Optical absorption and luminescence study of ZnS quantum dots

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Abstract: We report here ZnS quantum dots synthesized by chemical method at room temperature. In this technique ZnS quantum dots are produced by simple chemical reactions where Zeolite, acting as matrix, plays the key role in controlling particle growth during synthesis and irradiation. The nanodots exhibit self-assembly dependent luminescence properties such as Zn^{2+} related emission, efficient low voltage electroluminescence (EL). This study demonstrates the technological importance of aggregation based self assembly in semiconductor nanosystems.

Topic area: *Nanotechnology*

Key Words: *Quantum dots, SHI, Blue Shift, Zn vacancy, Electroluminescence*

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1. Introduction:

During recent years, fabrication[1-11] of quantum dots by various methods has been an emerging area of research for different optical, electronic, magnetic and spectroscopic applications. Synthesis of CdE, ZnE (E= S, Se, Te etc.) quantum dots by molecular- beam epitaxy technique as well as by simple chemical routes have been found in literature[1-11]. In this present article, we report synthesis of ZnS quantum dots in Zeolite by using chemical method_at room temperature. Zeolite controlls the size and shape of quantum dots during sample fabrication. The samples have been characterized by different techniques to reveal their nano nature. Also, the samples have been tested for their applications in electronics as nano LED by exploring the variation of EL intensity (Brightness) with dc voltage[5].

2. Experimental:

Synthesis of quantum dots by chemical method is a low cost and simple process. To synthesize ZnS quantum dots[6] by chemical route at room temperature, 8 grams of Zeolite are dissolved into 120 ml double distilled water. This mixture is taken in a three necked flask fitted with thermometer pocket and N_2 inlet. The solution is stirred in a magnetic stirrer at a stirring rate of 200 rpm at a constant temperature of 70^0 C for 5 hours. Thus, a water solution of zeolite has been prepared. Similarly, $ZnCl_2$ solution is made by dissolving 7 gms of $ZnCl_2$ in 100 ml double distilled water. The solution is degassed by boiling N_2 for 3 hours. Next, zeolite solution and

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$ZnCl_2$ solution have been mixed and few drops of HNO_3 is added to the mixture followed by moderate stirring while aqueous solution of Na_2S is put into it slowly by means of a dropper unless the whole solution turns white. This solution is kept in dark chamber at room temperature for 14 hours for its stabilization. Now the whole solution is filtered by filter paper and the powder sample of ZnS in Zeolite was prepared.

3. Result and discussion:

High resolution transmission electron microscopy (HRTEM) (using JEM 1000 C XII) shows the surface morphology and particle size of the sample (Fig.1). Optical absorption spectroscopy (using Perkin Elmer Lamda 351.24) also displays a strong blue shift in the absorption edge of quantum dot samples in comparison to that of bulk specimen.

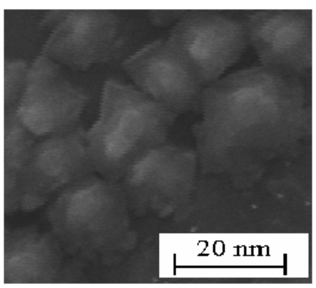

Fig 1. HRTEM Images

By considering strong absorption edge average particle size has been estimated theoretically by using the following hyperbolic band model [2].

$$R = \sqrt{\frac{2\pi^2 h^2 E_{gb}}{m^*(E_{gn}^2 - E_{gb}^2)}}$$

Where, R is the radius of quantum dot, E_{gb} is the bulk band gap, E_{gn} is the quantum dot band gap, h is Planck's constant, m*(for ZnS 3.64×10^{-31} Kg) is the effective mass of the specimen. This model yields the average particle size at around 10 nm. The reason for discrepancies between sizes obtained from HRTEM, and hyperbolic band model[2,6]. To obtain exact size from hyperbolic band model, the particle should be of exactly circularly shape. Form HRTEM images it is observed that the particles are not exactly circular, hence discrepancy occurs.

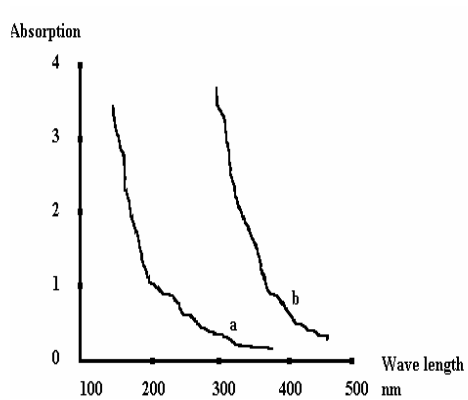

Fig 2. UV/VIS absorption spectre

Photoluminescence study (using HITACHI-F-2005) of the samples show that ZnS quantum dots produce emission [6-10] at 500 nm when excited with the optical signal of 200 nm.

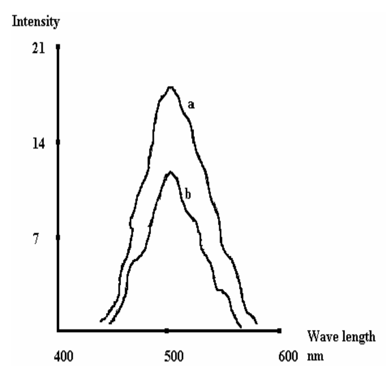

Fig. 3: PL spectra of ZnS: Excitation source200nm (a) for ZnS quantum dot and (b) for ZnS bulk

Fig 4 displays the room temperature EL spectra [8-11]. This experiment reveals that EL intensity is a function of excitation dc voltage at about 4.6 V but the EL emission peak position does not shift significantly and observed at around 500 nm irrespective of the excitation voltage. We believe that the reasons[7] behind emission in both the cases of PL and EL is the same and it is Zn^{+2} vacancies created during fabrication.

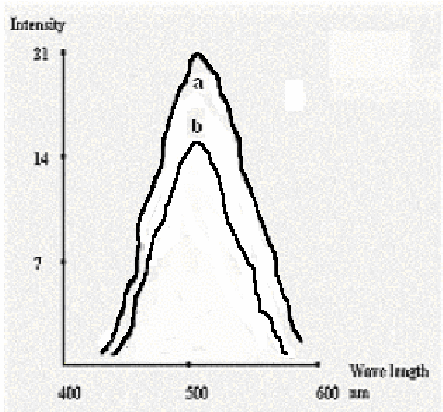

Fig 4: Electroluminescence Curve (a) for ZnS quantum dot and (b) for ZnS bulk

4. Conclusion:

ZnS quantum dots fabricated by chemical method, possesses Zn vacancies. These defects act as the optical sources in the specimen. Thus ZnS quantum dots can act as nano LED in green region .

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