Chalcogenide Letters Vol. 6, No. 11, November 2009, p. 617 – 622

TUNABILITY OF STRUCTURAL, SURFACE TEXTURE, COMPOSITIONAL AND OPTICAL PROPERTIES OF CdZnS THIN FILMS BY PHOTO ASSISTED-CHEMICAL BATH DEPOSITION TECHNIQUE.

T. PREM KUMAR, K. SANKARANARAYANAN*
School of Physics, Alagappa University, Karaikudi – 63000, India.

Cadmium zinc sulfide (CdZnS) thin films have been deposited by chemical bath deposition (CBD) technique under dark, white light and fluorescent white light illuminated condition. Influence of light illumination on the chemical bath deposited CdZnS thin films was investigated by means of X-ray diffraction (XRD), atomic force microscopy (AFM), energy dispersive analysis of X-rays (EDX), UV-VIS-NIR spectrophotometer and photoluminescence (PL) emission spectroscopy respectively. Tunability of structural, elemental, surface and optical properties by the influence of light illumination on the growth of CdZnS thin films have been demonstrated in the present work.

(Received November 3, 2009; accepted November 27, 2009)

Keywords: CBD- CdZnS thin films, X-ray diffraction, Room temperature PL emission, Optical properties.

1. Introduction

Because of their luminescence and nonlinear optical properties, quantum size effect, and other excellent physical and chemical properties, nano crystalline semiconductors of group II-VI have potential applications in many technical fields, including photo catalysts, gas sensors, imaging, solar cells, photo conductors, biological detection and UV sensors, short wavelength laser diodes and various luminescence devices. The optical band gap (E_g) tunability of the CdZnS thin films for various Zn^{2+} concentrations was successfully demonstrated in our previous work [1]. Nano crystalline thin films of CdS and ZnS are attractive materials in photo conducting cells and optoelectronic devices such as solar cells and photo conductors [2-4]. Also the related ternary compounds $Cd_xZn_{1-x}S$ are promising materials for high density optical recording and for blue or even UV laser diodes. These applications are based on the structure of $Cd_xZn_{1-x}S$ which exhibit fundamental absorption edges that can varied from green to UV [5-9]. The nano particles exhibit broad emission peaks that shift to shorter wavelength with increasing Zn content in the compound $Cd_xZn_{1-x}S$. The control of the composition of $Cd_xZn_{1-x}S$ nano particles may lead to the development of ideal materials for short wavelength diode laser applications [10]. Recently, the synthesis of blue emitting semiconductor nano crystals have been demonstrated with CdS, CdSe, $Cd_{1-x}Zn_xSe$, $CdSe_{1-x}S$ and $Cd_{1-x}Zn_xS$ through the moderate control of reaction conditions [11-17] such as type of surfactants or reaction temperature, but the suggested synthetic schemes do not guarantee blue emitting semiconducting nanocrystals with high PL efficiency and narrow spectral distribution in the wide range of blue emission region (410-460 nm), which are the critical elements for the applications to light emitting diodes or lasers [18-24].

In solar cell systems, where CdS films have been demonstrated to be effective, the replacement of CdS with the higher band gap $Cd_{1-x}Zn_xS$ alloys has led to a decrease in window absorption loss and an increase in the short circuit current [25, 26]. In the present work, tailoring the physical and optical properties of CdZnS thin films formation by light illumination on the chemical bath. The observed results on the structural, surface texture, elemental compositional,

*Corresponding author: premscientist@gmail.com

optical transmittance and room temperature photoluminescence emission properties are presented and discussed in detail.

2. Experimental

The deposition of CdZnS was carried out under dark, white light and fluorescent white light illuminated chemical bath condition on glass substrates by cleaned with (1:6:10) volume ratio of (hydro fluoric acid: HNO_3: H_2O). The composition of the chemical bath was maintained with 5ml of 0.12 mol/litter:$CdCl_2$, 5ml of 0.12 mol/litter:$ZnCl_2$, 10ml of 0.3 mol/litter:NH_4Cl, 5ml of 0.7 mol/litter:$CS(NH_2)_2$, 30ml of 2 mol/litter:NH_4OH and 50ml of de-mineralized H_2O. Deposition was carried out at room temperature under dark, white light and fluorescent white illumination. As reported earlier, the CdZnS growth occurs by formation of CdZnS colloids and their subsequent adsorption on substrate.

The substrates were suspended vertically inside the chemical bath using Teflon disc and rotated with 20 rpm. All the experiments were conducted over a period of 5 hours by keeping the chemical bath under dark, white light and fluorescent white light illuminated condition. The deposited film was cleaned in deionized H_2O to remove the loosely adhered particles.

3. Results and discussion

3.1. Structural analysis

The recorded diffraction pattern indicated growth of a polycrystalline phase of as-deposited CBD-CdZnS thin film on ultrasonically cleaned glass substrates. The peak positions and its corresponding Miller plane assignments have been indicated in Fig.1(a, b, c). The observed XRD pattern shows the fluorescent light illuminated CBD developed CdZnS thin film have better crystalline quality than the films deposited under dark and white light illumination.

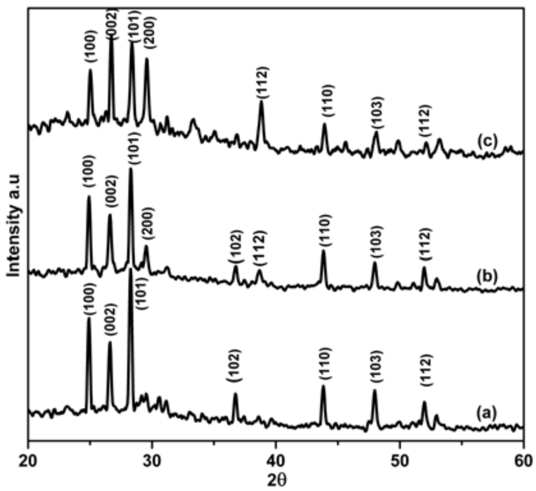

Fig.1. (a, b, c) The X-ray diffraction pattern of the CdZnS films prepared under (a) dark, (b) white light and (c) fluorescent white light illuminated.chemical bath condition.

3.2. Surface analysis

The observed AFM images are presented in the Fig. 2 (a, b, c), and can be seen that the film prepared under fluorescent light illuminated chemical bath exhibits the pinhole free smooth surface morphology. The deposited CdZnS thin film under dark condition shows poor surface with two big voids as shown in the Fig. 2 (a). The films deposited at fluorescent light illuminated chemical bath have better surface properties than the film deposited under dark and white light illuminated condition. Fig. 3 (a), 3 (b) and 3 (c) represents the elemental composition (EDX) analysis of the prepared CdZnS film under dark, white light and fluorescent white light illuminated chemical bath displays the S/Cd/Zn ratios are 30.2/38.2/31.6, 32.1/42/25.9 and 29.1/41/29.9 atom% respectively.

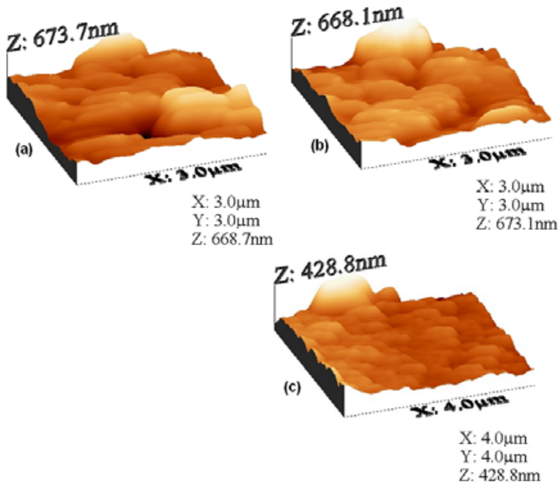

Fig. 2. (a, b, c) The AFM pictures of the CdZnS films prepared under (a) dark, (b) white light and (c) fluorescent white light illuminated.chemical bath condition.

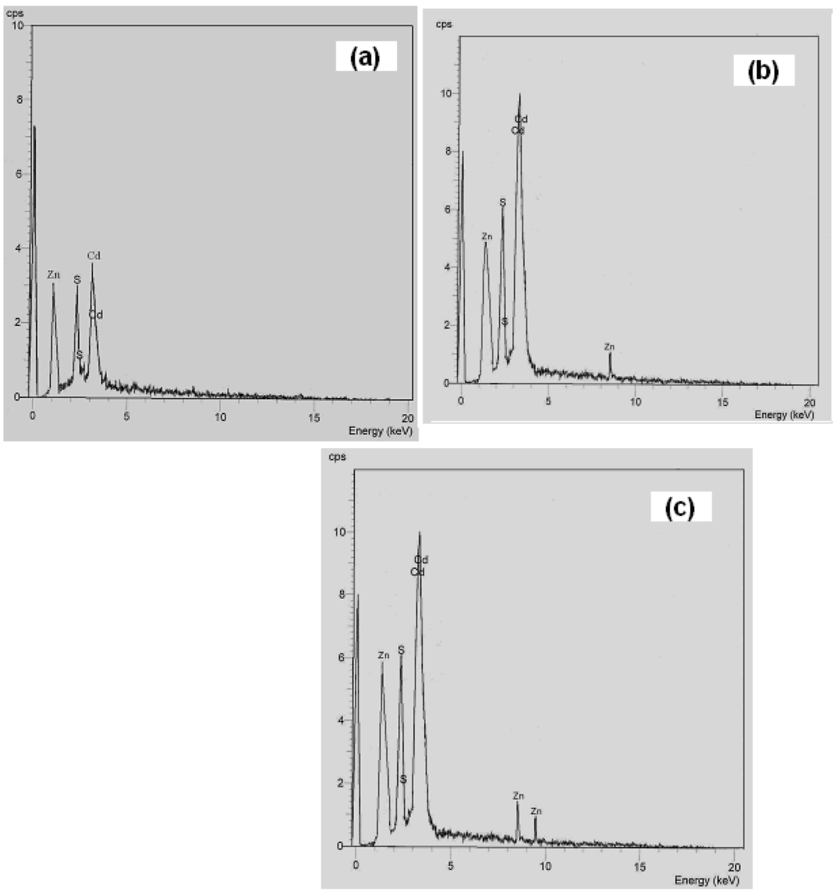

Fig. 3. (a, b, c) The elemental compositional (EDX) analysis of the CdZnS films prepared under (a) dark, (b) white light and (c) fluorescent white light illuminated.chemical bath condition.

3.3. Optical transmittance measurements

Optical quality of the film was investigated by UV-VIS-NIR spectrophotometer in the wavelength ranging from 300 to 1200 nm. The CdZnS thin film deposited under dark and white light illuminated chemical bath have the optical transmittance nearly 40 % and 60 % and the high optical transmittance nearly 90 % was observed in the formation of CdZnS film under fluorescent white light illuminated chemical bath are shown in the Fig. 4 (a, b, c).

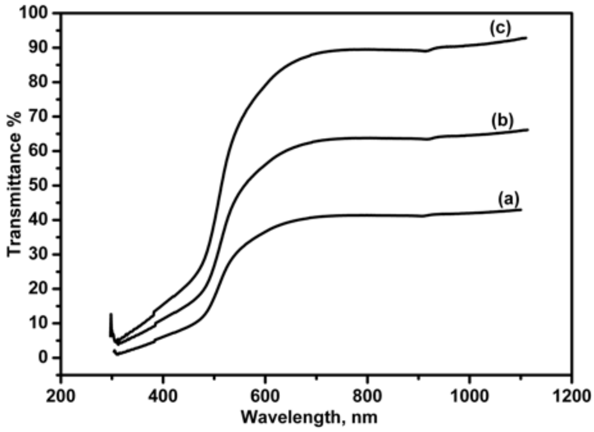

Fig. 4. (a, b, c) UV-VIS-NIR optical transmittance spectra of the CdZnS films prepared under (a) dark, (b) white light and (c) fluorescent white light illuminated.chemical bath condition.

3.4. Fluorescence spectra analysis

Generally, it is known that the photoluminescence in semiconductors is influenced by the stoichiometric defects at electronic levels. The role of surface and native defects has been invoked to explain the PL behavior. Our studies indicated that the influence of light illumination in the chemical bath on the formation of CdZnS films. The excitation wavelength chosen was 390 nm for all the samples at room temperature. In the Fig.5 (a, b, c) shows the room temperature photoluminescence spectra and it exhibits the defect structure characteristics of the films. The film deposited under dark, white light and fluorescent white light illuminated chemical bath displays the broad blue emission were centered at 494 nm and the week green emission occurred at 532.9 nm respectively and the PL intensity was higher for the film deposited under fluorescent white light illuminated chemical bath than the film developed under dark and white light condition.

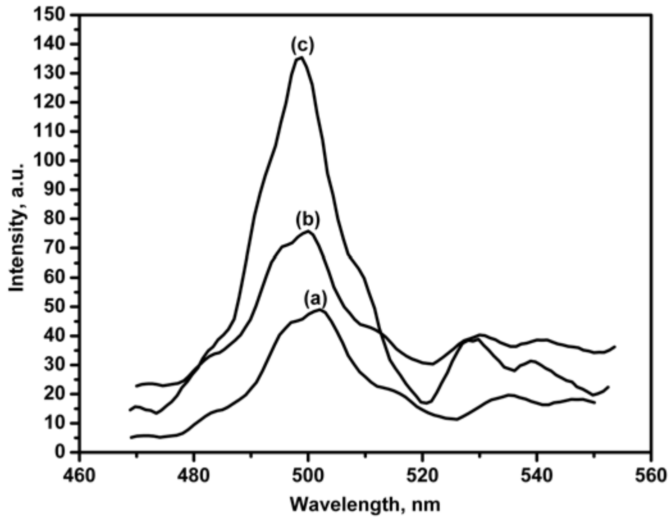

Fig. 5. (a, b, c) Room temperature photoluminescence emission properties of the CdZnS films prepared under (a) dark, (b) white light and (c) fluorescent white light illuminated.chemical bath condition.

4. Conclusions

The light illumination effect on the formation of CBD-CdZnS thin films was demonstrated in the present work. The growth of CdZnS thin films under fluorescent white light assisted chemical bath reveals the better structural, pinhole free surface properties, high optical transmittance, better stoichiometric and intense room temperature PL emission than the film deposited under dark and white light assisted chemical bath condition. This strongly evident that tailoring the properties of CdZnS thin films is mainly due to the illumination of light on the chemical bath.

References

[1] T. Prem kumar, K. Sankaranarayanan, Chalcogenide Lett. **6**, 555 (2009).
[2] A. G. Stanley, "Cadmium Sulfide Solar Cells" Applied Solid State Science 15; R. Wolfe, Ed, Academic Press: New York, 1975.
[3] C. T. Tsai, D. S. Chuu, G. L. Chen, S. L. Yang, J. Appl. Phys, **79**, 9105 (1996).
[4] J. Britt, C. Ferekides, Appl. Phys. Lett, **62**, 2851 (1993).
[5] T. Taguchi, Y. Endoh, Y. Nozue, Appl. Phys. Lett, **56**, 342 (1991).
[6] B. J. Wu, H. Cheng, M. A. Guha, M. A. Haase, J. M. De Puydt, G. Meis-Haugen, J. Qiu, Appl. Phys. Lett, **63**, 2935 (1993).
[7] S. Guha, B. J. Wu, H. Cheng, J. M. De Puydt, Appl.Phys.Lett, **63**, 2129 (1993).
[8] M. A. Haase, J. Qiu, J. M. De Puydt, H. Cheng, Appl.Phys.Lett, **59**, 1272 (1991).
[9] H. Geon, J. Ding, W. Patterson, A. V. Nurmikko, D. C. Xie Grillo, M. Kobayashi, R. L. Gunshor, Appl. Phys. Lett, **59**, 3619 (1991).
[10] Wenzhong Wang, Igor Germanenko, M. Samy El-Shall, Chem. Mater. 14, (2002), 3028.
[11] S. Jun, E. Jang, Chem.Commun, **36**, 4616 (2005).
[12] S. Kudera, M. Zanella, C. Giannini, A. Rizzo, Y. Li, G. Gigli, R. Cingolani, G. Ciccarella, W. Spahl, W. J. Parak, L. Manna, Adv. Mater, **19**, 548 (2007).
[13] W. Yu, W. Peng, X. Angew, Chem. Int. Ed, **41**, 2368 (2002).
[14] J. S. Steckel, J. P. Zimmer, S. Coe-Sullivan, N. E. Stott, V. Bulovic, M. G. Angew, Chem. Int. Ed, **43**, 2154 (2004).

[15] E. Jang, S. Jun, L. Pu. Chem. Commun, **24**, 2964 (2003).
[16] X. Zhong, Y. Feng, W. Knoll, M. Han, J. Am. Chem. Soc, **125**, 13559 (2003).
[17] X. Zhong, Z. Zhang, S. Liu, M. Han, W. Knoll, J. Phys. Chem. B, **108**, 15552 (2004).
[18] Z. Tan, F. Zhang, T .Zhu, J. Xu, A. Y. Wang, J. D. Dixon, L. Li, Q. Zhang, E. Mohney, J. Ruzyllo, Nano Lett, **7**, 3803 (2007).
[19] P. O. Anikeeva, J. E. Halpert, M. G. Bawendi, V. Bulovic, Nano Lett, **7**, 2196 (2007).
[20] A. Rizzo, Y. Li, S. Kudera, F. D. Sala, M. Zanella, W. J. Parak, R. Ciccarella, L. Manna, G. Gigli. Appl. Phys. Lett, **7**, 3803 (2007).
[21] Y. Chan, J. S. Steckel, P. T. Snee, J. M. Caruge, J. M. Hodgkiss, D. C. Nocera, M. G. Bawendi. Appl. Phys. Lett, **86**, 073102 (2005).
[22] Q. Sun, A. Wang, L. Li, D. Wang, T. Zhu, J. Xu, C. Yang, Y. Li. Nat. Phonics, **1**, 717 (2007).
[23] Y. Li, A. Rizzo, R. Cingolani, G. Gigli. Adv. Mater, **18**, 2545 (2006).
[24] M. Ali, S. Chattopadhyay, A. Nag, A. Kumar, S. Sapra, S. Chakraborty, D. D. Samara. Nanotechnology, **18**, 075401 (2007).
[25] N. Gaewdang, T. Gaewdang. Mater. Lett, **59**, 3577 (2005).
[26] G. C. Morris, R. Vanderveen. Sol.Energy Mater. Sol. Cells, **26**, 217 (1992).