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STUDY OF WAVELENGTH DEPENDENCE OF OPTICAL CONSTANTS FOR ZNSE VACUUM EVAPORATED THIN FILMS

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Abstract-* *Vacuum evaporated crystalline films of Zinc Selenide (ZnSe) have been characterized by using optical spectroscopy (especially transmission and absorption spectra). Thin films of ZnSe have been deposited by vacuum evaporation technique on highly clean glass substrates and their optical properties such as refractive index (n), extinction coefficient (k), and energy band gap have been studied. The transmission spectra in the spectral range 300-2000 nm has been used to calculate the refractive index (n), extinction coefficient (k), and wavelength (λ) dependence of n and k of the films have been studied. Optical spectroscopy of the films has been done with the help of the Shimadzu-3600 (UV-Vis-NIR) Spectrophotometer.

Keywords: *Vacuum evaporated crystalline films, ZnSe, optical constants.*

INTRODUCTION

Interest in the physical properties of amorphous chalcogenide glasses and other noncrystalline materials, especially their potential applications in areas of optoelectronics such as laser technology and fiber optics, has gained attention since the 1950's and has coalesced within a field known academically as "Physics of Non crystalline Solids". However, in contrast to crystalline solids, for which the physical properties and structures are essentially understood, their remain considerable theoretical difficulties with amorphous solids, and these have been amplified by a lack of precise, organized experimental information. Chalcogenide glasses are truly emerged as multipurpose materials and have been used to fabricate technological devices such as IR detector, electronic and optical switches and optical recording media. The growth of the group of II–VI compound semiconductors has attracted considerable attention due to their novel physical properties and wide range of applications in optoelectronic devices. II–VI compound semiconductors such as sulphide (S), Selenide (Se) and Telluride (Te) of Cadmium (Cd), Zinc (Zn), Mercury (Hg) are of interest as high-refractive-index materials in multilayer optical coatings since they all have low absorption over a broad wavelength range. They are now widely used for the preparation of semi conductive elements. The II–VI group compounds semiconductor films have not only figured prominently for many years in a wide variety of commercial electronic applications, but they also have played an important role in the development of semiconductor device physics. Among these materials, Zinc selenide (ZnSe) is well known as a high refractive index material in multilayer film combinations and as an infrared antireflection coating for solar cells, due to its wide band gap. Zinc selenide material with a direct band gap of 2.7 eV at room temperature, has potential application in light emitting diodes [1] and photoluminescence [2]. In photo-electronic and other properties of the II–VI class of compounds, thin films are highly structure sensitive which in turn can severely influence the device performance.

ZnSe thin films have attracted considerable interest over the years owing to their wide range of applications in various optoelectronic devices and in solar cells. ZnSe has a direct band gap of 2.7 eV and is transparent over a wide range of the visible spectrum and has long been found as promising material for optoelectronic devices such as LED, thin film transistor, blue laser diode etc [3-5]. Because of its large band gap, ZnSe has been used as window layer for the fabrication of photovoltaic solar cells. It is also used as window material in high efficiency solar cells, because its large band gap permits a large number of photons to reach the absorber layer [6]. The fabrication of general electronics and optoelectronics devices requires both n and p type materials, ZnSe has been found in both n and p type conduction [7]. ZnSe is the first choice for high power laser windows. There are a number of reports on the different structural, optical and electrical properties of ZnSe polycrystalline thin films prepared by various techniques such as chemical vapour deposition, MOCVD, Electro deposition, Photochemical deposition, chemical bath deposition(CBD), pulsed laser deposition and thermal evaporation [8-16]. It is seen that different parameters of a film are structural dependent which is also depends on the method of preparation, its thickness and other factors. The thermal evaporation method is cost effective and suitable for large area deposition. For deposition of ZnSe thin films several techniques have been reviewed: Electro deposition [17], photochemical deposition [18], Vacuum evaporation [19], and Pulsed laser deposition [20].

EXPERIMENTAL PROCEDURE

Thin films of ZnSe will be prepared by vacuum evaporation technique. Well degassed corning glass plates, having predeposited aluminium/silver/copper electrode for electrical contact, will be used as a substrate for depositing amorphous/crystalline films in the planer geometry and different electrode gap. For deposition of film, highly polished and thoroughly cleaned substrates are required. First the substrates are cleaned using liquid detergent. Then it is kept in dilute nitric acid. After this, they are cleaned using distilled water and agitated ultrasonically in acetone. Subsequently the substrates are subjected to ionic bombardment for five minutes as a final cleaning before deposition. The ions are produced by high tension (HT) discharge. The films are deposited onto clean substrates. We have used molybdenum boats as the vapour sources. The evaporant materials in the powder form is kept in the boat. The low tension (LT) supply for evaporation source is obtained from a 230V input transformer by means of parallel connections in the secondary side of the transformer. Films will be prepared at a base pressure of 10^{-5} Torr by keeping the substrate at room temperature. Thickness of thin films measure by using the single crystal thickness monitor. Optical measurements can also be measure in thin film by spectrophotometer.

OPTICAL CHARACTERIZATION

The optical constants (especially refractive index and extinction coefficient) of these films have been determined from transmission spectroscopy by using Manifcier's envelope method. The transmission spectra for ZnSe have been shown in Fig. 1 within the wavelength range 300-2000 nm. The refractive index of thin film material at a particular wavelength is calculated using Manifcier's envelope method

Transmission spectra of vacuum evaporated ZnSe films were recorded at room temperature with the help of Spectrophotometer (Shimadzu-3600) in the wavelength range 300-2000nm. The optical constant like refractive index of vacuum evaporated thin films of Zinc Selenide has been determined in the range 300-2000 nm. The refractive index (n) has been determined from transmission spectra by using the formula.

$$n = [N + (N^2 + n_0^2\, n_1^2)^{1/2}]^{1/2} \quad \ldots..(1)$$

Where n_0 and n_1 are the refractive index of air and substrate, respectively. The number N is given by the following equation

$$N = [(n_0^2 + n_1^2)/2] + 2n_0n_1\, [(T_{max} - T_{min})/ (T_{max} + T_{min})] \quad \ldots..(2)$$

Where T_{max} and T_{min} are the upper extreme point and lower extreme point at a particular wavelength, respectively.

The extinction coefficient (k) is given by an expression:

$$K = (-\lambda/4\pi t)\ \ln P \quad \ldots\ldots(3)$$

Where t is the thickness of the film and P is given by the following equation:

$$P = C_1/C_2\, [1-(T_{max}/ T_{min})] / [1 + (T_{max} / T_{min})] \quad \ldots\ldots(4)$$

Where, $C_1 = (n + n_0)\ (n + n_1)$

And $C_2 = (n - n_0)\ (n_1 - n)$

Where n is the refractive index of the films at a particular wavelength, n_1 the refractive index of the substrates and n_0 is the refractive index of the air as given earlier. It is observed that the refractive index decreases, as the wavelength increased. However, the extinction coefficient increases with the increase of wavelength.

As the wavelength increases the transmission coefficient, extinction coefficient increases and refractive index decreases, it may possible that as the wavelength increases (lowering the photon energy), the photon energy is not sufficient for ZnSe atom, due to this reason the maximum no. of photons are transmitted through the band gap of ZnSe thin film and a fewer no. of photons are interacted with the ZnSe atom due to this, the refractive index decreases and extinction coefficient increase with wavelength.

The optical absorption and transmission measurements will be performed on sample in the range 300-2000 nm. For determination of optical band gap E_g, the Tauc's plot method will be used. The spectral dependence of the absorption coefficient has the form $\alpha h\nu = B\ (h\nu - E_g)^{n/2}$ where $h\nu$ is the photon energy, e_g is the optical band gap and n is a parameter depending on both the type of transition (direct or indirect) and the profile of the electron density in the valance and conduction band.

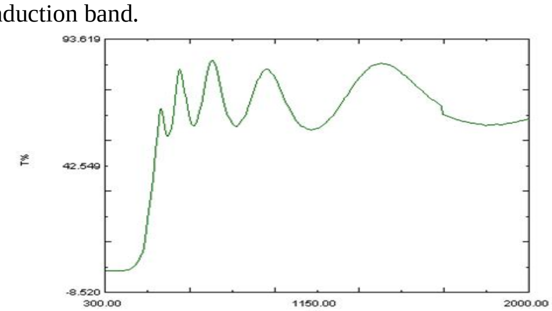

Fig 1. Tranmission spectra of ZnSe vacuum evaporated thin films

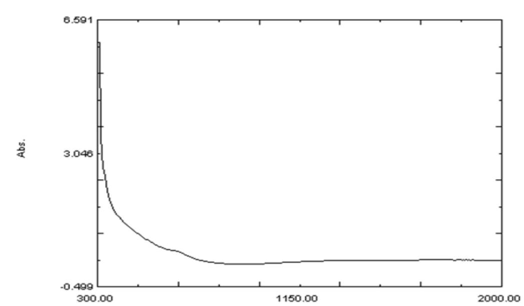

Fig 2. Absorbance spectra of ZnSe vacuum evaporated thin film

RESULTS AND DISCUSSION

The values of T_{max} and T_{min} were determined at different wavelengths and then values of N and n were calculated by substituting T_{max} and T_{min} in a standard equation. The data so obtained is given in Table: 1

S.N.	λ (nm)	T_{max} (%)	T_{min}	N	n	k
1.	655	86.400	56.000	3.518	2.599	.0002897
2.	730	85.107	58.463	3.278	2.487	.0003229
3.	830	83.342	58.331	3.218	2.461	.0003671
4.	950	81.576	57.702	3.196	2.451	.0004202

Table: 1

λ = wavelength, T_{max} = Upper extreme point,
T_{min} = lower extreme point , k =extinction coefficient.
N= Number, n = Refractive index,

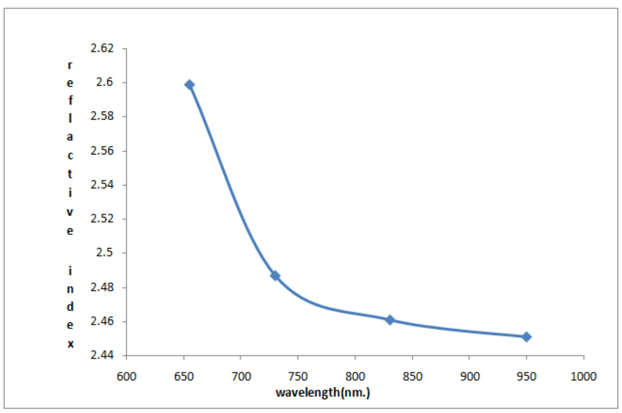

Fig 3. Curve between refractive index and wavelength

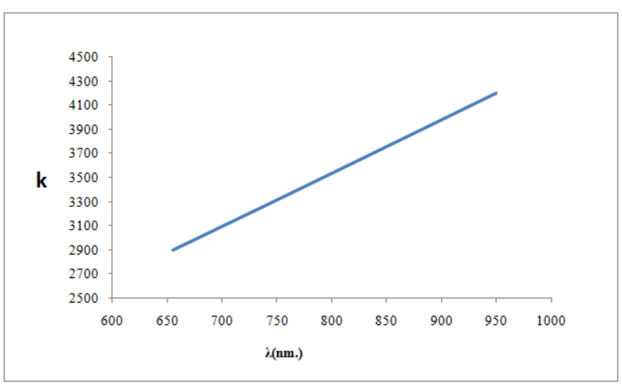

Fig 4. Curve between Extinction coefficient and wavelength

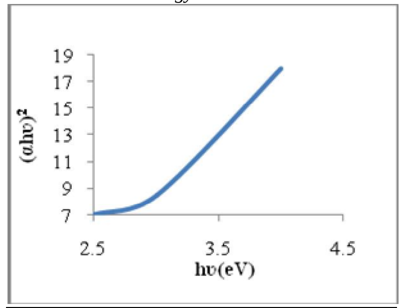

Fig 5. Variation of $(\alpha h\nu)^2$ with hν (eV) of vacuum Evaporated ZnSe thin film

CONCLUSION

The ZnSe films prepared on glass substrates by using vacuum evaporation method. The ZnSe film has direct band gap of 2.7 eV and found to be in good agreement with 2.68 eV which makes it a good material for optoelectronic applications. From the above discussion, it can be concluded that the refractive index (n) of ZnSe thin film decreases with the increase in wavelength and extinction coefficient (k) increases with the wavelength.

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