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INVESTIGATION OF OPTICAL PROPERTIES OF THE PbS/CdS THIN FILMS BY THERMAL EVAPORATION

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ABSTRACT

In this work, we have investigated optical properties of the thermally evaporation PbS/CdS thin films. The optical constant such as (refractive index n, dielectric constant $\varepsilon_{i,r}$ and Extinction coefficient κ) of the deposition films were obtained from the analysis of the experimental recorded transmittance spectral data. The optical band gap of PbS/CdS films is calculate from $(\alpha h\upsilon)^{1/2}$ vs. photon energy curve.

Keywords. Thermal evaporation; optical properties; transmission spectra; energy band gap.

I. INTRODUCTION

CdS and PbS are metal-chalcogenide compound semiconductors with adequate optoelectronic properties, which make them suitable for the fabrication of a great variety of devices such as solar cells, infrared detectors, gas-sensors, etc. These semiconductors can be obtained as polycrystalline thin films by several deposition techniques, one of the simplest being the chemical bath deposition [1]. Cadmium sulfide (CdS) is a wide gap semiconductor with bulk bandgap energy of 2.41 eV [2,3], corresponding to an optical cut-off of 515 nm, with exciton Bohr radius (r_B) of 3 nm. CdS has been used in photodetectors and for solar cell application [4]. By tuning the size of CdS nanoclusters, it is possible to engineer the bandgap from the visible region to the UV region of the spectrum. Lead sulphide (PbS) is another interesting material with an exciton Bohr radius 9 nm and a bulk bandgap of 0.41 eV [5,6], corresponding to an optical cut-off of 3020 nm [7]. PbS has been used in IR detectors. Stong quantum confinement effect in PbS nanocluster permits the tuning of the optical absorption edge from IR region to the UV-VIS region leading to remarkable changes in its optical properties across the spectrum.

II. EXPERIMENTAL PART

PbS/CdS films were prepared by thermal evaporation technique using vacuum coating unit in a vacuum about 4×10^{-5} mbar. PbS/CdS films were deposited on glass substrates placed directly above the source at a distance of nearly 16 cm. The glass substrates were cleaned with freshly prepared acetone, detergent solution and distilled water the substrates were subjected to ultrasonically cleaning prior to the evaporation of PbS/CdS. The thickness PbS/CdS of thin films were measured by using an optical interferometer method employing He-Ne laser (0.632µm) wavelength with incident angle 45° as shown schematically in Fig. (1). This method depends on the interference of the laser beam reflected from thin film surface and then substrate, the films thickness (t) was determined using the following formula [8] :

$$t = \frac{\lambda}{2} \cdot \frac{\Delta X}{X} \qquad (1)$$

where x is the fringe width, Δx is the distance between two fringes and λ is the wavelength of laser light.

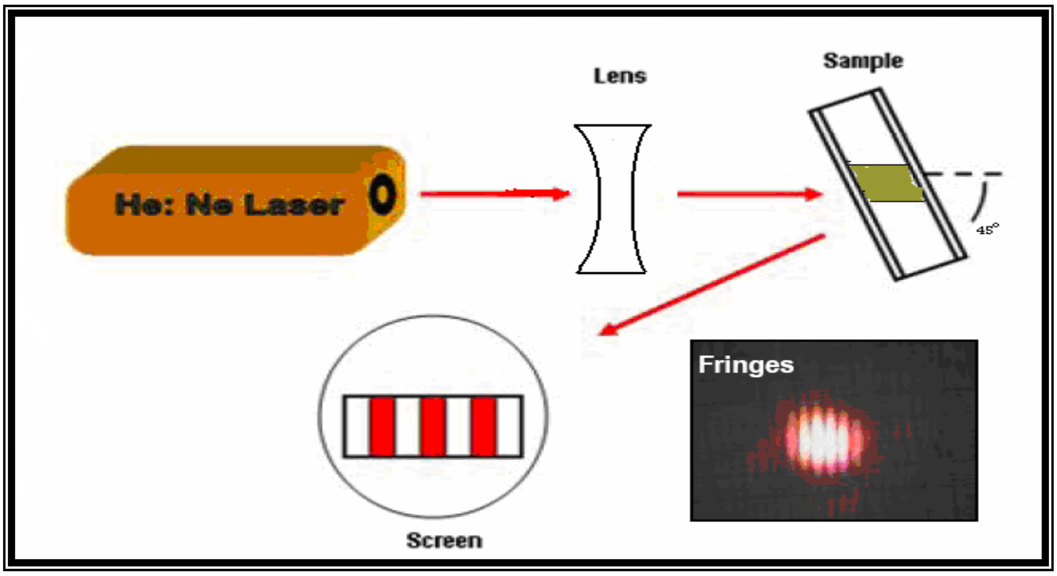

Figure (1) The schematic diagram of the film thickness measurement.

III. RESULTS AND DISCUSSION

Optical properties of PbS/CdS thin films were studied with the help of Absorption spectra in the UV–visible region. Fig.2 shows the absorption spectra of the as-deposited

PbS/CdS thin films recorded in the range 200–900 nm. The obtained thin films have high optical absorption (80%). Fig.(2) shows the Absorption vs wavelength spectra of PbS /CdS thin films of thickness 500 nm. It can be observed that the absorption increases with increase wavelength. Optical absorption continuously decreases with wavelength from near infrared through visible region due to the increase of scattering loss at the porous surface.

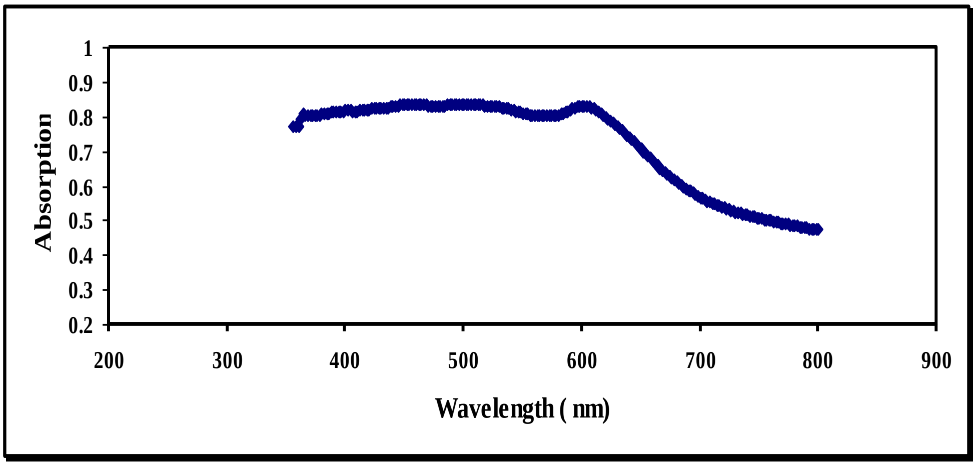

Figure (2): Absorption spectrum as a function of wavelength for PbS/CdS films

The direct optical energy gaps value (E_g^{opt}) for PbS/CdS films have been determined by using Tauc equation which is used to find the type of the optical transition. A plot of $(\alpha h\upsilon)^2$ versus hυ for PbS/CdS is shown in Fig.(3).The plot is linear indicating the direct band gap of the films. Extrapolation of the linear of the line to the hυ axis gives the band gap.

From this Fig.(3), the optical bandgap energy for PbS/CdS and CdS/PbS superlattices was obtained. The value was found to be 1.65 eV for PbS/CdS. Our value is in close agreement with a reported by Popescu et al. for PbS coated with CdS thin film.

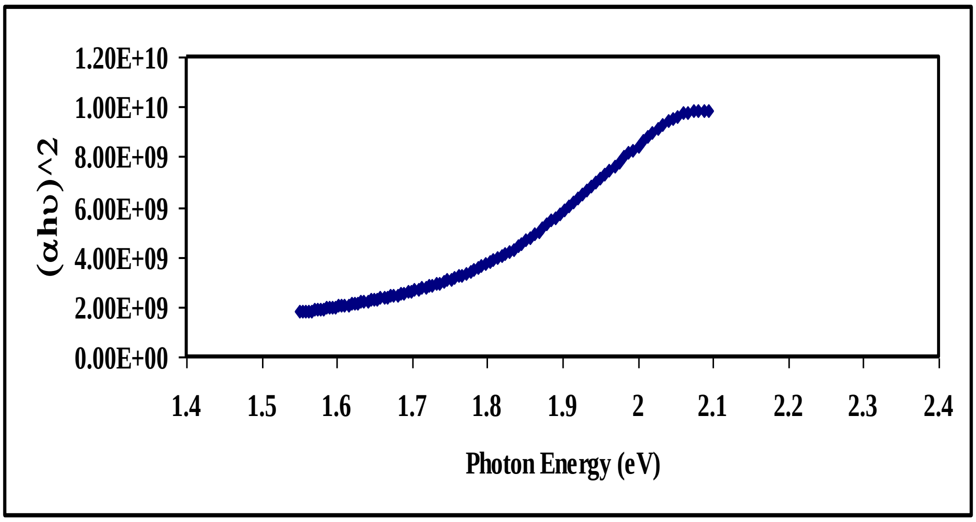

Figure (3): $(\alpha h\nu)^2$ as a function of hν for PbS/CdS films

The variation of the refractive index as a function of the wavelength for PbS/CdS thin films is shown in Fig.(4), which indicate that the refractive index increases with the increasing wavelength.

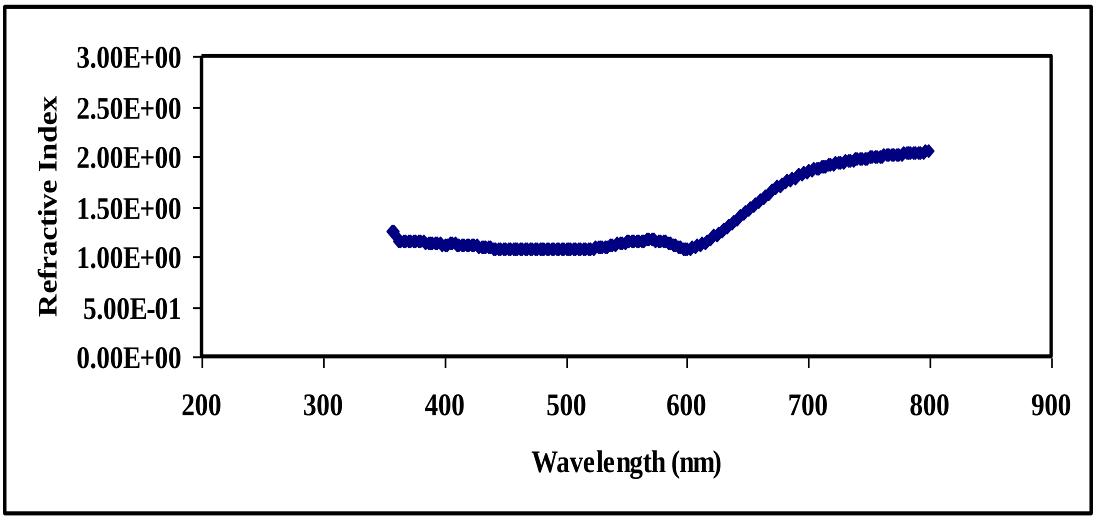

Figure (4): Variation of refractive Index as a function of wavelength for PbS/CdS films

The relation between the extinction coefficient and wavelength for PbS/CdS films deposited are shown in Fig.(5).From this figure we can see that the extinction coefficient (k) takes the similar behavior of the corresponding absorption coefficient.This is attributed to the same reason mentioned previously in the absorption coefficient. We can observe from this figure that extinction coefficient decreases with increasing of wavelength.

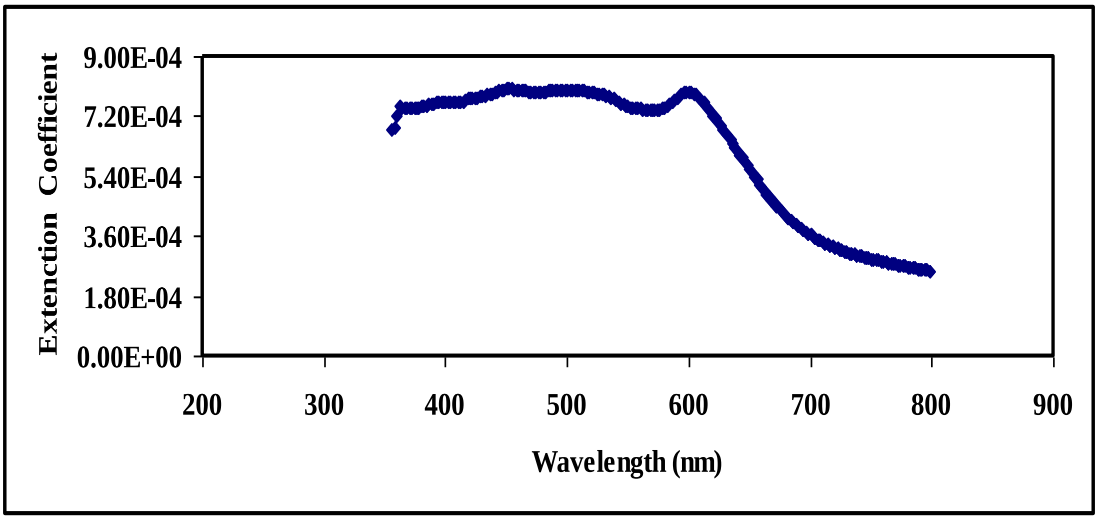

Figure (5): Variation of Extinction coefficient as a function of wavelength for PbS/CdS films

The variation of the real and imaginary parts of the dielectric constant values versus wavelength in the range(200-900) nm are shown in Fig.(6 ,7). We can conclude from Fig.(4, 5, 6) that real parts of the dielectric constant increase as the wavelength increase. Also the variation of ε_r mainly depend on the value of the refractive index. The imaginary part of the dielectric constant as shown in Fig.(7) mainly depends on the extinction coefficient values which are related to the variation of absorption coefficient

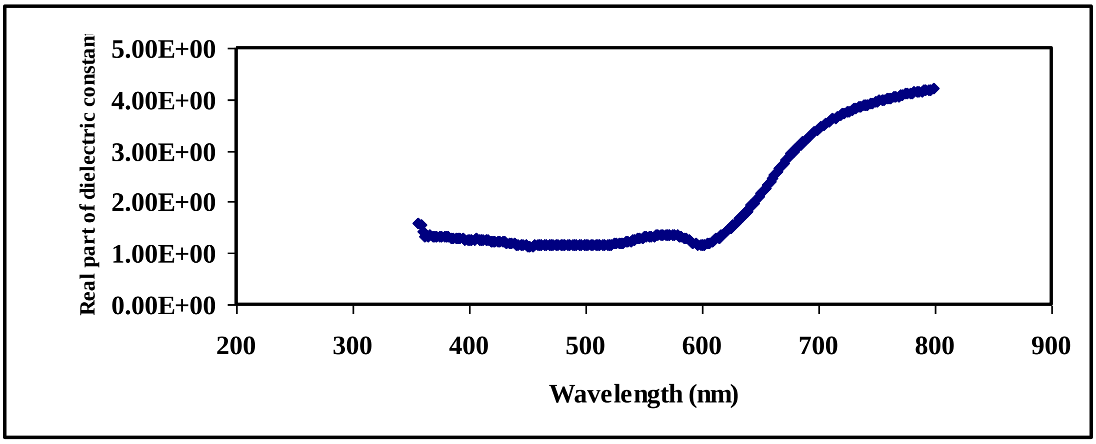

Figure (6): Variation of ε_r as a function of wavelength for PbS/CdS films

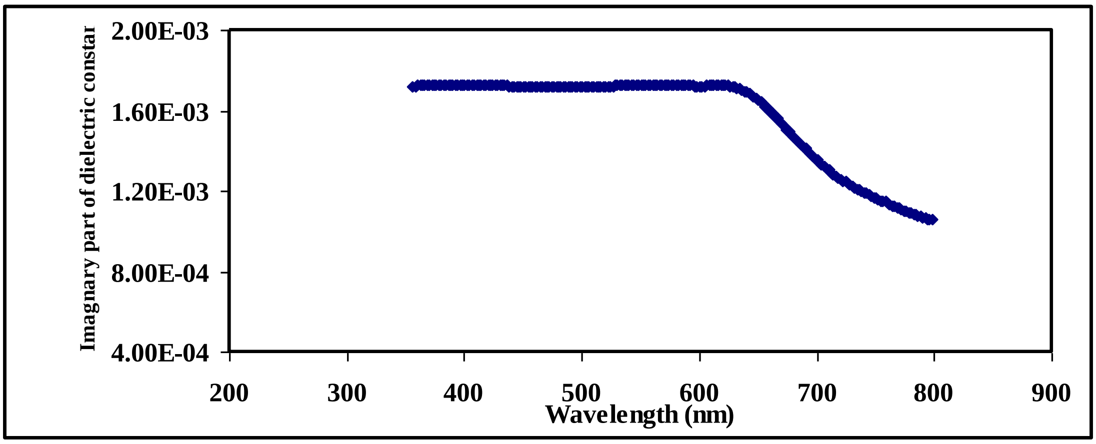

Figure (7): Variation of ε_i as a function of wavelength for PbS/CdS films.

IV. CONCLUSION

PbS/CdS thin films were prepared using thermal evaporation technique onto glass substrate under vacuum equal to $4x10^{-5}$ mbar.The thickness f the films was 500 nm. From UV-Visible transmittance, absorbance spectra , it observed that the optical transition in the PbS/CdS films to be allowed direct transition. The energy gap, extinction coefficient, refractive index and, real part of dielectric constant and imaginary part of dielectric constant at λ cut off equal to 750 nm (1.65eV,$3.94x10^{-4}$,1.98,3.95 and $1.17x10^{-3}$) respectively were obtained for this superlattice.

References

1-M.O. Ortuno-Lopez, J.J. Valenzuela-Jauregui, R.Ramirez-Bon, E. Prokhorov and J.Gonzale-Hernandez**", Impedance Spectroscopy Studies on Chemically Deposited CdS and PbS Polycrystalline Films",** Journal of Physics and Chemistry of Solid **63**, 665-668 (2002).

2- K. Suresh Babu, T. Ranjith Kumar, P. Haridoss, C. Vijayan**", Effect of the organic solvent on the formation and stabilization of CdS and PbS nanoclusters",** Talanta **66**, 160-165 (2005).

3- D.Sreekantha Reddy, B. Kang , S. Cho Yu, K. R. Gunsekhar, K. Narasimha, A. Divya, P. Sreedhara, "**Microstructure, optical and photoluminescence properties of simple thermal evaporated CdS nanocrystalline films",** Journal of Optoelectronics and Advanced Material **9**, 3747-3750 (2007).

4- D. Patidar, R. Sharma,N. Jain, T. P. SHarma and N. S. Saaxena, **"Optical properties of CdS sintered film",** Bull. Mater. Sci., **29**, 21-24 (2006).

5- M.Navaneethan, K.D.Nisha, S.Ponnusamy and C.Muthamizhchelvan, "**Optical, Structural and surface Morphological Studies of N-Methylaniline Capped Lead Sulphide Nanoparticles"**, Rev. Adv. Mater. Sci. **21**, 217-224 (2009).

6- E. Pentia, L. Pintilie, I. Matei, T. Botila, E. Ozbaya**," Chemically Prepared Nanocrystalline PbS Thin Films"**, Journal of Optoelectronics and Advanced Materials **3**, 525-530 (2001).

7- J.J. Valenzuela-J´aureguia, R. Ram´ırez-Bona, A. Mendoza-Galva´na, M. Sotelo-Lermab**,"Optical properties of PbS thin films chemically deposited at different temperatures"**, Thin Solid Films **441**, 104-110 (2003).

8- K. L. Chopra, **"Thin Film Phenomena"** McGraw-Hill, Inc., New York, (1969).