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STUDY OF TEMPERATURE DEPENDENCE OPTICAL PROPERTIES OF (Cd-Zn)S THIN FILM

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ABSTRACT:

The present paper reported the temperature dependence optical properties of the ternary (Cd-Zn)S thin films deposited on the glass substrate by using chemical bath deposition (CBD) method. For the deposition of (Cd-Zn)S thin film used high purity cadmium sulphate ($CdSO_4$) for Cd^{2+} ion, thiourea $(NH_2)_2SC$ for S^{2-} ion, Zinc Acetate $ZN(CH_3COO)_2$ is source of Zn^{2+} ion, Ammonia can be used for maintaining pH value, TEA used as complexing agent. The outcomes of UV-Visible absorption spectra, Tauc's plot and band gap are reported for prepared sample.

Keywords: ***(Cd-Zn)S thin film, Tauc's plot, Absorption spectra, Complexing agent, Temperature dependence***

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I. INTRODUCTION

The Thin Film technology is the ubiquitous and new emerging technology in the field of Nano technology. The tremendous collection of new techniques requires material that fulfills their requirement. In the past few decades the nanotechnology and nanomaterial science make significant impact on the daily life routine. Recently there has been a substantial interest in the synthesis, characterization and an application of semiconducting nanoparticles. When the sizes of the semiconducting nanoparticle reduce to nanosize range its electronic and optical property changes drastically due the quantum size effect and large surface area. The conductivity and optical properties of semiconducting particles can be altered.

Thin films of (Cd-Zn) S are interesting because their properties lie between those of ZnS and CdS (1,2,3,4,5). It is considered a relatively useful transparent metal sulfide, for use as a window in photovoltaic cells. It has a lower absorbance in the UV with band gaps typically in excess of ~ 2.4eV (1, 5,6,7,8). The Chemical Formula of ternary compound, Cadmium Zinc Sulfide is (Cd-Zn)S, it belongs to II-VI group compound. (Cd-Zn)S thin films have been widely used as a wide band-gap window material in hetero junction solar cells and in photoconductive devices. In solar cell systems, where CdS films have been demonstrated to be effective, the replacement of CdS with the higher band gap ternary compound (Cd-Zn)S has led to a decrease in window absorption losses, and has resulted in an increase in the (Cd-Zn)S has an excellence optical, electronic and morphological property that made it importance key component in the area of nano technology and thin film based technology. (Cd-Zn)S received much attention due to its direct band gap around 2.27 eV resulting in the visible region. It has widely application in many fields such as lasers, buffer layer in solar cell thin film heterojunction biological application, non linear optical device and display devices due to their high absorption coefficient.

The CBD method can be defined as the controlled precipitation followed by the condensation of the solution on the substrate, the parameters like temperature; concentration of solution, pH value, Thickness can be easily maintained and controlled in this method. The film deposited by this method is adherent, smooth, opaque and homogeneous. In our study the (Cd-Zn)S thin film strongly depend on the deposition condition and varying of various optical property .

II. EXPERIMENTAL STUDIES

2.1 Film Preparation:-

For the deposition of (Cd-Zn)S thin film on Soda lime glass substrate (Scientific Plaza Company) (75mm X 25mm) were to be cleaned before use, The Stock solution of high purity cadmium sulphate, ($CdSO_4$), thiourea $(NH_2)_2SC$, Zinc Acetate $Zn(CH_3COO)_2$ & Ammonia in aqueous medium were prepared using distilled water, ($CdSO_4$) is the source of cadmium ions and$(NH_2)_2SC$ is source of sulfur ions. TEA used as complexing agent, The solution of 0.1M $CdSO_4$ prepared by taking 2.66 gram of powder cadmium sulphate in 100 ml distilled water, 1M $(NH_2)_2SC$ solution by taking 7.6 gram and 0.1 M $Zn(CH_3COO)_2$by taking 1.83 gram. The films were prepared with two different temperatures 70^0 C and 80^0 C in 1 hour in the water bath.

2.2 Reaction Mechanism :-

Hydrolysis of Ammonia :-

$$NH^{4+} + OH^- \rightarrow NH_3 + H_2O$$

Formation of Complex :-

$$Cd^{2+} + 4NH_3 \rightarrow [Cd(NH3)_4]^{2+}$$

Formation of Sulphide ion :-

$$SC(NH_2)_2 + 2OH^- \rightarrow S^{2-} + CH_2N_2 + 2H_2O$$

Formation of CdS Film :-

$[Cd(NH_3)_4]^{2+} + S^{2-} \rightarrow CdS + 4NH_3$

$Zn^{2+} + 4NH_3 \rightarrow [Zn(NH_3)_4]^{2+}$

Formation of ZnS Film :-

$[Zn(NH_3)_4]^{2+} + S^{2-} \rightarrow ZnS + 4NH$

$[Cd(NH3)4^{2+}] + [Zn(NH3)4^{2+}] + S^{2-} + NH3 \rightarrow CdZnS$

2.3 Instrumentation:-

UV-Visible Absorption spectra measured in shimadzu spectrophotometer UV-1800. The characterization was done in National Institute of Technology (NIT) Raipur Chhattisgarh.

RESULTS & DISCUSSION :-

3.1 Thickness Measurement:-

We use following formula in order to calculate thickness of deposited thin film:-

$$t = m / A\rho$$

Where t is the thickness of film, m- is the mass of deposited material, A is the area of deposition, ρ is the standard value of density of material. The thickness was found **1.17** µm for undoped sample in both the temperature. (**Khare et al. 2006 reported thickness as 1-2 µm**)

3.2 Absorption Spectra:-

The absorption spectra were recorded under 200nm to 800nm and represented in fig 3.1. The peaks fall in the visible region and absorption edge was shifted toward the lower wavelength side when temperature was 80^0C hence it is clear that the blue shift comes into picture.

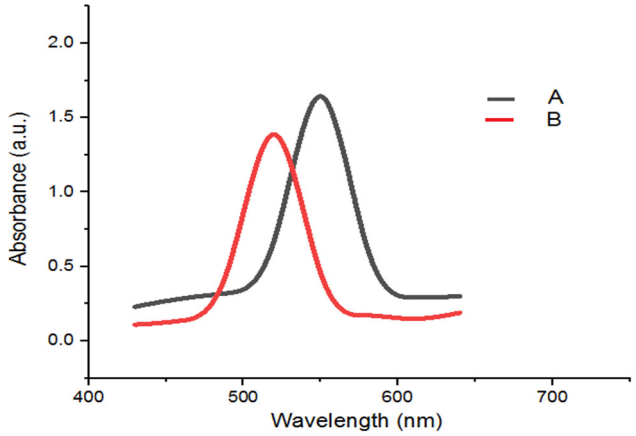

Figure – 3.1 Absorption Edge Spectra of prepared (A) (Cd-Zn)S(70^0 C) (B) (Cd-Zn)S(80^0 C)

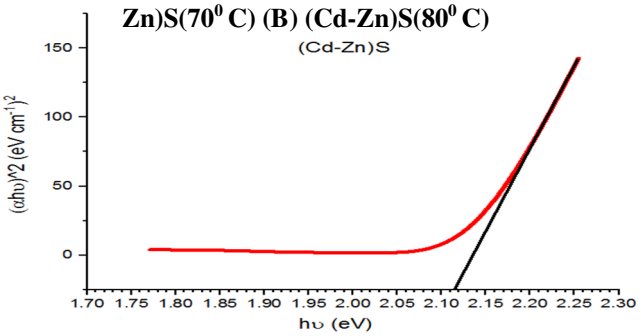

Figure – 3.2 (A) Tauc Plot of (Cd-Zn)S(70^0 C)

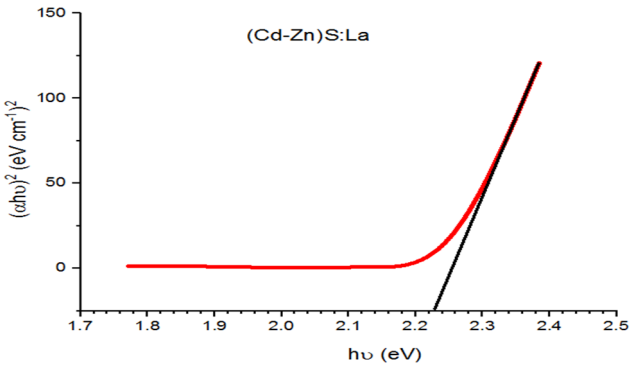

Figure – 3.2 (B) Tauc Plot of (Cd-Zn)S(80^0 C)

S.NO.	Sample Name	Absorption edge (nm)	Band gap (eV)
1	(Cd-Zn)S:70^0 C	550 nm	2.12
2	(Cd-Zn)S:80^0 C	520 nm	2.26

Table 3.1- Absorption Edge and Band gap data of prepared thin film

The optical absorption spectra of undoped (Cd-Zn)S films are presented in fig.3.1.The absorption edge found at 550nm for undoped (Cd-Zn)S thin film on70^0 C and 80^0 C the absorption shifted to the (520nm) lower wavelength side that means blue shift observation found. This shift is because of the expansion in the band gap. The expansion of the band gap with the adjustment in the bearer fixation can be clarified by the M-B impact (Moss-Burstein impact). The Moss-Burstein effect comes due to the Pauli Exclusion Principle and mostly observed in semiconductors materials. Increasing band-gap reflects information the separation in energy between the top of the valence band and the unoccupied energy states in the conduction band. The shift observed when the Fermi energy (E_F) lies in the conduction band for heavy n-type doping (or in the valence band for p-type doping). The filled states therefore block thermal or optical excitation. Consequently the measured band gap determined from the onset of interband absorption moves to higher energy. In the consequence of increased band gap values observed in doped films might also be due to the decreased crystallite size value. Shift toward shorter wavelength side in absorption edge not only shows reduce particle size but also because of the individual containments of the electron and holes.

For determination of the band gap and nature of materials prepared, plots a curve between $(\alpha h\nu)^2$ and hν. This plot is known as tauc's plot. The following equation

$$\alpha = c(h\nu - E_g)^{1/2}/h\nu \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where α is the absorption coefficient, E_g is the direct band gap. The extrapolation of the linear portion of the graph to the energy axis at α=0 gives the band gap energy E_g. The energy band gap value presented in table 3.1.Fig 3.2 (A&B) presented the tauc's plot of (Cd-Zn)S films.

Fig. 3.2 depicts the variation of $(\alpha h\nu)^2$ versus hν for the (Cd-Zn)S films. The optical band gap of the (Cd-Zn)S thin film was found to be 2.12 eV for 70^0 C and 80^0 C it become 2.26 eV. Thus, the optical band gaps of the thin films are found to increase with increase in temperature. This reflect the size quantization found in the (Cd-Zn)S films which also influence the other optical properties.

Conclusion:-

The (Cd-Zn)S undoped thin films can be successfully formed on soda lime glass Substrates by chemical bath deposition technique in 70^0C and 80^0C. The films were characterized by, UV–VIS-NIR spectroscopy.

- By Gravimetric method he thickness of the material calculated by the Thermo gravimetory Method and obtained 1.17μm.
- As part of Optical study, the Absorption edge founded in the visible region as 550

nm and 520 nm for Undoped films with two different temperature. The band gap of the material increases from 2.12 eV to 2.26 eV for (Cd-Zn)S films

The quantum confinement comes into the picture when the temperature to be raised. The Other properties of the prepared material will be definitely changed.

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