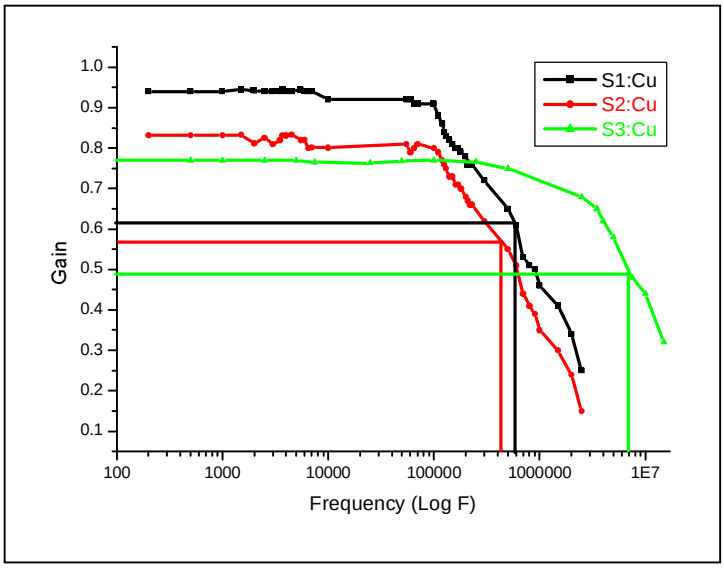

Figure 7: Freq vs. Gain curve of the doped samples

Sample Name	Gain	Cut-off Frequency
S1	.675	1.1 MHz
S1:Cu	.94	600 KHz
S2	.725	1 MHz
S2:Cu	.84	500 KHz
S3	.65	90 KHz
S3:Cu	.76	6.5 MHz
S4	.53	80 KHz
S4:Cu	.55	900 KHz

Table 1: Gain and Cut-off frequency of the samples.

Acknowledgement

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Reference

1. S.S. Nath, D. Chakdar, G. Gope and D K Avasthi (2008), Characterization of CdS and ZnS Quantum Dots prepared via a chemical method in SBR Latex,
2. Jumi Kakati∗, Hirendra Das, and Pranayee Datta (2012), PVA/CdS and PVA/CdS:Cu Quantum Dots as Low-Pass Filter, Advanced Science, Engineering and Medicine Vol. 5, pp. 119–125 .