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ENERGY GAP INVESTIGATION AND CHARACTERIZATION OF KESTERITE CU_2ZNSNS_4 THIN FILM FOR SOLAR CELL APPLICATIONS

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***Abstract*—Solar cell absorber Kesterite- type Cu_2ZnSnS_4 (CZTS) thin films have been prepared by Chemical Bath Deposition (CBD). UV–vis absorption spectra measurement indicated that the band gap of as-synthesized CZTS was about1.68 eV, which was near the optimum value for photovoltaic solar conversion in a single-band-gap device. The polycrystalline CZTS thin films with kieserite crystal structure have been obtained by XRD. The average of crystalline size of CZTS is 27 nm**

***Index Terms*— CZTS, CBD, Band gap, XRD, UV–vis absorption**

I. INTRODUCTION

Nanotechnology is revolutionizing human's life. In the PV industry, a lot of solar cell companies have reduced solar power cost toward the current conventional cost of electricity [1]. For low-cost solar cell, among the various compound semiconductors and computer science [2]. In recent years, Kesterite- type Copper zinc tin sulfide Cu_2ZnSnS_4 (CZTS) are widely used as an alternative absorber layer to Cu(In,Ga)$(S,Se)_2$ (CIGS) and CdTe due to its earth abundant and environmentally benign constituents [3]. Kesterite structure and element group are shown in fig. 1 below:

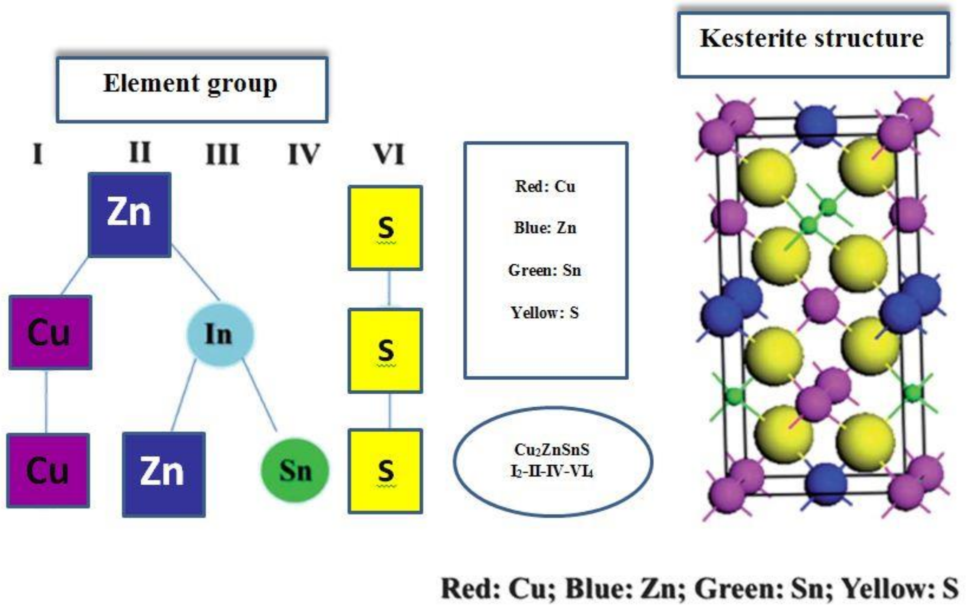

Fig. 1 shown the element group and Kesterite structure of CZTS

CZTS has a direct band gap of 1.68 eV which is the optimum band gap for high efficiency solar cells [4]. The polycrystalline CZTS thin films with kieserite crystal structure have been obtained by XRD. The average of crystalline size of CZTS is 27 nm. In the past, several chemical routes for CZTS synthesis have been studied as well as their thin film deposition. Synthesis and deposition of CZTS thin films have been made by non-vacuum processing as sol–gel [5]. Secondary phases can provide shunting current paths through the solar cell or act as recombination centers, both degrading solar cell performance. Here we report an alternative method for deposition of CZTS thin films that has the potential to be scaled up to large area deposition for use in mass manufacturing of monolithically integrated solar panel modules with high throughput and low cost [6]. Our aqueous approach is based on chemical bath deposition (CBD) [7]. These characteristics would lead to increase in conversion efficiency in the photovoltaic devices [8]. Moreover we will study effect of [9]. The use of nanotechnology in solar cells can boosts the cells performance because conventional solar cells cannot convert all the incoming light into usable energy due to some of the light can escape the cell into the air and lost as heat, not electricity. These mean that the structures from nanotechnology products could absorb more sunlight [10]. Nanotechnology in solar cell devices can be based on nanostructured application, which could be classified in terms of nanocomposites, nanotubes, nanorods, nanoparticles and quantum dots, which are also being applied for various functions. The advantages of the nanostructured solar cells are: can increase the effective optical path for absorption due to multiple reflections, thickness absorber layer can be reduced to avoid recombination losses because light generated electrons and holes need to travel over shorter path, and the band gap of various layers can be varied by varying the size of nanoparticles[10,11].

II. EXPERIMENTAL

Chemical Bath Deposition has been used to synthesis of CZTS, CZTS deposited on glass substrate, The $Cu_2\ SO_4$, $ZnSO_4$, $SnSO_4$ and $Na_2S_2O_3$ are used as sources of Cu^{+}, Zn^{2+}, Sn^{4+} and S^{2-} ions, respectively. The chemical bath containing 0.05 M Cu_2SO_4, 0.1 M $ZnSO_4$, 0.05 M $SnSO_4$ and 0.2 M $Na_2S_2O_3$ solutions in equal volume ratio was prepared by mixing them in a beaker. The solutions of aqueous ammonia added to it. The final pH of the resulting solution is 12. Previously cleaned glass substrate was immersed in the bath and then the bath was heated up to 40 ^{0}C for 75 min.

III. RESULT AND DISCUSSION

Fig. 2 shows XRD patterns of as deposited CZTS thin films on glass substrate. The CZTS thin film shows the crystalline nature. The average crystalline size of CZTS thin film around of 27 nm.

The UV-ViS- absorption and band gap spectra of each of the Copper Zinc Tin Sulfide (CZTS) film. The absorption spectra range from 700 to 900 nm. The band gap of CZTS thin film shows 1.68 eV, it is match to solar cell absorber layer.

Fig 3 and Fig 4 shows the absorption and band gap respectively.

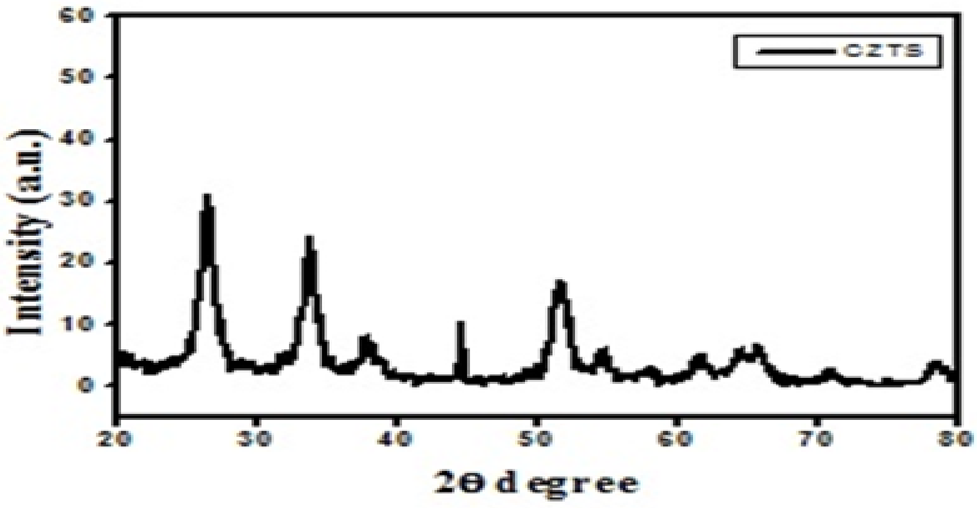

Fig. 2 XRD of CZTS thin film

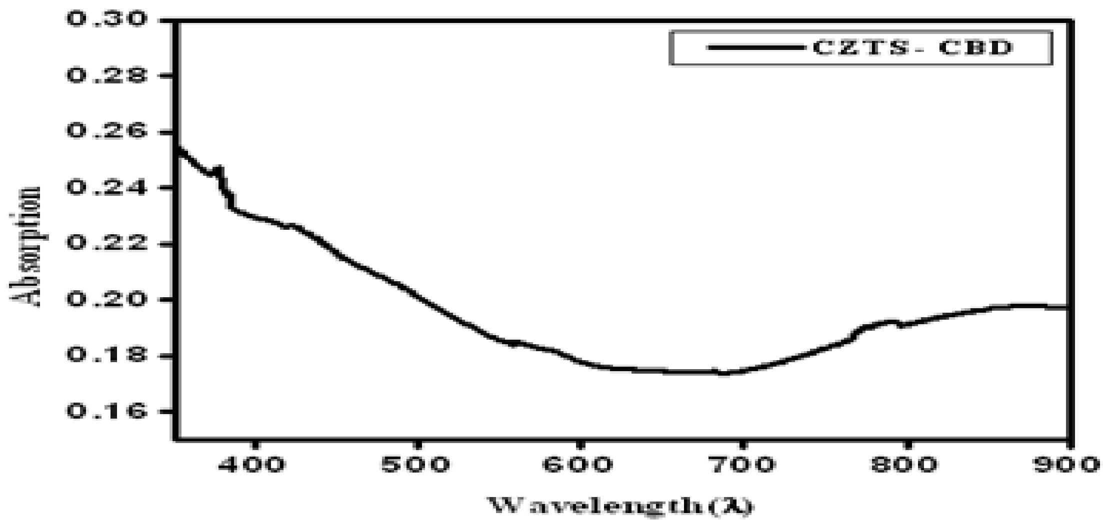

Fig. 3 Absorption of CZTS thin film

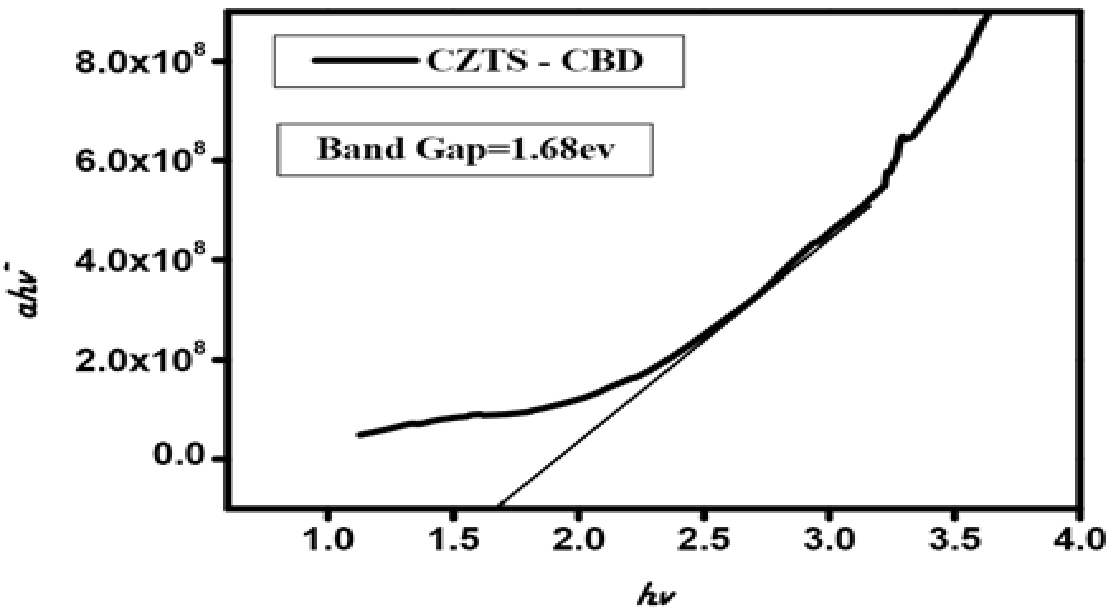

Fig. 4 Band gap of CZTS thin film

IV. Conclusion

The CZTS thin film deposited by chemical bath deposition. The XRD show the CZTS has polycrystalline nature and the crystalline size 27 nm. The band gap of CZTS thin film was 1.68eV found by optical properties.

References

[1] D. Kim et al., "Synthesis of CZTS nanoparticles for low-cost solar cells," J. *Nanosci. Nanotechnol*, vol. 16, no. 5, pp. 5082–5086, 2016.

[2] A. Hasan, J. Working, and C. E. Techniques, "STUDY OF NANO-SYSTEMS FOR COMPUTER," vol. 3, no. 5, pp. 63–68, 2015.

[3] P. Karami Moghadam and M. Hayati, "A novel optimized double junction CZTS/CIGS solar cell with improved performance: A numerical simulation," Optik (Stuttg)., vol. 154, pp. 676–684, 2018.

[4] A. G. Kannan, T. E. Manjulavalli, and J. Chandrasekaran, "Influence of Solvent on the Properties of CZTS Nanoparticles," Procedia Eng., vol. 141, pp. 15–22, 2016.

[5] I. Calvet, E. Barrachina, R. Mart??, D. Fraga, T. S. Lyubenova, and J. B. Carda, "Synthesis, deposition and crystal growth of CZTS nanoparticles onto ceramic tiles," Bol. la Soc. Esp. Ceram. y Vidr., vol. 54, no. 5, pp. 175–180, 2015.

[6] S. Mahajan, E. Stathatos, N. Huse, R. Birajdar, A. Kalarakis, and R. Sharma, "Low cost nanostructure kesterite CZTS thin films for solar cells application," Mater. Lett., vol. 210, pp. 92–96, 2018.

[7] M. Q. Hamzah, Abdullah Hasan Jabbar, Salim Oudah Mezan, "Synthesis and Characterization of Cu2ZnSnS4 (CZTS) Thin Film by Chemical Bath Deposition (CBD) for Solar Cell Applications", International Journal of Scientific Engineering and Research (IJSER), http://www.ijser.in/archives/v5i12/v5i12.php, Volume 5 Issue 12, December 2017, 35 - 37

[8] C. Wang and S. Tanaka, "Fabrication of Vertical Cu2ZnSnS4 Na-nowire Arrays by Two-Step Electroplating Method into Anodic Aluminum Oxide Template," J. Mater. Sci. Nanotechnol., vol. 1, no. 1, pp. 1–4, 2014.

[9] A. H. Jabbar, P. D. P. Jayapandian, and V. Kumar, "Study-Magnetic-Properties-And-Synthesis-With-Characterization-Of-Nickel-Oxide.docx," vol. 6, no. 8, pp. 94–98, 2015.

[10] O. A. M. Abdelraouf and N. K. Allam, "Nanostructuring for enhanced absorption and carrier collection in CZTS-based solar cells: Coupled optical and electrical modeling," Opt. Mater. (Amst)., vol. 54, pp. 84–88, 2016.

[11] N. A. M. Yunus, I. A. Halin, N. Sulaiman, N. F. Ismail, and N. H. N. Aman, "A Compilation of Nanotechnology in Thin Film Solar Cell Devices," World Acad. Sci. Eng. Technol. Int. J. Electr. Comput. Energ. Electron. Commun. Eng., vol. 9, no. 8, pp. 724–728, 2015.