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Research Article

Influence of Tin sulfide (SnS) nanoparticles grown on Silicone (Si) as heterojunction

Imad Kadhim Khudhair

Ministry of Education –Baghdad Education Directorate of Al- Karkh 2. Iraq

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Abstract:

Tin sulfide (SnS) nanoparticles have been deposited on glass and n-Si substrates using wet chemical method The as- prepared SnS nanoparticles were characterized using XRD, As waves interact with a regular structure that the diffraction occurs. SEM show aggregates of small nanoparticles. The optical properties were acquired from the UV-VIS absorption spectrum and results showed energy gap of allowed direct transition to be (1.8) eV, To prepare heterojunction (p-SnS/n-Si) which include (I.V) characteristics in state of light and dark conditions for forward and reverse bias as well as calculation (C.V). the results showed the (V_{bi}) value in illumination is less than in the dark

Corresponding Author E-mail : emad_kk_799@yahoo.com

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1- Introduction:

Tin sulfide the semiconductor nanocrystals have been studied extensively [1]. Tin sulfide nanoparticles show major promise in field of the photoelectric [2,3] , solvothermal [4,5], thermoelectric [6,7] and hydrothermal [8], successive ionic layer adsorption and reaction [9,10], devices [11], wet chemical method [12,13], pulsed laser deposition (PLD) [14], physical vapor deposition [15] thermal evaporation [16], electrochemical [17] methods etc. Friendly environment, low cost material, can be p or n type depending on kind of application. Tin sulfide is also used in perovskite [18,7] and quantum dot sensitized [19,9,20,21] solar cells. photodetectors, solid-state batteries [15,5], capacitors [22,17], holographic recording medium [23] Sensors [24,25], and efficient photocatalytic materials driven by visible light [26] because its favourable chemical and physical properties. Tin sulfide nanoparticles have attracted a lot of attention because its high absorption ($>10^4$ cm^{-1}) [27,28,29,30]. The optical properties of Tin sulfide can be adapted using varying the manufacturing process, but almost all researchers agree with tunable indirect (1.0 - 1.2) eV and tunable direct (1.2 - 1.5) eV band gap values, These properties make Tin sulfide nanoparticles as a good candidate for optoelectric and photovoltaic applications [31,32,33,34,35,36,37]. In this article, performance of SnS-based p-SnS/n-Si hetrojunction and improve its properties for using photovoltaic applications.

2- Experimental:

The tin sulfide nanoparticles prepared by wet chemical method were deposited on glass and n-Si substrates. In this method, Tin (II) chloride ($SnCl2.\ 2H_2O$) and sodium sulfide (Na_2S) they were taken as sources of tin (Sn) and sulfur (S) respectively. water without ions was used as solvent. 1.72 gm of sodium sulfide and 1.2gm of tin (II) chloride were dissolved in water without ions. Sodium sulfide solution is added dropwise into solution. The colourless tin (II) chloride solution turns dark brown with addition of sodium sulfide solution. This indicates the nanoparticle composition of tin sulfide.. This reaction was carried out at room temperature for (2) hour. The deposit was centrifuged, washed with water without ions and ethanol for several times, and dried at room temperature. To prepare heterojunction (p-SnS/n-Si), film SnS nanoparticles was deposited on a silicon layer (n-type) substrates. For (I.V) measurements, were used. Capacitance measurement (C-V) for p-SnS/n-Si And then measurement of spectral responsivity

Results:

3.1 Structural properties:

XRD is an analytical method that determines the different crystalline forms of materials.

In fig(1) All diffraction peaks are indexed to the pure rhombic phase of this tin sulfide because of the agglomeration of particles in the powder sample and therefore

XRD was used to determine the phase only, sharp and strong diffraction peaks indicate that the product is well crystallized. No other graying peaks were observed, and with knowledge full width at half maximum (FWHM), wavelength (λ) of peaks β, and particle size (D), diffracting angle (θ) was calculated through Scherrer equation.

$$D = \frac{0.9\,\lambda}{\beta \cos\theta} \ldots\ldots\ldots\ldots\ldots (1)$$

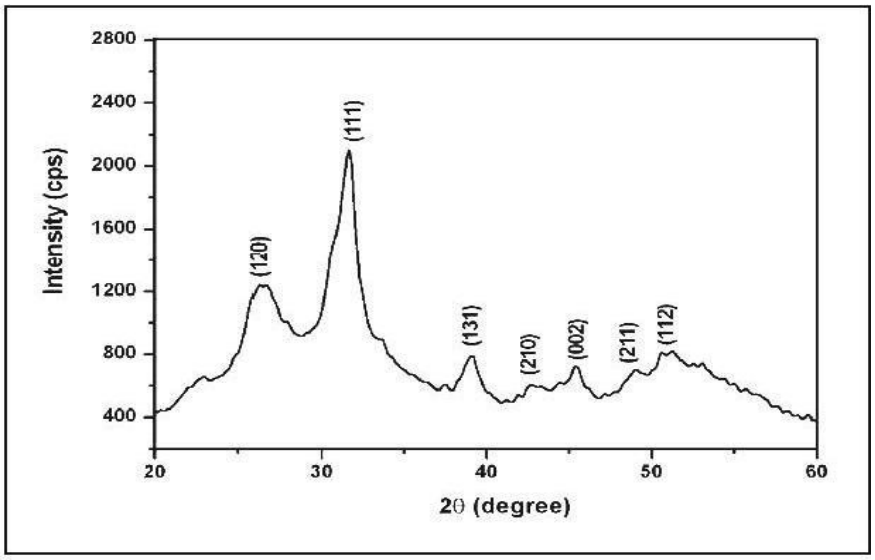


Fig (1). X-Ray diffraction of SnS nanoparticles.

Fig (2) Scanning electron microscopy image reveals that particles are in state of aggregation because their dimensions are very small and the surface energy is high. It also turns out that particles were very agglomerated in nature. The reason may be that agglomeration occure during the growth of crystals because of the clear small size system from the XRD analysis.

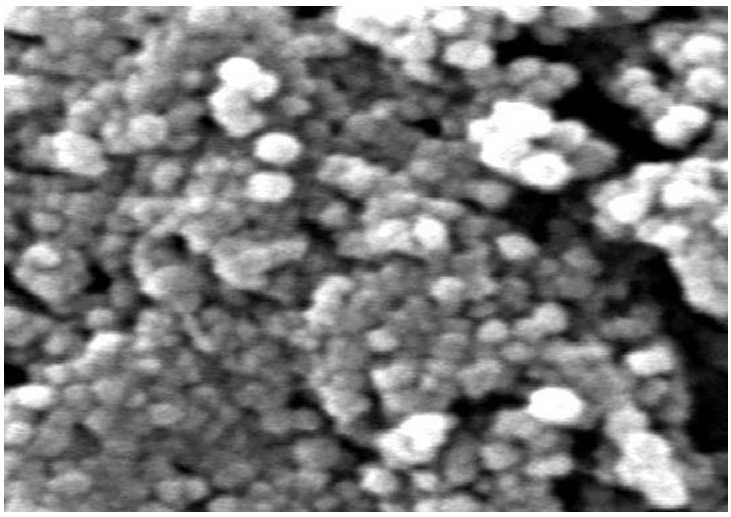
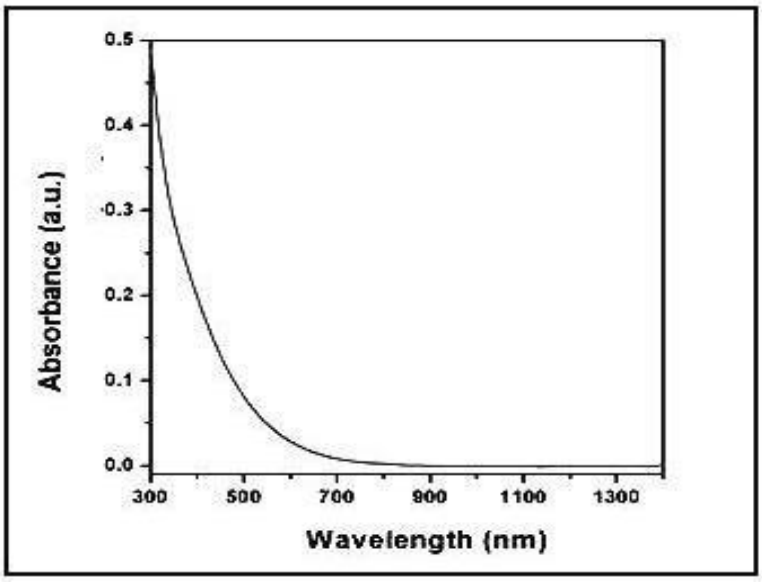


Fig (2). SEM image of tin sulfide nanoparticles.

3.2Optical properties:

The optical absorption was measured on the SnS nanoparticles. Fig 3 explain contrast of optical absorbance with wavelength (λ) of as-prepared SnS nanoparticles.. It turns out that the nanoparticles have a wide absorption from NIR to UV radiation, which means that they absorb sunlight well The absorption edge has been obtained at a shorter wavelength.



Fig(3). Optical absorption of tin sulfied nanoparticles.

Energy gap of SnS nanoparticles gives us a clear idea of optical absorption and a basis for spectral selectivity. The results showed the energy gap of the allowed direct transition to (1.8) eV, Shows figure (4). In semiconductor nanoparticles, particle size decreases as the energy gap increases.

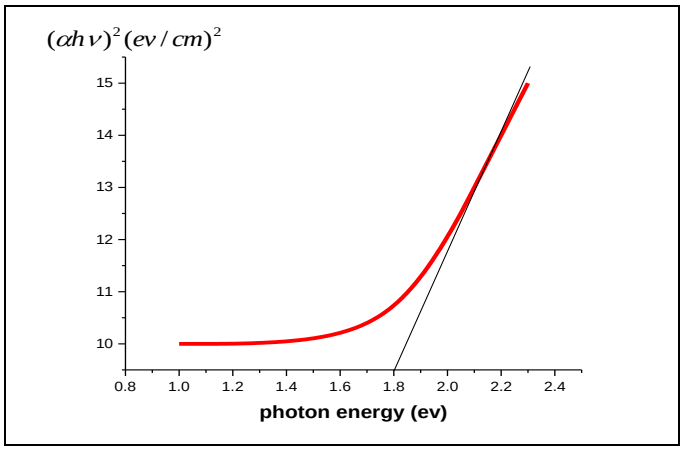


Fig (4) Band gap determination of tin sulfide nanoparticles.

Fig.5 explain results obtained from light and dark (I-V) current-voltage measurements in forward and reverse direction for (p-SnS/n-Si) heterojunction.That figure shows current values in light are more than the current values in dark because illumination increases the mobility and concentration of charge carriers with the increase of bias voltage So light absorption occurs in the layer of depletion in the area . Fig(6) explain highest pesk of R(λ) Spectral response (0.89) A/W at (850) nm this means the light is absorbed by silicon after it was transmitted from SnS film, and calculated from the following relationship [21,22,24]

$R(\lambda) = \frac{I_{ph}}{P_{in}}$ .....(2) where (P_{in}) is the input power, (I_{ph}) is the photocurrent.

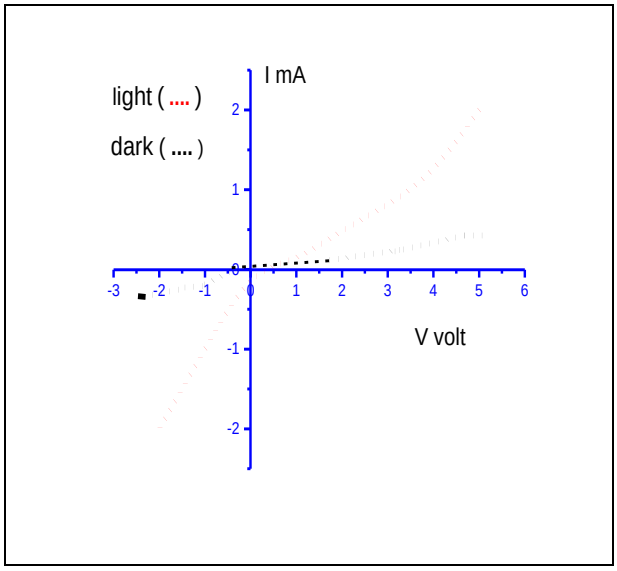


Fig.(5) Light and dark (I.V) characteristics p-SnS/n-Si heterojunction at wet chemical

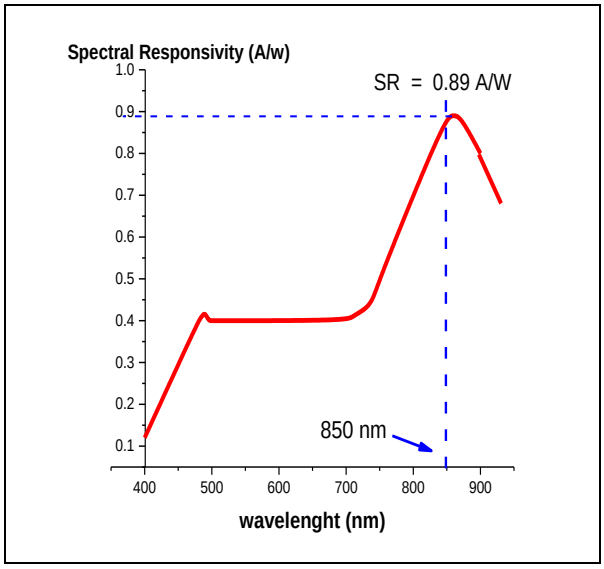


Fig.(6) R(λ) of p-SnS/n-Si heterojunction at wet chemical method

(C-V) measurement determine the type of heterojunction is abrupt, figure. 7. Explain The intercept of a straight line with a voltage-built-in voltage axis (V_{bi}) was found to about (0.3) volts in Light which is less than (1.25) volts in dark. Deposition of SnS nanoparticles leads to a decrease in value of (V_{bi}) because increased concentration of defects resulting from lattice and thermal mismatch between constituent materials of hetrjunction and improve its properties [38].

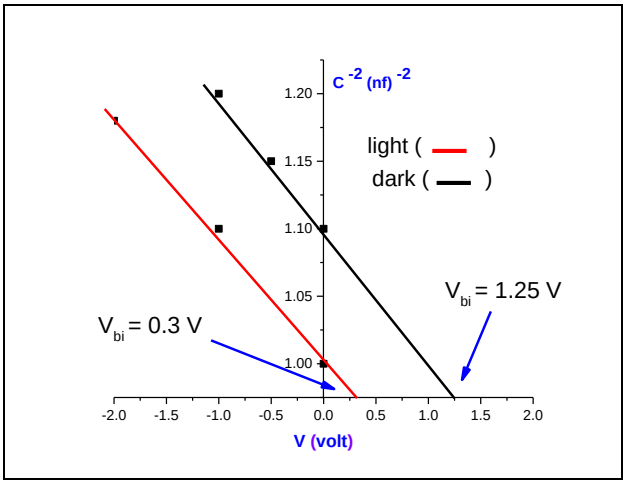


Fig.(7) $1/C^2$ versus reverse voltage of p-SnS/n-Si heterojunction.

Conclusions:

X-Ray diffraction revealed the orthorhombic structure of SnS nanoparticles. Scanning electron microscopy explain the state of aggregation of SnS nanoparticles. In UV-VIS absorption spectrum, it appears that nanoparticles have a wide absorption and 1.8 eV direct allowed transition energy gap. The resulting SnS nanoparticles are a good crystalline, which makes them promising for applications in optical devices such as in solar cells. Heterojunction (p-SnS/n-Si) is abrupt. Deposition of SnS nanoparticles leads to a decrease in value of (V_{bi}) because increased concentration of defects resulting from lattice and thermal mismatch between constituent materials of hetrjunction and improve its properties for using photovoltaic applications.

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