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STRUCTURAL, OPTICAL AND ELECTRICAL CHARACTERIZATION OF CdSe NANOPARTICLES

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In the present work a simple chemical reduction route has been followed to grow CdSe (size controlled) nanoparticles at room temperature. The grown sample has been ultra-sonicated in ethanol. The dispersed sample has been characterized structurally, optically, and electrically. The result supports the formation of nanoparticles and hence an increase in band gap compared to bulk CdSe (bulk band gap is 1.74 eV).

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Keywords: CdSe nanoparticles, Chemical synthesis, Crystal structure and symmetry, Optical and electrical properties

1. Introduction

For the past year, semiconductor quantum dots have attracted large interest from the community due to the peculiar role played by quantum confinement and the consequent potential for size- tunable nano devices. Among the colloidal nanocrystals, CdSe (generally Gr-II to Gr-VI) is studied due to the efficiency of its synthesis, the high quality of the resulting sample, and the fact that the optical gap is in the visible range. Also it is an important semiconducting material with unique electrical properties, which makes it a promising material in the field of opto-electronic devices such as Light Emitting Diode, Photovoltaic Cells, Solar Cell, Photo Detector, High Density Magnetic Information Storage, Biosensors e.t.c [1-6]**.** There are various methods [7-14] to prepare CdSe nanoparticles. Some of the above mentioned methods have some drawbacks. Used precursors are unstable causing environmental hazards and require very high temperature. These methods are not cost effective also. Hence a simple chemical reduction route has been preferred.

2. Experimental section

A stoichiometric amount anhydrous $CdCl_2$, selenium powder and sodium borohydride has been taken. Ethylenediamine has been used as a capping agent. Sodium borohydride has been taken to initiate the reaction at room temperature. The stirring has been continued for 3 hours at a particular speed. For TEM and TED measurements, the as-prepared CdSe nanoparticles have been dispersed in ethanol by ultrasonification. A small drop of dispersed CdSe nanoparticle has been taken on a thin carbon film supported on the copper grid and kept for some time for drying. TEM, TED and EDX of the as- prepared sample has been taken using JEOL-JEM-200 transmission electron microscope operating at 200 kV. Optical absorption measurements of the dispersed samples have been studied in the range of 500nm-800nm using Shimadzu Pharmaspec 1700 UV-VIS spectrometer. Photoluminescence spectra of the same sample have been obtained using Hitachi F-7000 FL Spectrophotometer.

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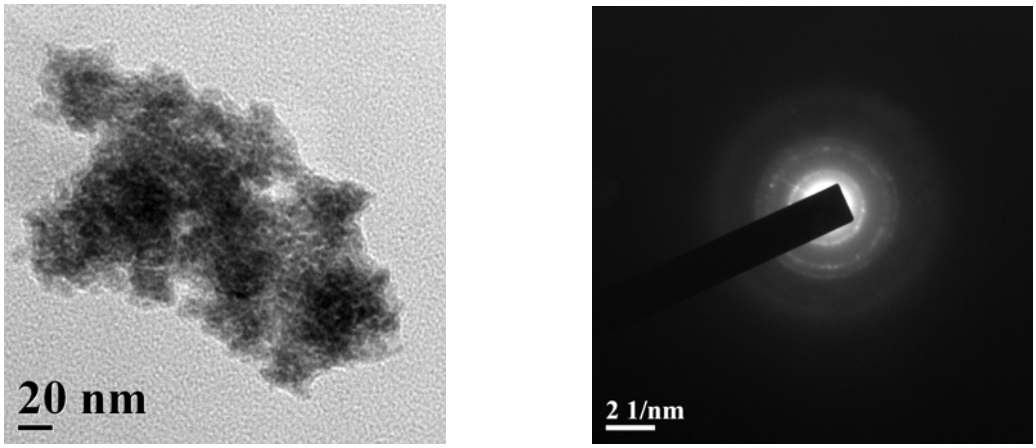
Thin film of the CdSe nanoparticles has been grown from the dispersed sample. The glass substrate has been dipped in to the dispersed solution at least for 6hrs. Uniformly thin film of CdSe nanoparticles has been deposited on the glass substrate. Silver paint is used as ohomic contact. I-V characteristics are found to be linear. The photoelectrical characteristics have been studied using Kiethly electro-meter-6514. From the long photoconductive decay relaxation time has been measured. Intensity of light falling on the sample is measured by a luxmeter & is found to be 50 lux

3. Results and discussion

TEM image of the bright field of CdSe nanoparticles and its selected area diffraction pattern are shown in figure 3(a) and 3(b) respectively. Particle size is determined to be approximately 5–8 nm [15].



a b

Fig. 3(a) The TEM image of as prepared CdSe nanoparticles. (b) The SAD pattern of as prepared CdSe nanoparticles.

A clear hexagonal phase of the as-prepared CdSe nanoparticles is revealed in the TED pattern (figure 3(b)) .The interplaner spacing (d) is determined from the SAD pattern. The determined d values are 3.828, 3.141, 2.213 Å respectively for first, Second and third rings respectively. The calculated d values match well with JCPDS file values of 3.720, 3.290, 2.151 Å respectively which corresponds to (1 0 0), (1 0 1), (1 1 0) planes respectively [15].

The EDX analysis is also performed on these nanoparticles.

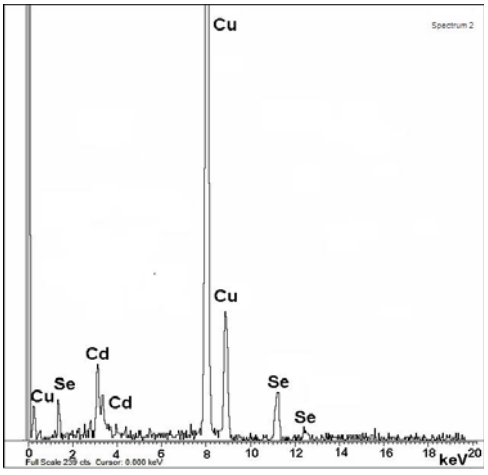


Fig.4. EDX analysis of the sample.

The EDX pattern shows that weight percentage of Se & Cd is 53.68 & 46.32 respectively. Cu peak arises from the Cu grid.

Figure 5 displays the variation of optical absorbance with wavelength of the as-prepared nanoparticles. Optical absorption coefficient has been calculated in the wavelength region of 500 – 800 nm.

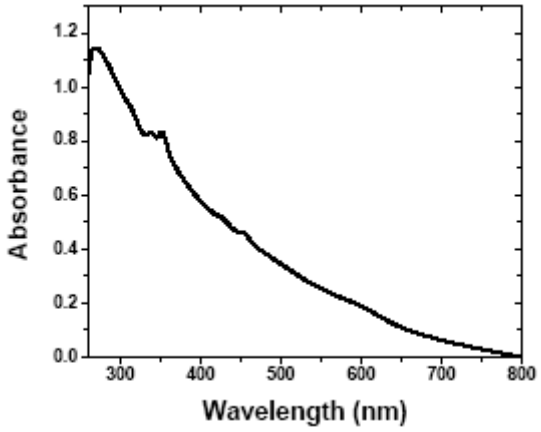


Fig.5. The optical absorption spectra of as prepared CdSe nanoparticles.

The band gap of the as- prepared nanoparticles is determined from the relation $(\alpha h\nu) = C (h\nu - \Delta E_g)^{1/2}$ where C is a constant, ΔE_g = 2.02 eV whereas the bulk band gap is 1.74eV. It confirms that the absorption peak is shifted from their bulk edge 704nm. This is due to the quantum confinement effect. Hambrock et al obtained CdSe band gap of 2.01 eV (617 nm) [7].

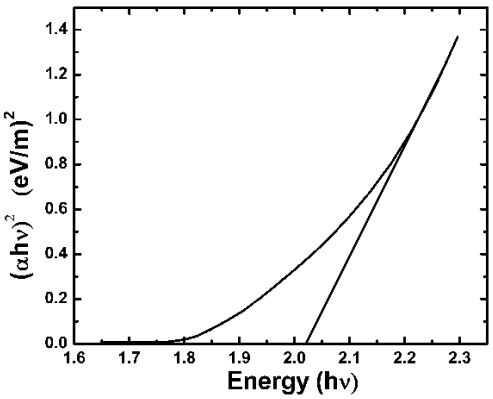


Fig.6. The band gap determination of as prepared CdSe nanoparticles.

The photoluminescence spectrum of the as-prepared CdSe nanoparticles is displayed in the figure 7.

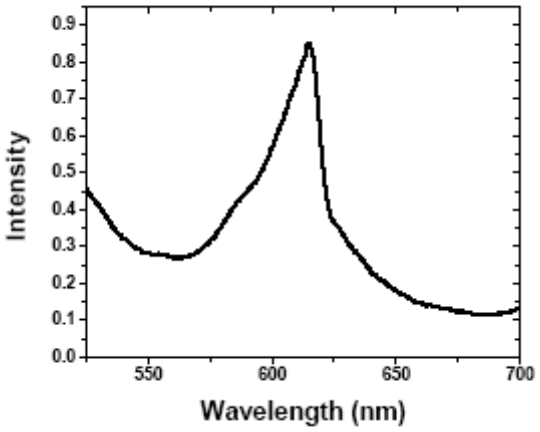


Fig.7. The photoluminescence spectra of the as-prepared CdSe nanoparticles.

A sharp peak at 615nm is obtained [9-12]. This is due to band edge luminescence. The band edge is close to the value determined by optical absorption.

The growth of photocurrent is shown in figure 8. After the steady current is reached the light is switched off. Relaxation time is measured from long time photodecay graph. The corresponding graph is displayed by the figure 9. Relaxation time is measured using the relation $\Delta n = \Delta n_s \exp(-t/\tau)$. This relation can be correlated to experimentally measurable parameter by $\Delta n/\Delta n_s = \Delta I_{ph(s)}/\Delta I_{ph(t)} = \exp(t/\tau)$,where $\Delta I_{ph(s)}$ is the change of photo current with respect to dark current value and $\Delta I_{ph(t)}$ is the change of photo current at any arbitrary time t with respect to the dark. The plot of ln $(\Delta I_{ph(s)}/\Delta I_{ph(t)})$ vs. t gives the straight line and is displayed in figure 10. From the slope, the long time relaxation is estimated and is found to be 30.134 sec.

The slow photoconductive decay is attributed here to the reconstruction of recombination barrier which has spatially separated the photogenerated electron-hole pairs by trapping minority carriers. The dark conductivity is established only after equilibrium filling of the recombination barrier states, the process being self hampering because it involves the barrier being overcome by majority carriers. The exponential decay shows that recombination barrier height does not change at all under illumination & this is the case under weak illumination.

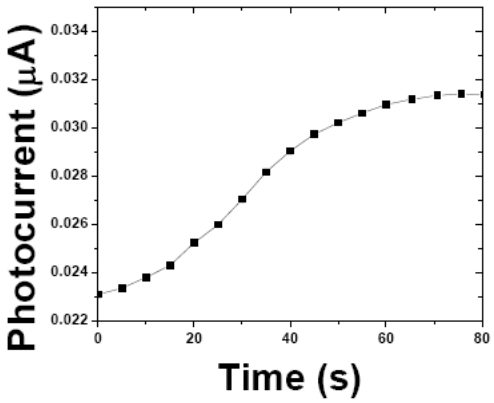


Fig.8. The growth of photocurrent with time of CdSe nanoparticles.

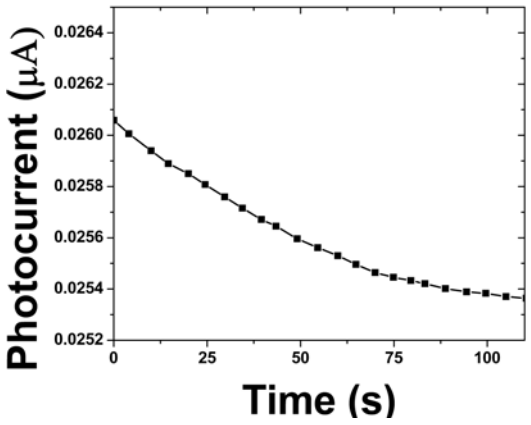


Fig.9. The decay of photocurrent with time of CdSe nanoparticles.

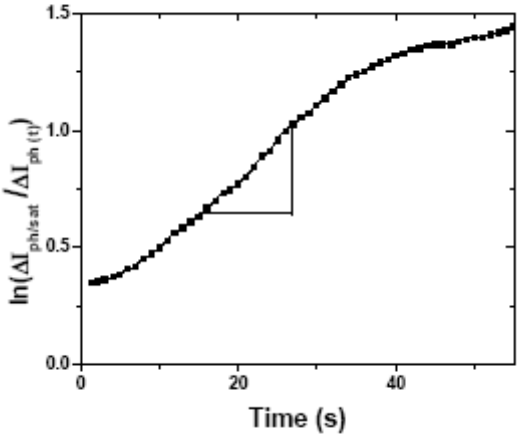


Fig.10. Determination of lifetime of carrier of CdSe nanoparticles.

4. Conclusions

The CdSe nanoparticles are synthesized by simple chemical reduction route at room temperature. The TEM image shows that the sizes of nanoparticles are in the range of 5 – 8 nm. As a result the band gap of the material is increased & it is confirmed from optical measurements. The photoconductive decay of CdS nanofilm follows exponential variation.

Acknowledgements

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