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Structural and Optical Properties of Cu_2ZnSnS_4 Films Prepared by Sol-Gel method

*Abdulhameed Saeed Sattar Jabbar Kasim
Department of physics, College of Science, Basrah University, Basrah, Iraq.
*Corresponding Author E-mail: abdulhameedsaeed916@gmail.com

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ABSTRACT:

Chest x-ray medical images are widely used for diagnostic purposes for Cu_2ZnSnS_4 thin films are prepared by sol gel and spin coating methods. In this study, some physical properties such as structural and optical properties of Cu_2ZnSnS_4 thin films are investigated. Prepared thin films are annealed at 400°C for 1 h under N_2 atmosphere. XRD pattern for the peaks 28.31°, 47.26°, and 56.12° which have indexed plans (112), (220) and (312) confirmed that all Cu_2ZnSnS_4 thin films prepared have kesterite structure. The results of XRD patterns and UV–Visible spectra demonstrated kesterite phase and a great optical absorption coefficient more than 10^5 cm^{-1} in visible region. The estimation of the band gap which equal Eg ≈ 1.5 eV by dependent at the optical characteristics.

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الخصائص التركيبية والبصرية لأغشية Cu_2ZnSnS_4 المحضرة بواسطة طريقة

عبد الحميد سعيد عبد الحميد ستار جبار قاسم
جامعة البصرة كلية العلوم قسم الفيزياء

الكلمات المفتاحية:
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الـــخُــلاصـــة:

تم تحضير أغشية Cu_2ZnSnS_4 الرقيقة بواسطة طريقة (محلول – هلام). في هذا البحث، أجريت دراسة بعض من الخصائص البصرية والتركيبية لأغشية Cu_2ZnSnS_4 الرقيقة المحضرة بواسطة طريقة (محلول – هلام). أجري التلدين على الزجاج المطلي عند 400°C درجة مئوية في النتروجين. كشفت حيود الأشعة السينية ان القمم 28.31°، 47.26° و 56.12° والتي لها المستويات (112) و (220) و (312) لجميع أغشية Cu_2ZnSnS_4 الرقيقة أظهرت بنية kesterite. كذلك أظهرت نتائج أنماط حيود الأشعة السينية وأطياف الأشعة المرئية UV-Visible في المستوى kieserite ومعامل امتصاص بصري كبيرة أكثر من 10^5 cm^{-1} في المنطقة المرئية. تم حساب قيمة فجوة الطاقة ووجدت انها Eg ≈ 1.5 eV بالاعتماد على دراسة الخصائص البصرية.

1. INTRODUCTION

Kesterite Cu_2ZnSnS_4 (CZTS) has created a significant enthusiasm as a potential absorber material conveying a promising a substitute to $CuIn_xGa1{-}xSe_2$ (CIGSe) for thin film solar cells due to the non-toxicity and plenitude of its constituents [1,2]. CZTS thin films have near ideal band gap Eg ≈ 1.5 eV for the photoelectric energy change and are recognized by an extensive absorption coefficient ($>10^5 cm^{-1}$)[3]. The components elements of CZTS thin film, for example, Cu, Zn, Sn, S are abundant , minimized effort, and non-toxic, accordingly empolying of CZTS thin film will bring about both huge cost savings and in addition environmental benefits[4]. Industrial methods for CZTS solar cells including vacuum and non-vacuum deposition, for example, evaporation [5], sputtering [6,7,8], and pulsed laser deposition[9] have been used. The non-vacuum methods open possibilities for the low-cost fabrication process. CZTS films, set by the spin coating of a sol-gel solution are described by the most elevated strength and technologically reproducible electro-physical and optical properties. Thin film solar cells with a CZTS absorber, prepared by the sol-gel method, achieve the photoelectric transformation efficiency of 8% [10]. In 2013, the evaporated CZTS thin film solar cells have exhibit 8.4% conversion efficiency [11] and more recently a most elevated transformation efficiency of 9.2% was reached [12]. The objective of this commitment is the make of high quality CZTS films by spin coating. This technique should bring about the advancement of a basic and slight effort manufacture process of CZTS films.

2. EXPERIMENTAL SECTION

CZTS thin films solution were prepared by used $Cu(Ac)_2$ as a source of Cu^{+2} with purity of 98% mixed with 0.25M $Zn(Ac)_2$ also as the main source of zinc ions together with 0.25M $SnCl_2$ 99.9%, 2M $(NH_2)_2CS$ 99% used to supply sulphur particle, Weigh materials using a sensitive balance type Metller. A E-160 with high sensitivity up to 10^{-4}gm. Different compounds were mixed, $Cu(Ac)_2$, hydrated $SnCl_2$ $SnCl_2$ and in addition $(NH_2)_2CS$ to mixture were dissolved in 50 ml 2-methoxyethanol and set in a magnetic stirrer , 5 ml from diethanolamine used with little of same solvent, stirred about 10 min, the mixture was added drop by drop using syringe . The action was continue up to one hour at RT.and in addition $(NH_2)_2CS$ to mixture were dissolved in 50 ml 2-methoxyethanol and set in a magnetic stirrer , 5 ml from diethanolamine used with little of same solvent, stirred about 10 min, the mixture was added drop by drop using syringe. The action was continue up to one hour at RT. After fast solubility the Cu_2ZnSnS_4 was show up and kept in volumetric flask for 24h period. The mixing ratio was 8:1:1:2 for Cu/Zn/Sn/S compound 10 min period time was in magnetic stirrer before precipitate the solution after using filter paper, the acidity was measured using pH meter and found it 8. The solution was covered in glass plate after cleaner by water and acetone. The prepared sol-gel was spin coated at 3000 rpm during 40 s. The first thermal treatment of the deposition layers was done at =220°C in air. The samples are then placed in a convection oven at 400 ° C in 1h with nitrogen. Thermal processing has reduced the crystalline defects caused by the preparation and the defects of the interface by giving the atoms of the material sufficient energy to rearrange itself. CZTS films with this thickness can be obtained by the successive spin coating of 3–6 layers of a sol-gel depending upon its consist.

2.2 Characterization

The CZTS thin films have been considered using X-Ray Diffraction (XRD) (X' Pert Pro MPD) with Cu Kα radiation (λ=1.5406 A°). The general morphology of the items was portrayed by Field Emission Scanning Electron Microscopy (FESEM, Zeiss Supra 55VP, Germany).The optical properties of the CZTS thin films were estimated using an UV/VIS/NIR spectrophotometer (Shmadzu) in the range 300-1100 nm at room temperature.

3. RESULTS AND DISCUSSIONS

3.1 STRUCTURAL PROPERTIES

Fig. 1(a) show the XRD patterns of the spin coating method Cu_2ZnSnS_4 thin films comprise of a single phase and have the kesterite structure. the better XRD peaks showed up at 2θ = 28.38°, 47.3°, and 56.03° can be credited to the diffraction of (112), (220), and (312) planes of kesterite stage CZTS thin films, respectively (JCPDS no. 26-0575). Fig. 1(b) When the process is performed at 400 ° C with N_2 for the CZTS membrane. The results of X-ray diffraction show that there is an increase in height and intensity (FWHM). This means that thermal treatment has reduced the crystalline defects caused by the preparation and the defects of the interface by giving the material atoms sufficient energy to rearrange itself., The XRD patterns showed 2θ = 28.31°,32.77 °,47.26°, and 56.12° equivalent to the planes (112), (200), (220),(312).

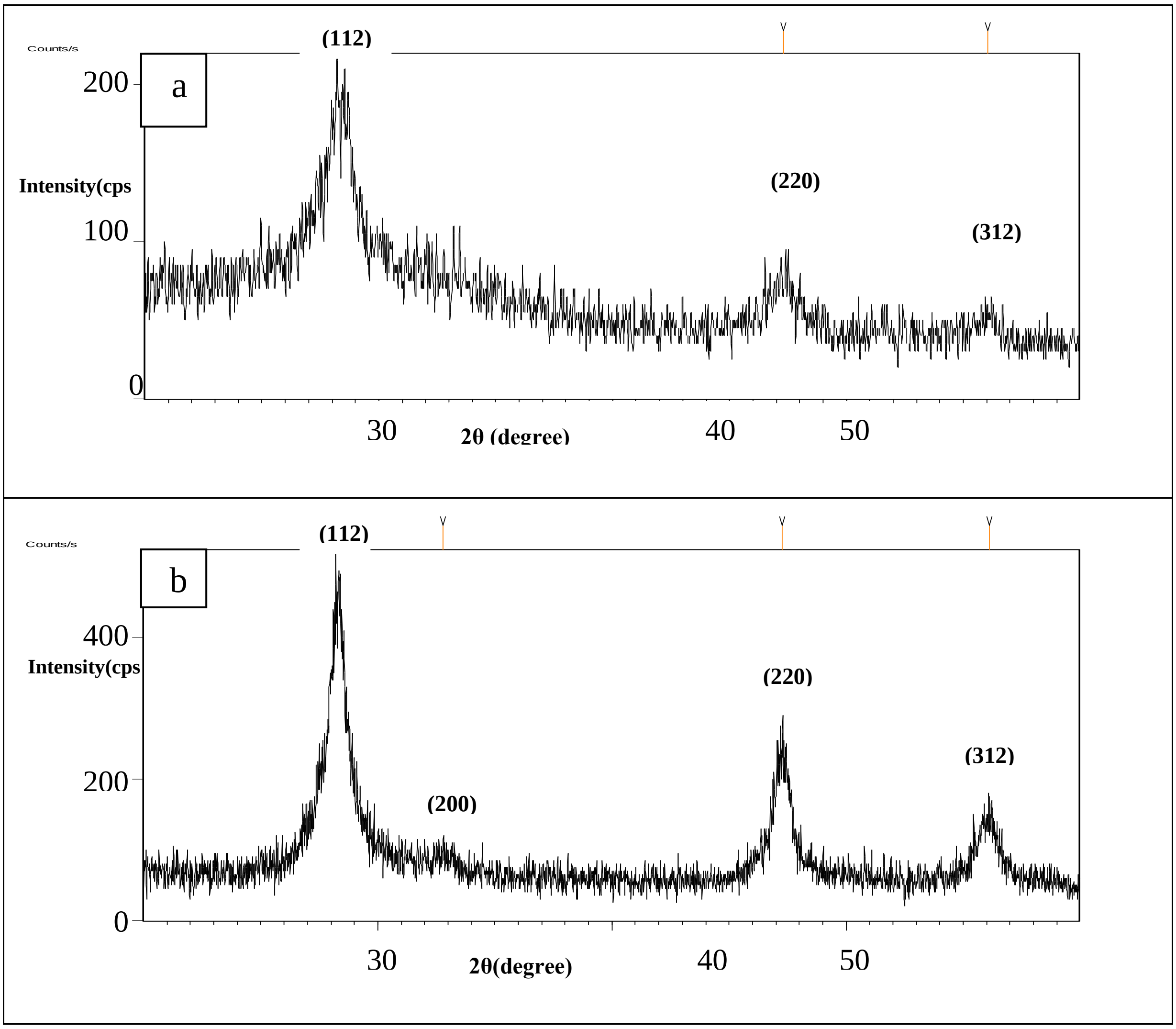


Figure 1: XRD pattren of CZTS (a) Before annealing (b) at annealing 400°C

3.2 FIELD EMISSION SCANNING ELECTRON MICROSCOPY (FE-SEM) ANALYSIS

Figure (2) shows a FESEM picture of the prepare item by responding to copper, zinc,tin and sulphur precursors in 2-methoxyethanol dissolvable for 1h.The surface picture of the CZTS thin films was appeared in the figure(2). The surface properties of the membrane of the composite CZTS shows the emergence of (nanosheet), and the results indicates that the thickness of the sheet is about 10 nm. Which provides a large surface area to help absorb more electrons and this advantage can be used as an application for photovoltaic cells

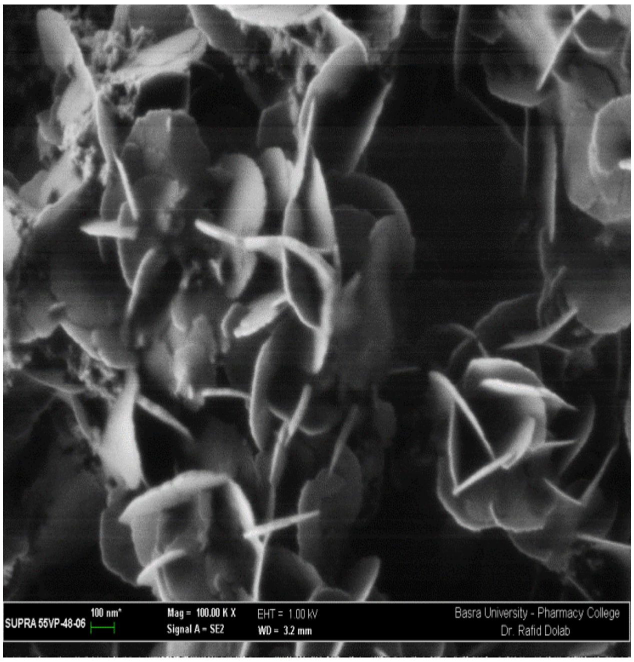
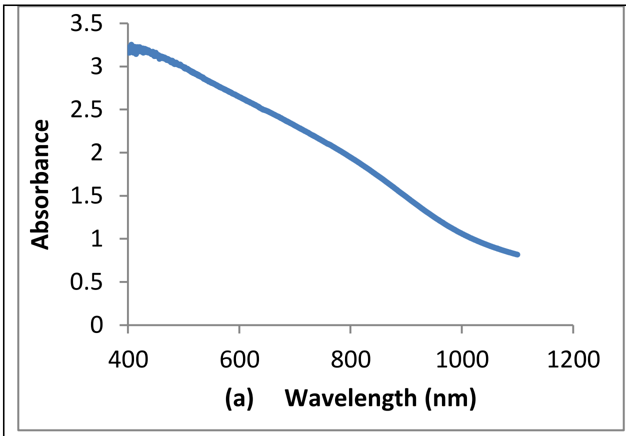


Figure 2: FESEM image of the CZTS nanosheet.

3.3 UV-VISIBLE SPECTROSCOPY ANALYSIS

Fig(3a) shows the UV-Vis absorption spectroscopy of the CZTS thin films, CZTS is an immediate band gap semiconductor, it was measured in the range of wavelengths (400-1100) nm. In the present investigation, the band gap was achieve by plotting the $(\alpha h\nu)^2$ versus photon energy ($h\nu$) (Where α = absorbance, h = Planck's steady, and ν = frequency), Figure (3b) shows the change in the absorbance spectrum as a function of the wavelength of the CZTS membrane, after attaching at 400 °C for one hour with N_2. The results showed that the film had a optical gap value of 1.5 eV, being reliable with the announced estimations of CZTS in writing (1.45 – 1.5 ev) [13-14].



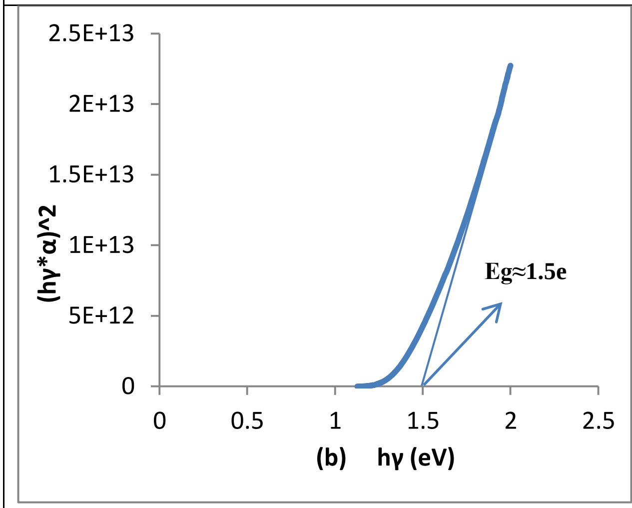


Figure 3a: UV-vis absorption of the CZTS film (b)the energy gap of CZTS at 400°C in N_2.

4. CONCLUSION

Cu_2ZnSnS_4 Nanosheet with kesterite structure can be prepared by Sol-Gel method which synthesized at room temperature using solution method by taking copper, zinc, Tin chloride and Thiourea at molar concentration ratio (Cu: Zn: Sn: S). XRD, FESEM characterizations confirm the structure, composition and morphology of as-obtained nanosheet. XRD characterization resembled with JCPDS number (26-0575) confirmed the kesterite phase of CZTS (Cu_2ZnSnS_4). annealing temperature has important positive effect on removal of secondary phases and achieved single phase kesterite CZTS at annealing temperature 400°C for 1h in N_2 atmosphere. the diffraction peaks (112),(312) and (220) related to tetragonal structure of Cu_2ZnSnS_4. Sheet thickness is about 10 nm. and a high absorption coefficient as 10^4 cm^{-1} completed by this synthesis technique. The optical energy band-gap of the prepared nanosheet CZTS sample is about 1.5 eV, which is very close to the optimum value for a solar-cell. These results show that CZTS films could be easily prepared by this technology for the solar cell application. The simple preparation and low cost nature of Sol-Gel method make it quite charming.

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