International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
Index Copernicus Value (2015): 62.86 | Impact Factor (2015): 3.791

Synthesis and Characterization of Cu_2ZnSnS_4 (CZTS) Thin Film by Chemical Bath Deposition (CBD) for Solar Cell Applications

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Abstract: ***The search for alternative energy sources has solar energy as one of the primary solutions. Thin film solar cells are a technology that uses less material, but still keeps or even beats efficiencies of normal silicon solar cells. However, some of the materials used in thin film solar cells are either rare or toxic. Kesterite- type Cu2ZnSnS4 (CZTS) thin film for low-cost thin film solar cell were successfully synthesized using a relatively easy to use and comfortable Chemical bath deposition (CBD). Using chemical path deposition to deposit CZTS on the glass substrate. Time, temperature, AND concentration of each one from CZTS compound are effect parameter to prepare of CZTS.CZTS films based on a stacked precursor were prepared and characterized by Scanning electron microscopy (SEM) and Energy Dispersive X-ray Analysis (EDAX).***

Keywords: CZTS, Thin Film, Solar Cell, Chemical Bath Deposition (CBD)

1. Introduction

Copper zinc tin sulfide (CZTS) is a quaternary semiconducting compound which has received a growing attention since the late 2000s for applications in solar cells [1]. The class of related materials includes other I_2-II-IV-VI_4 such as copper zinc tin selenide (CZTSe) [2] and the sulfur-selenium alloy CZTSSe. CZTS offers favorable optical and electronic properties similar to CIGS [3] (copper indium gallium selenide) making it well suited for use as a thin-film solar cell absorber layer, but unlike CIGS (or other thin films such as CdTe [4]), CZTS is composed of only abundant and non-toxic elements. Concerns with the price and availability of indium in CIGS and tellurium in CdTe, as well as toxicity of cadmium have been a large motivator to search for alternative thin film solar cell materials. Recent material improvements for CZTS have increased efficiency to 12.6% in laboratory cells, but more work is needed for their commercialization [5-7].

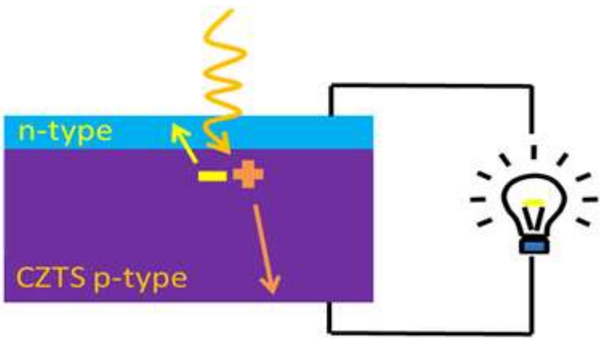


Figure 1: CZTS p-type

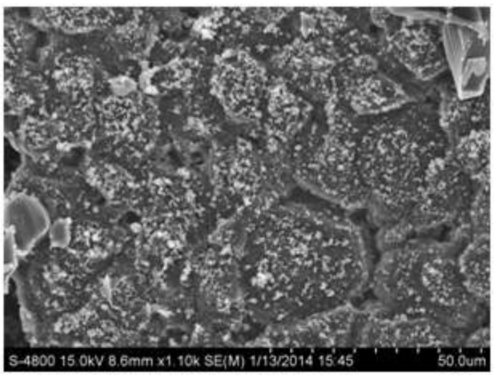
This figure refers to types of junction in solar cell where the CZTS is p-type and second one is n-type. Carrier concentrations and absorption coefficient of CZTS are similar to CIGS. Other properties such as carrier lifetime (and related diffusion length) are low (below 9 ns) for CZTS. This low carrier lifetime may be due to high density of active defects or recombination at grain boundaries. Many secondary phases are possible in quaternary compounds like CZTS and their presence can affect the solar cell performance. Secondary phases can provide shunting current paths through the solar cell or act as recombination centers, both degrading solar cell performance. From the literature it appears that all secondary phases have a detrimental effect on CZTS performance, and many of them are both hard to detect and commonly present.

2. Experimental

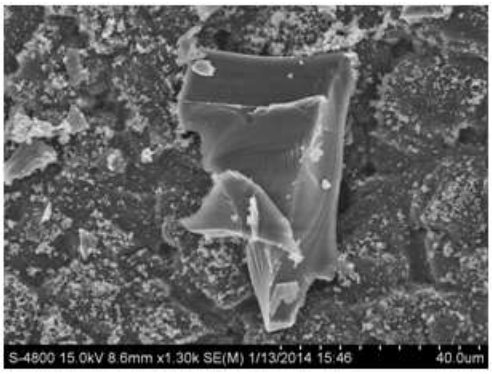
The CZTS thin films have been deposited on the glass substrates using chemical bath deposition. The Cu_2SO_4, $ZnSO_4$, $SnSO_4$ and $Na_2S_2O_3$ are used as sources of Cu^+, $Zn^{2+,}$ $Sn4^+$ and S^{2-} ions, respectively. The chemical bath containing 0.05 M Cu_2SO_4, 0.1 M $ZnSO_4$, 0.05 M $SnSO_4$ 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}Cfor 75 min.

3. Result and Discussion

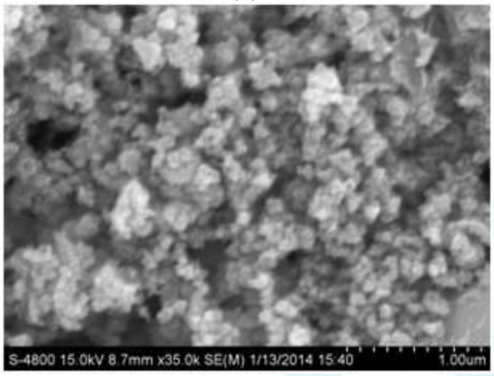
Morphological Study of CZTS thin film



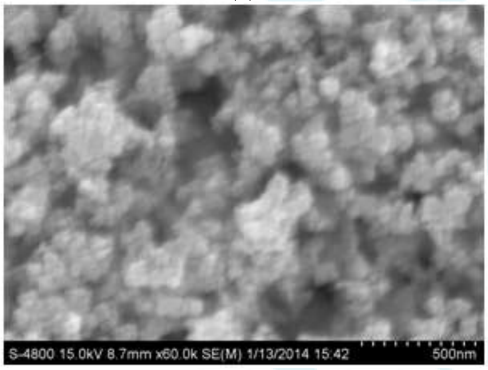
(a)



(b)



(c)



(d)

Figure 2: SEM images of Different resolution of CZTS thin film

Compositional Study of CZTS thin film

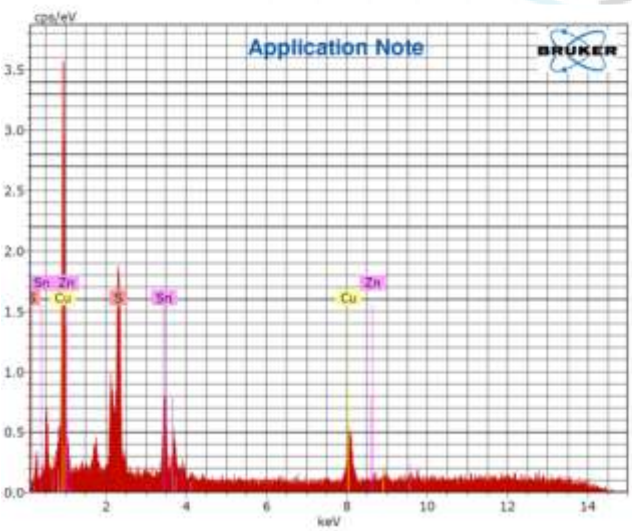


Figure 3: EDAX image of CZTS thin film

Figure 2 (a-d) shows scanning electron micrograph (SEM) images CZTS thin film with different resolution. It is observed that the CZTS thin film is uniform and covers the entire substrate surface. The fine grains were well defined, spherical with different sizes and were uniformly distributed over a smooth homogeneous background corresponding to the nanocrystalline phase of CZTS film [8, 9, 10].

Figure 3 shows the EDAX spectrum of as-deposited CZTS thin film deposited by CBD. The elemental analysis was carried out only for Cu and S and the average atomic percentage. But Zn and Sn has very poor ratio.

4. Conclusion

CZTS thin films prepared by Chemical bath deposition method at different temperature. This spectrum revealed that CZTS thin films have high absorbance in the visible region, indicating applicability as a solar cell application. The absorbance band indicates the direct intra band transitions. Using SEM images are observed that the CZTS thin film is uniform and covers the entire substrate surface. The elemental analysis was carried out only for Cu and S and the average atomic percentage. But Zn and Sn has very poor ratio confirmed by EDAX ratio.

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