Optical Characterization of CB Deposited CdZnS Thin Films

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***Abstract*—$Cd_{1-x}Zn_xS$ thin films were deposited by Chemical Bath Deposition (CBD) in aqueous medium onto bare silicon glass substrates, The synthesized thin films were characterized by UV-Visible spectrophotometer for optical studies. The energy band gap of $Cd_{1-x}Zn_xS$ thin films deposited for different reagent concentration in the bath solution was determined from UV-VIS absorption data. The band gap energy and optical transmissions were studied under optimum parametric conditions. The band gap was increased with Zn content from 2.7 to 3.9 eV.**

Keywords-$Cd_xZn_{1-x}S$; band gap; optical characterization

I. INTRODUCTION

Increasing world's population and demands of utilization of natural resources causes serious problems of energy crises in near future. All the reservoirs of fossil fuels, coal, oil and natural gases are going to exhausts at the end of century.

Now day solar cell devices play vital role in converting solar energy into usable form. The science and technology of photovoltaic devices (solar cells) and systems have undergone revolutionary developments. Many type of thin film solar cells exists today; the major contributors being crystalline silicon, amorphous crystalline gallium-arsenide, poly-crystalline copper-indium gallium di-sellenide (CuIGS) and polycrystalline cadmium telluride (CdTe)[1-8].

In the past few years, II-IV semiconductors thin films have attracted considerable attention from the research community because of their wide range of applications in the fabrication of solar cells and other electronic and opto-electronics devices. Cadmium (CdS) is mostly used as a window layer for photo voltaic devices.

Cadmium sulphide (CdS) is an important n-type semiconductor with a low direct band gap used as window layer material in solar cell devices. CdS absorbs blue portion of solar radiations and decrease the current density of solar cells. Doping with Zn to CdS window material improves the electrical and optical properties of thin films. The CdZnS provides the wider band gap and higher optical transmittance as compared to CdS. The efficiency of solar cell devices is fund to be enhanced by increasing the band gap of buffer layer.

Out of available thin film deposition technique, the most simple and non-vacuum technique Chemical Bath Deposition (CBD) is implemented in present work. It is a low cost and always proffered for larger surface area deposition [9-15].

The present study aims with deposition of $Cd_xZn_{1-x}S$ thin films by using chemical bath deposition Technique (CBD) and to study the synthesized thin films optically for investigating the effect of Zn doping on the optical properties.

II. EXPERIMENTAL

The $Cd_xZn_{1-x}S$ thin films were synthesized by simple Chemical Bath Deposition technique. Cadmium chloride ($CdCl_2$), zinc chloride ($ZnCl_2$) and thiourea (NH_2CSNH_2) were used as Cd^{+2}, Zn^{+2} and S^{-2} ions respectively. The stock precursors of $CdCl_2$ (0.25M), $ZnCl_2$ (0.25M) and NH_2-CS-NH_2 (0.3M) were prepared. The experimental precursors with different proportions were employed in reaction beaker for deposition of $Cd_xZn_{1-x}S$.

The pH of the solution was adjusted to 11 by adding the aqueous NH_3. The reaction beaker was kept in temperature bath, maintained at constant 80°C. Glass substrates were cleaned by 24 hr immersion in chromic acid, rinsed with acetone and double distilled water. The experimental bare glass substrates were mounted on substrate holder and immersed in the reaction beaker. The substrate holder was rotated at slow speed (45 rpm) by means of Direct Current geared motor for 30 minutes. The pH of the precursor, reaction temperature, rotation speed and dipping time of the substrate were kept constant throughout the experiment at optimized values. The thin, uniform $Cd_xZn_{1-x}S$ films were obtained at the end of the reaction process.

TABLE I. SYNTHESIZED $CD_XZN_{1-X}S$ FILM SAMPLES

Compositi on x	Deposition Precursors		
	$CdCl_2$*(ml)*	$ZnCl_2$(ml)	NH_2CSNH_2(ml)
0.0	5	0	5
0.2	4	1	5
0.4	3	2	5
0.6	2	3	5
0.8	1	4	5
1.0	0	5	5

The different sets of $Cd_xZn_{1-x}S$ thin films were prepared. Synthesized films were rinsed with de-ionized water to remove the loosely bound particles and are annealed at 100 ^oC for three hours. The synthesized $Cd_xZn_{1-x}S$ films were subjected to optical characterizations to study the effect of Zn content. All the $Cd_xZn_{1-x}S$ thin films were prepared on optimizing the bath parameters.

The deposition parameters are summarized in following Table I.

III. OPTICAL CHARACTERIZATIONS OF $CD_XZN_{1-X}S$ THIN FILMS

Absorbance data of $Cd_xZn_{1-x}S$ thin films was recorded by using UV-Visible spectrophotometer (Systronics Double Beam 2201). The energy band gap of CdS films deposited for different reagent concentration in the bath precursors was determined from UV-VIS absorption data. The band gap was obtained by plotting (αhν)2 versus photon energy (hν) and extrapolating the straight-line portion to α=0 and shown in following Figure I. The optical band gap was plotted as a function of concentration of $CdCl_2$. It is clear from the figure that the energy band gap initially increases in linear manner, with reagent concentration. When concentration 0.225 M to 0.25 M of $CdCl_2$ the variation of band gap was observed very less and thereafter band gap increased. The film deposited for 0.25M concentration $CdCl_2$ exhibits the higher crystalline nature with minimum grain size. However band gap obtained was 2.8 eV which is greater than band gap of bulk CdS (2.42 eV) this is due to quantum confinement effect of the grains.

The reagent concentration or S/Cd ratio of the bath solution effectively control the growth rate of the CdS thin film. Following Figure I revels the band gap variation.

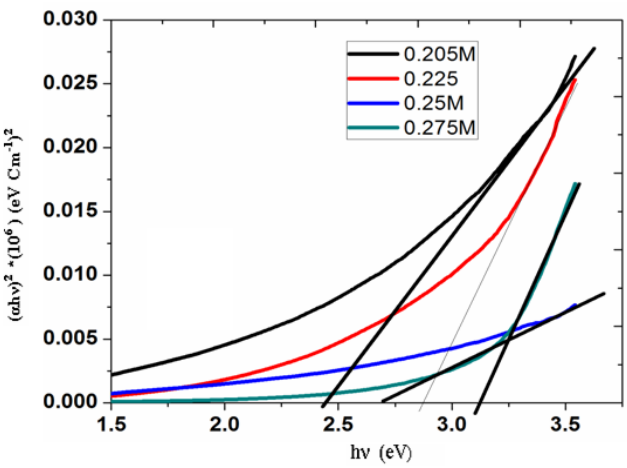

FIGURE I. OPTICAL BANDGAP VARIATION OF $CD_XZN_{1-X}S$ THIN FILMS

Extrapolating the straight line portion of the $(\alpha h\nu)^2$ versus (hν) to the zero absorption (α=0) gives the band gap (Eg).

IV. RESULTS AND DISCUSSIONS

The band gap of composition ($Cd_{1.0}Zn_{0.0}S$) is 2.45 eV which is approximate value as that of band gap of bulk CdS material (2.42 eV). The variation of band gap with Zn content was observed. The band gap was increased with Zn content from 2.7 to 3.9 eV. In the composition x=0.2, the band gap was found to be 3.9 eV. The study concludes that particular combination $Cd_xZn_{1-x}S$ (x=0.2) thin film may be used as an ideal alternative window material to CdS and ZnS for solar cell devices.

The variation of band gap versus composition (x) was presented observed. The maximum band gap 3.9 was observed for $Cd_xZn_{1-x}S$ thin films in the composition x=0.2. The x=0.2 composition having maximum transmittance 78% show the maximum 3.9 eV optical band gap which may be high enough for solar cell applications. The decrease of grain size effectively tuned the band gap to higher value. This is attributed to quantum confinement effect.

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