Optical Characterization of CB Deposited CdZnS Thin Films

Angad Nagorao Jadhav1,* and Maheshwar Mallikarjun Betkar2
1Yeshwant Mahavidyalaya, Nanded-431602, MS, India
2Shri Kumarswami Mahavidyalaya, Ausa, Dist. Latur-413520, MS, India
*Corresponding author

Abstract—Cd1-xZnxS 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 Cd1-xZnxS thin films deposited at various 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—Cd1-xZnxS; 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 gas 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-selenide (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 photovoltaic 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 Cd1-xZnxS 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 Cd1-xZnxS thin films were synthesized by simple Chemical Bath Deposition technique. Cadmium chloride (CdCl2), zinc chloride (ZnCl2) and thiourea (NH2CSNH2) were used as Cd2+, Zn2+ and S2- ions respectively. The stock precursors of CdCl2 (0.25M), ZnCl2 (0.25M) and NH2-CS-NH2 (0.3M) were prepared. The experimental precursors with different proportions were employed in reaction beaker for deposition of Cd1-xZnxS.

The pH of the solution was adjusted to 11 by adding the aqueous NH3. 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 Cd1-xZnxS films were obtained at the end of the reaction process.

| Compositon x | Deposition Precursors |
|--------------|-----------------------|
|              | CdCl2(ml)  | ZnCl2(ml) | NH2-CS-NH2(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 Cd1-xZnxS thin films were prepared. Synthesized films were rinsed with de-ionized water to remove the loosely bound particles and are annealed at 100 °C for three hours. The synthesized Cd1-xZnxS films were subjected to optical characterizations to study the effect of Zn content. All the Cd1-xZnxS thin films were prepared on optimizing the bath parameters.
The deposition parameters are summarized in following Table I.

III. OPTICAL CHARACTERIZATIONS OF Cd_{x}Zn_{1-x}S THIN FILMS

Absorbance data of Cd_{x}Zn_{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 (ahv)^2 versus photon energy (hv) and extrapolating the straight-line portion to a=0 and shown in following Figure I. The optical band gap was plotted as a function of concentration of CdCl₂. 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 CdCl₂, the variation of band gap was observed very less and thereafter band gap increased. The film deposited for 0.25 M concentration CdCl₂ 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 reveals the band gap variation.

The variation of band gap versus composition (x) was presented observed. The maximum band gap 3.9 was observed for Cd_{x}Zn_{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.

ACKNOWLEDGMENT

The authors wish to thank to University Grants Commission, WRO, Pune, for sanctioning Faculty Development Scheme and Physics Research Centre, Mahatma Gandhi Mahavidyalaya, Ahmedpur, Distt. Latur, for providing the Cd_{x}Zn_{1-x}S thin films CB deposition facility.

REFERENCES

[1] Huan Ke, et al, “Effect of temperature on structural and optical properties of ZnS thin films by chemical bath deposition without stirring the reaction bath,” Materials Science in Semiconductor Processing, vol. 18, pp. 28-35, 2014.
[2] Jung Hoon Ahn, Kwan Nam Hui, Kwan San Hui, Young Guk Son, and Dong Hyun Hwang, “Structural and optical properties of ZnS thin films deposited by RF magnetron sputtering,” Nanoscale Research Letters, vol. 7(2), 2012.
[3] Raphad Zein, and Ibrahim Alhorabhi, “Effect of Deposition Time on Structural and Optical Properties of ZnS Nanoparticles Thin Films Prepared by CBD Method,” International Journal of Chem. Tech Research CODEN (USA), vol. 6(5), pp. 3220-3227, 2014.
[4] Nada K. Abbas, Lamia K. Abbas, and Suaid A-Muhamed, “Effect Of Thickness on Structural and Optical Properties of ZnoCd1-xS Thin Films prepared by Chemical Spray Pyrolysis,” Int. J. Thin Film Sci., vol. 2(2), pp. 127-132, 2013.
[5] T.O. Berestok, D.I. Kurbatov, N.M. Opanasyuk, A.D. Pogrebniak, O.P. Manzhos1, and S.M. Danilchenko, “Structural Properties of ZnO Thin Films Obtained by Chemical Bath Deposition Technique,” J. of Nano and Elect. Phys, vol. 5(1), 2013.
[6] W. Wang, I. Germanenko, and M. Samy El-Shell, “Room Temperature Synthesis and Characterization of Nanocristalline CdS, ZnS, and CdZn1-xS,” Chemistry of Materials, vol. 14(7), pp. 3028-3033,2002.
[7] S. Ilican, Y. Caglar and M. Caglar, “Effect of the Substrate Temperatures on the Optical Properties of the Cd 0.22 Zn0.78S Thin Films by Spray Pyrolysis Method,” Physica Macedonica, vol. 56, pp. 43-48, 2006.
[8] Jie Cheng, DongBo Fan, Hao Wang, BingWei Liu, YongCai Zhang, and Hui Yan, “Chemical bath deposition of crystalline ZnS thin films,” Semiconductor Science and Technology, vol. 18, (7), 2003.
[9] G. Nabiyouni, R. Sahraei, M. Toghiany, M. H. Majles Ara, and K. Hedayat, “Preparation and characterization of nano- structured ZnS thin films grown on glass and n-type Si substrates using a new chemical bath deposition technique,” Rev. Adv.Mater.Sci., vol. 27 , pp. 52-57, 2011.
[10] I. Nkrumah, F.K. Ampong, B. Kwakye-Awiah, R.K. Nkum, and F. Boakye, “Synthesis and characterization of ZnO thin films deposited by chemical bath technique,” International Journal of Research in Engineering and Technology, vol.02(12), 2014.
[11] Rakshkhany y., Makdisi, and Ramazaniyan, “Electronic and optical properties of fluorine-doped tin oxide films,” J. Applied Phys., vol. 83, pp.1049-1057, 1998.
[12] Dong Hyun Hwang, Jung Hoon Ahn, Kwan Nam Hui, Kwan San Hui, and Young Guk Son, “Structural and optical properties of ZnS thin films deposited by RF magnetron sputtering,” Nanoscale Research Letters, vol. 7 (26), 2012.
[13] H.M.M.N. Hennayaka, and Ho Seong Lee, “Structural and optical properties of ZnS thin film grown by pulsed electrodeposition,” Thin Solid Films, vol. 548(2), pp. 86-90, 2013.
