International Journal of Engineering Research & Management Technology ISSN: 2348-4039
July-2015 Volume 2, Issue-4
Email: editor@ijermt.org www.ijermt

Ellipsometric Analysis CdS_xSe_{1-x} Thin Films Prepared by a Thermal Evaporation Technique

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ABSTRACT:
CdS_xSe_{1-x} glass was prepared by melt quenching technique and the thin films were successfully deposited by thermal evaporation route. Optical constant such as the refractive index (n) & excitation coefficient (k) has been determined from transmittance spectrum in the ultraviolet–visible–near infrared (UV–VIS–NIR) regions using the envelope method in this paper, we study the variation of refractive index with composition and wavelength. X-ray diffraction showed that the prepared films are homogenous and amorphous in nature.

KEYWORDS: Melt-Quenching, Chalcogenide, Refractive Index, Transmission Spectra.

INTRODUCTION:

II-VI composite semiconducting chalcogenides, especially Sulfides and Selenides have been investigated extensively, owing to their interesting opto-electronic properties. CdS_xSe_{1-x}(x = 0, 4, 6, 8,) having specific physical properties such as direct band gap widths, high absorption coefficients in the visible and infrared part of the solar spectrum, good electrical properties (e.g carrier mobility and lifetime) and increased capability in obtaining adjustable n or p-type conductivity by doping [1]. Semiconductor compounds of the II-VI group have drawn considerable interest due to their potential applications in photovoltaic devices, photo resistors, hetrojunction diodes, electroluminescent layers and surface acoustic wave devices. Chalcogenides, especially of cadmium (Cd), Lead (Pb), Zinc (Zn) have proved their potential as efficient absorbers of electromagnetic radiation [2-4]. Cadmium chalcogenides form a technically important class of materials owing to their widespread utility in a variety of electronic and optoelectronic devices [5].The optical properties of chalcogenide thin films such as optical band gap, absorption coefficient, refractive index, extinction coefficient, and dielectric constant provides knowledge about the suitability of the material for designing and fabrication of optoelectronic devices[6].CdSe thin films are well known for their extensive applications as an optoelectronic material in solar cells and photo detectors. They are also used in the fabrication of optical filters, multilayer LED'S, photodiodes, phototransistors etc. Cadmium selenide, with a band gap of 2.03eV, is an ideal material for use as the window layer of hetrojunction solar cells. The II-VI binary semiconducting compounds, belonging to the cadmium chalcogenide family (CdS, CdTe, CdSe), are considered to be very important materials for a wide spectrum of optoelectronic applications as having specific physical properties such as direct band-gap width, high absorption coefficients in the visible and infrared part of the solar spectrum, good electrical properties (e.g. carrier mobility and lifetime) and increased capability in obtaining adjustable n- or p-type conductivity by doping. When S content increases in the CdS_xSe_{1-x} composition, which leads to increase the capacitance and as a result the depletion region width decreases, this means the carrier of CdS_xSe_{1-x} films have more diffusion when the Se content decreases [7].

The width of the depletion layer (W) has a large value when the S content decreases to zero. Particularly, the visible and near infrared, direct band-gaps of CdSe (1.75 eV and CdS (2.44 eV) respectively, make them candidates for the conversion of low energy light into electricity. Moreover, homogeneous alloys formed over the entire composition range by combination of these compounds allow the production of very interesting ternary CdS_xSe_{1-x} ($0 < X < 1$) systems [8]. In the decade Se-based metal containing chalcogenide glassy alloys became attractive materials for investigations in optoelectronics and photonics [9-10]. The ternary compound CdS_xSe_{1-x} is a highly photosensitive material, so it is used in many practical application such as discrete and multi element photo resistors, in optical filters, signal memory devices, laser screens, LSI circuits, Infrared imaging devices, Optoelectronic switches, linear image sensor for digital facsimile page scanners, Electro photography, Image intensifiers and exposure meters.

EXPERIMENTAL:

Glassy alloys of CdS_xSe_{1-x}(X= 0, 4, 6, 8,) are prepared by melt quenching technique. The exact proportions of high purity (99.999%), Cd, S and Se elements, in accordance with their atomic percentages, are weighed using an electronic balance (Labor) with the least count of 10^{-4}gm. The material was then sealed in evacuated (~10^{-5} Torr) quartz ampoule (length~5cm, outer diameter ~10 mm and internal diameter ~8 mm). The ampoule containing material is heated to 950^{0C} and was held at that temperature for 24 hours. The temperature of the furnace was raised slowly at a rate of $3\text{-}4^{0C}$/ minute. During heating, the ampoules are constantly rocked, by rotating a ceramic rod to which the ampoule was tucked away in the furnace. This is done to obtain homogeneous glassy alloys, after rocking for about 24 hours. The obtained melt was rapidly quenched in liquid nitrogen to avoid crystallization. The chalcogenide thin films used in the present study of the system were deposited by thermal evaporation technique on to glass substrates at the base pressure of ~2×10^{-6}mbar using a high vacuum coating unit (HIND HIGH VACCUM 12A4D).Before the deposition process to carry, the substrates were carefully cleaned. Commercially available glass slides are dipped in chromic acid for three hours, then washed with liquid detergent and finally ultrasonically cleaned with acetone. Thin films of glassy alloys of CdS_xSe_{1-x} are prepared by vacuum evaporation technique, in which the substrate is kept at room temperature at a base pressure of 10^{-6} Torr using a molybdenum boat. To attain thermodynamic equilibrium the films were kept inside the deposition chamber for 24h as suggested by Abkowitz [11]**.** The glassy nature of the alloy was ascertained by X-ray diffraction. UV/VIS/NIR Computer Controlled Spectrophotometer (ShimadzuU-3600) is used for measuring optical transmission of CdS_xSe_{1-x} thin films as a function of wavelength of the incident light.

RESULT & DISCUSSION:

OPTICAL CHARACTERIZATION:

Transmission Spectra of CdS_xSe_{1-x} thin films were taken in the 800 - 2800 nm spectral range with the help of UV/VIS/NIR Spectrophotometer (ShimadzuU-3600). The optical system under consideration CdSSe is amorphous, homogeneous and uniform. Optical transmission (T) is a very complex function and is strongly dependent on the absorption coefficient (α). According to Swanepoel method [12], which is based on Manifacier [13], the envelope of the interference maxima and minima, occurs in the spectrum, can be utilized for obtaining optical parameters. The presence of maxima and minima of transmission spectrum of the same wavelength position confirmed the optical homogeneity of the deposited film and that no scattering or absorption occurs at long wavelength.

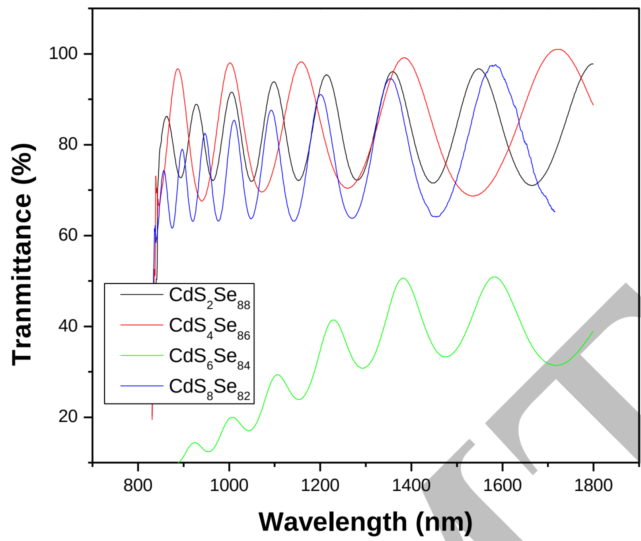

Fig.1 Transmission spectra of CdS_xSe_{1-x}(X= 0, 4, 6, 8,) thin films.

DETERMINATION OF OPTICAL CONSTANTS (N & K):

For the method proposed by Swanepoel, the optical constants are deduced from the fringe patterns in the transmittance spectrum. Generally, since α is related to the extinction coefficient k, which is defined as the imaginary part of the complex refractive index, where n is the real part of refractive index, an accurate determination of n and k is possible. But this often becomes difficult due to the presence of multiple solutions. It is necessary to have a rough idea about the thickness t and refractive index n to start with, and by a judicious adjustment of the magnitude of thickness it is possible to secure a continuous solution of n and k throughout the whole spectral range.

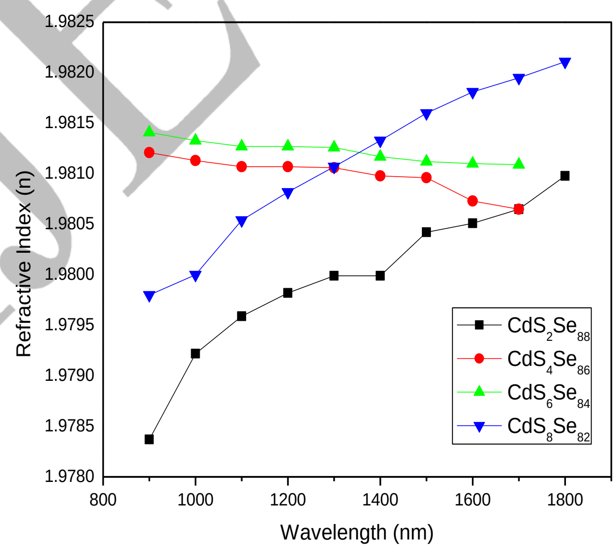

Fig.2 Variation of Refractive Index (n) vs Wavelength.

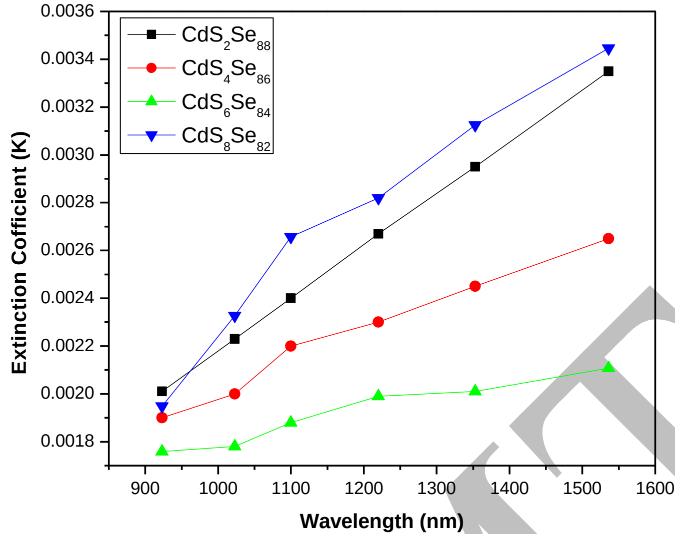

Fig.3 Variation of Extinction Coefficient (k) vs Wavelength.

In the transmittance region where the absorption coefficient ($\alpha = 0$), the refractive index n is given by

$$n = [N + (N^2 - s^2)^{1/2}]^{1/2} \qquad (1)$$

Where $N = (2s/ T_m) + (s^2 + 1)/2$

T_m is the envelope function of the transmittance minima and s is the refractive index of the substrate. In the region of weak and medium absorption, where ($\alpha \neq 0$), the transmittance decreases mainly due to the effect of α and the refractive index n is given by

$$n = [N + (N^2 - s^2)^{1/2}]^{1/2} \qquad (2)$$

Where $N = [2s(T_M - T_m) / T_M . T_m] + (s^2 + 1)/2$ and T_M is the envelope function of the transmittance maximum.

The extinction coefficient k can be calculated from the relation

$$k = \alpha\lambda / (4\pi)$$

$$= (\lambda / 4\pi d) \ln (1/x) \qquad (3)$$

Where x is the absorbance and d is the film thickness.

If n_1 & n_2 are the refractive indices at two adjacent maxima or minima at λ_1 & λ_2 then the thickness t is given by,

$$d = \lambda_1\lambda_2 / 2[\lambda_1 n_2 - \lambda_2 n_1] \qquad (4)$$

DETERMINATION OF DIELECTRIC CONSTANTS:

The real & imaginary dielectric constant of amorphous thin films has been calculated by the relation (5) & (6), respectively.

$$\varepsilon' = n^2 - k^2 \qquad (5)$$

$$\varepsilon'' = 2nk \qquad (6)$$

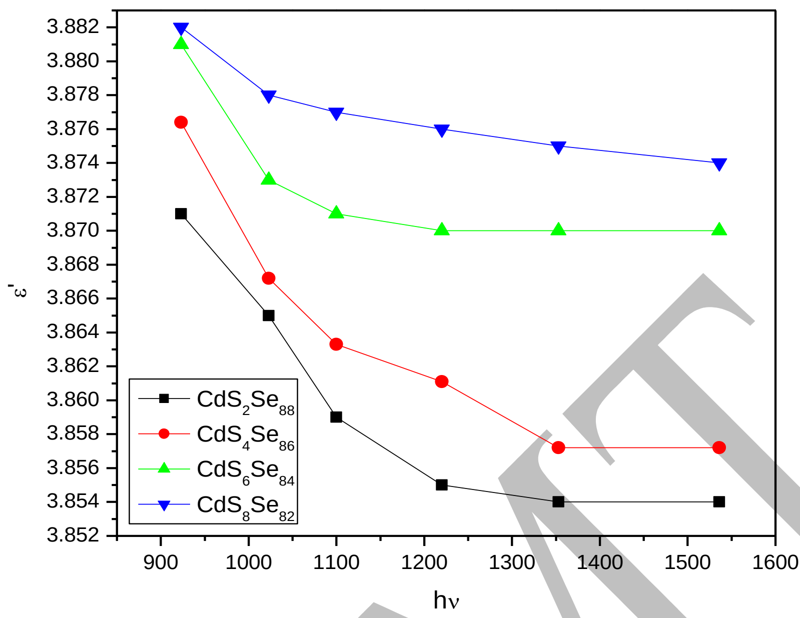

Fig.4 Variation of Real dielectric Constant (ε') with photon Energy (hν).

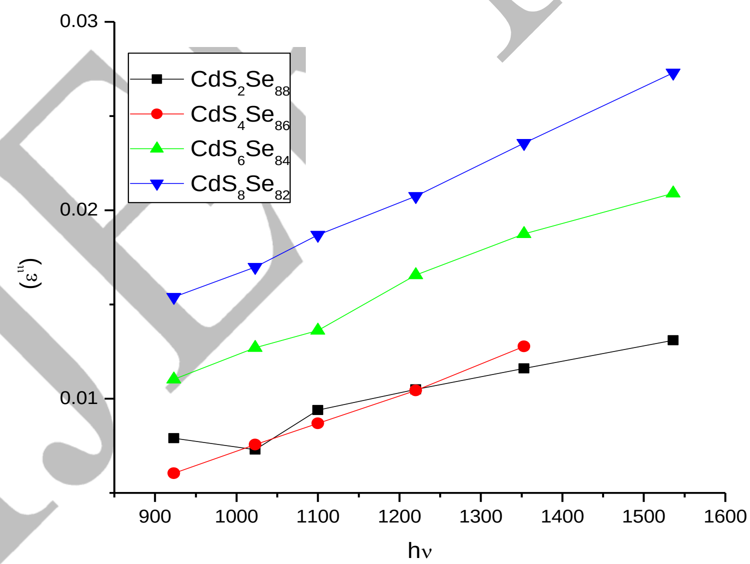

Fig.5 Variation of Real dielectric Constant (ε") with photon Energy (hν).

STRUCTURAL CHARACTERIZATION:

X-ray diffraction patterns of as prepared thin films were taken by using Philips Model PW 1710.The copper target was used as a source of X-ray with λ =1.5406A^0 (Cukα_1) with Scanning angle 10-100^0.A Scan speed of 2^0/min and a chart speed of 1cm/min were maintained. Absence of sharp structural peaks in as-prepared films confirms the amorphous nature of the material.

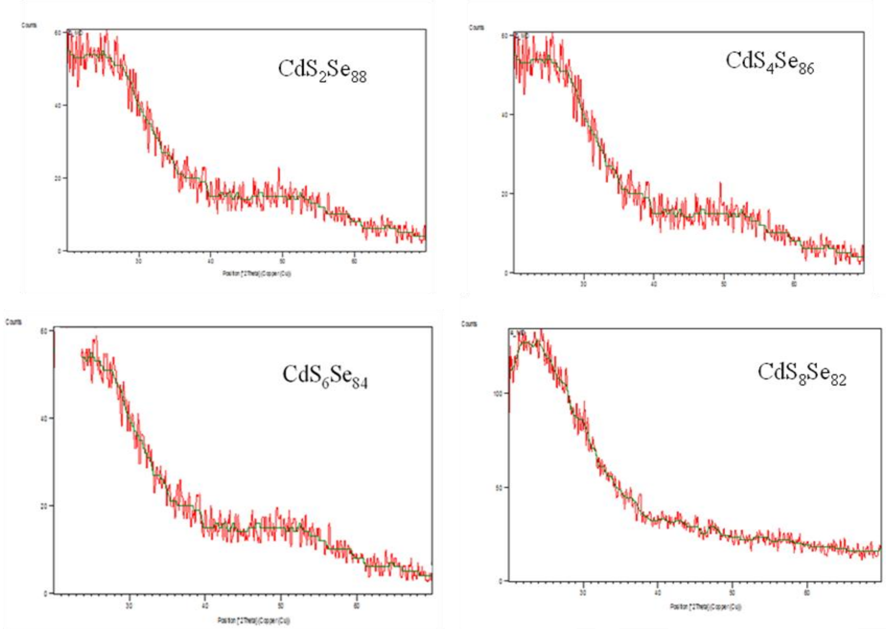

Figure. 6 X-ray diffractograms of CdS_xSe_{1-x} films at different Compositions.

CONCLUSION:

An ellipsometric Study along with Optical and Structural of CdS_xSe_{1-x} thin films prepared by the resistive thermal evaporation technique were investigated. The ellipsometric analysis reveals that the optical constants decrease with the Increase of S content in the alloy by using transmission analysis. XRD results show that all the films of the CdS_xSe_{1-x} system are amorphous nature the entire composition range. From the above arguments, the developed CdSSe prepared materials have the promise for use in photonics device fabrication and solar cell applications.

ACKNOWLEDGEMENT:

The authors are thankful to Instruments Research and Development Establishment (IRDE), DRDO, Raipur Road, Dehradun for providing the financial assistant for carry out the researcher work in the Material Science Research Laboratory, Department of Physics, Gurukula Kangri Vishwavidyalaya, Haridwar (India).

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