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Al/MnS/Si/Al Nanostructure Solar Cell

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***Abstract*— The nanocrystalline Al/P-MnS / n-Si/Al are prepared by thermal evaporation technique at different temperature (as prepped and 150 °C).The structural, morphology and optical of MnS has been studied. XRD measurement disclosed that the MnS were of cubic crystal structure. AFM detect showed that the produced MnS films have ball-shape with perfect homogenous. The energy band gap of MnS films prepared by thermal evapora-tion technique at different temperature (as prepared and 150) °C determined from optical properties and found to be in the range (3.05-3.19) eV. The responsively photo detector after deposited MnS and annealing temperature revealed increasing in response with increasing temperature.**

Keywords—Al/MnS/Si/Al, efficiencies , Different temperature and nano-structure

I. Introduction

Recently metal chalcogenide thin film materials have opened a new area in the field of electronic applications. Their properties can be changed by changing the crystallite size and/or thickness of the film Depending upon the deposition conditions , the structural , electrical and optical properties of these materials can be controlled in many ways [1–5] Materials containing manganese are interesting because their applications are possible in many areas of modern technology. Manganese sulfide (MnS) is a magnetic semiconductor material (E_g=3.1eV) that is of potential interest in short wavelength optoelectronic applications such as in solar selective coatings, solar cells, sensors, photoconductors, optical mass memories [6–9]. MnS thin films or powders can be found in several polymorphic forms: the rock salt type structure (αMnS) .which is the most common form, by low temperature growing techniques it crystallizes into the zinc blende (βMnS) or wurtzite (γMnS) structure [10,11].

MnS is extensively studied in the literature, preparation of its thin films has been carried out by different metho-ds such as radiofrequency sputtering [12,13] ,hydrothermal[14-16] ,molecular beam epitaxy [17] and chemical bath deposition (CBD) [9,18–20]. The prope-rties of thin films prepared by different methods are critically dependent on the nature of preparation technique

II. Experimental work

Glass and silicon wafer was used as substrate materials for the deposition of MnS thin films. Glass slides were cut into (1.5×1.5) cm compatible with the dimension of substrate holder by using a steel cutter tool. The glass slides were thoroughly cleaned before the deposition process in to attain a plausible adhesion coefficient as in the following procedure. The glass slides were first cleaned with a dilute solution of chemical detergent to remove the impurities and the protein materials on the surface of the slides. Then Si samples were cleaned with alcohol and an ultrasonic bath in order to remove the impurities and residuals from their surface. These substrates were etched with HF (10%) for 5 min to remove the native oxide.The bottom electrode was coated with thick Aluminum layer before the anodization process and measuring the electrical properties, ohmic contacts are needed .It is obtained under vacuum of Aluminum wire of high purity (99.99%). The evaporation process started at a pressure of 10-5Torr.The best condition for good ohmic contact was satisfied by a layer of 200 nm. The Manages sulfide (MnS) deposited by thermal evaporation technique using coating unit in vacuum about(2×〖10〗^(-5)) Torr and put it in a special evaporation molybdenum boat .The rate of evaporation was (23.5 nm/min) and the film thickness (400 nm) was measured by interference method .The substrate glass was placed directly above the source at a distance about 18 cm after cleaned the glass and the this film which deposited one study the structural , topography and optical properties of all films (as-prepared and 150) °C were investigated separately by means of (CuKα) XRD-6000, Shimadzu X-ray diffractmeter ,Fourier transform-ation infrared spectroscopy, JEOL (JSM-5600) scanning electron microscopy, Philips CM10 pw 6020 transmission electron microscopy , Angstrom AA 3000 Atomic Force Microscopy and Cary 100 Conc plus UV-Vis spectrophotometer.

III. Result and Discussion

Figure (1) show the XRD different pattern of prepped thin films by thermal evaporation technique and deposited on glass substrate than annealing at tow temperature (as-prepared and150) °C . The figure (1) revels a strong peak of MnS (as prepared and 150 °C) at 2θ (〖29.66〗^°, 〖 29.92〗^°) respectively only along the(111) direction at annealing temperature , correspond ASTM .All the diffraction peaks in figure (1) are indicates to cubic structure with no trail of hexagonal or other faces.

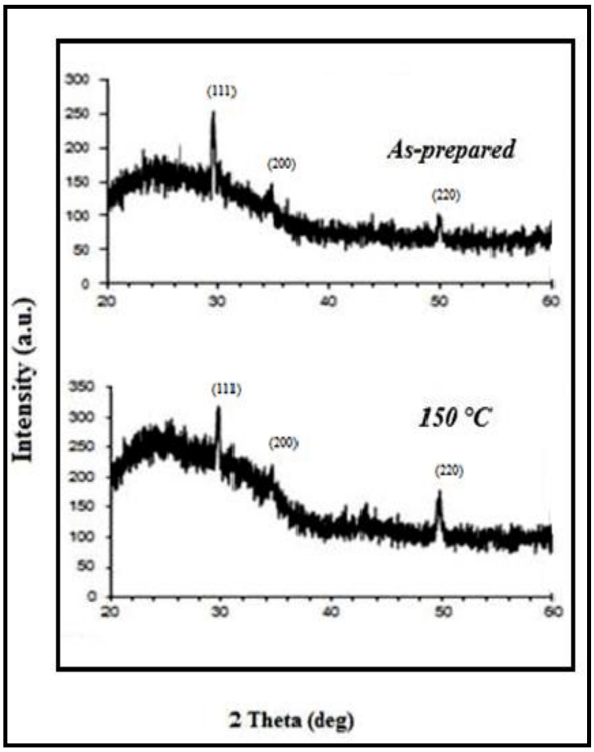

Fig. (2): XRD spectra of MnS films deposited as prepped and MnS films annealed at 150°C.

The crystalline size C for a knowing by X-ray wavelength λ at the diffraction angle θ from the equation as given by[1]:

C =a λ/FWHM cos(θ)……..(1)

Where the FWHM is the full width at the half maximum of the characteristic spect- rum in units of radians, and λ are in nm . a is the Scherrer constant (1>a>0.89),fund to be (10.3and15.3) nm which are prepared at (as- prepared and 150)°C respectively, which is agreement with the determined AFM in visitation.

Figure (2) shows 3D AFM image and Granularity accumulation distribution chart of MnS nanostructure prepared by thermal evaporation technique and deposited on glass than annealing temperature (as-prepared and150) °C on glass substrate . Substrate is well covered with MnS nanostructure; distributed uniformly on the surface. It is obvious from this figure that the nanostructure have small ordered particles with semispherical shape. The average particle size estimated with the aid of software. In Table (1), it is clearly seen that the root mean square of surface roughness decreases with annealing temperature (150 °C) means delivering of more energy implies a high polycrystalline.

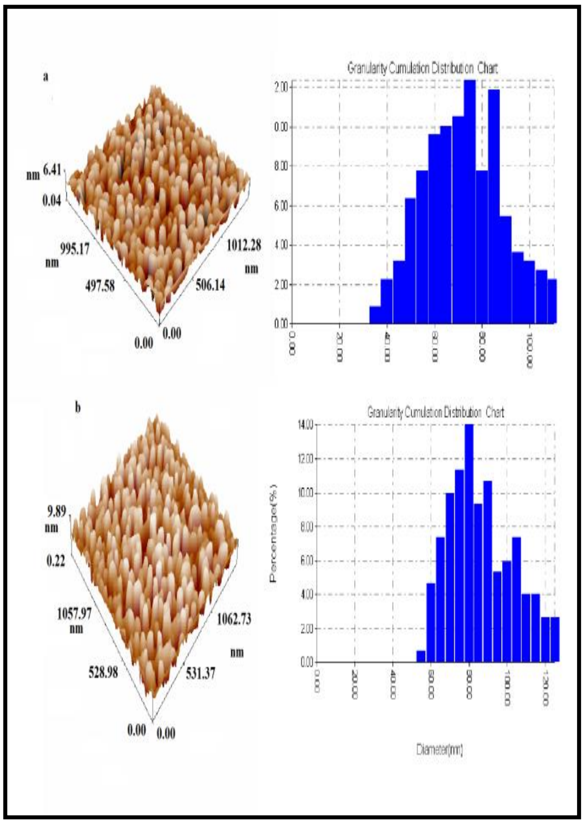

Fig. 2: 3D AFM images of (a)MnS as prepped and (b)MnS 150°C thin film surface and Granularity accumulation distribution chart

Table (1): Average grain, Roughness density and RMS of thin films which as-prepared and annealing temperature 150°C

Sample MnS	Averge G.S(nm)	Rough-ness (nm)	R.M.S (nm)
As prepared	70.01	2.01	2.37
150°C	83.92	1.37	1.62

Figure (3) shows displays the transmission as a function of wavelength of MnS thin films is which prepared by thermal evaporation techniques and deposited on glass substrate . It is obvious that the film gives good transparency characteristics at the spectral range (600- 1000) nm .The date is corrected for glass in UV-regain ,the transmission is sharply increases because of the wide of absorbed particle size .Also the Figure (3) that transmission decrease at the annealing temperature (as prepared and 150) °C, the maximum value of transmittance (90.15 and 61.23)%, (as prepared and and 150) C^° respectively, that is indicated as window on solar cell application at the rang to N- IR or the material (MnS) can be describe in absorber material below 550 nm.

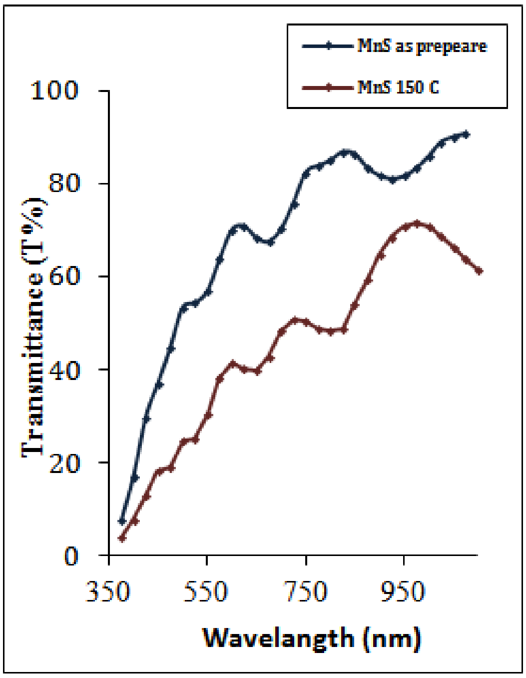

Fig.3: Optical transmittance of MnS thin films which prepared at annealing temperature (as-prepared , and 150) °C

The optical energy gap of MnS was calculated by the tauc relation [9].

$\alpha hv = A(hv - Eg)^n$ ... (2)

Where A is a constant, v is the transition frequency and the exponent n characterizes the nature of band transition. $n = 1/2$ and $3/2$ corresponds to direct allowed and direct forbidden transitions and $n = 2$ and 3 corresponds to indirect allowed and indirect forbidden transitions, respectively.Figure (4) shows the band gap of MnS thin films is which prepared by thermal evaporation techniques and deposited on glass substrate. measured from the plot of the square of $(\alpha h\upsilon)^2$ versus photon energy hυ (where α is the absorption coefficient) by extrapo-lating the linear part of the curve toward the photon energy axis.The optical energy gap of MnS is found to be (3.05 and 3.19) eV for (as prepared and 150) °C respectively, where the (E_g) increases with increases the annealing temperature this values are agree with the values obtained by [18].

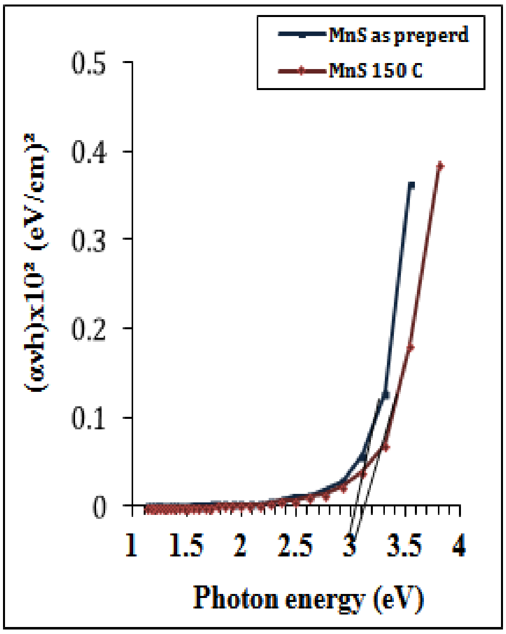

Fig. 4: Plot of (αhv)2 versus hv curve of as-prepared MnS and MnS 150 °C thin films

Figure (5) show the I-V dark characteristics in forward and reverse direction of Al/MnS/Si/Al hetero-junction (as prepared and 150) °C respectively. The forward current of hetrojunction is very small at voltage less than (1.2) V for MnS) as-prepared and (0.8)V for 150 °C annealing temperature . The current is known as recombination current which occurs at low voltages only. It is generated when each electron excited form valence band to conductive band. The second region at high voltage represented the diffusion or bending region ,which depending on serried resistance .In this region; the bias voltage can deliver electrons with enough energy to penetrate the barrier between the two sides of the junction.

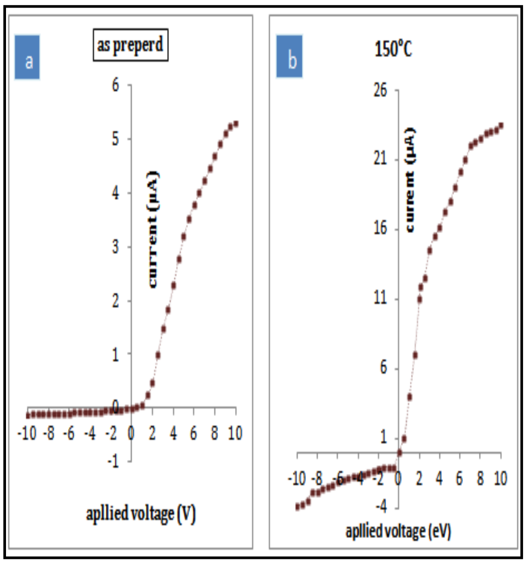

Fig.5.I-V characteristic under forw-ard reverse bias of the Al /MnS/Si /Al for (a)-MnS as prepared and (b) MnS 150°C

Figure 6 show that the reversed current-voltage characteristics of the device measured in the photocurrent under (26.6) W/cm tungsten lamp illuminations. It can be seen that the reverse current value at a given voltage for Al/MnS/Si/Al heterodiode (as prepared and 150) °C under illumine-tion is higher than that in the dark and it can be seen from these figure that the current value at a given voltage for hetero-junction under illumination is higher than that in dark , this indicate that the light generated carrier –contributing photocurrent due to the production of electron –hole as a result of the light absorption. This behavior yield useful information on the electron-hole pairs, which are effectively generated in the junction by incident photons .

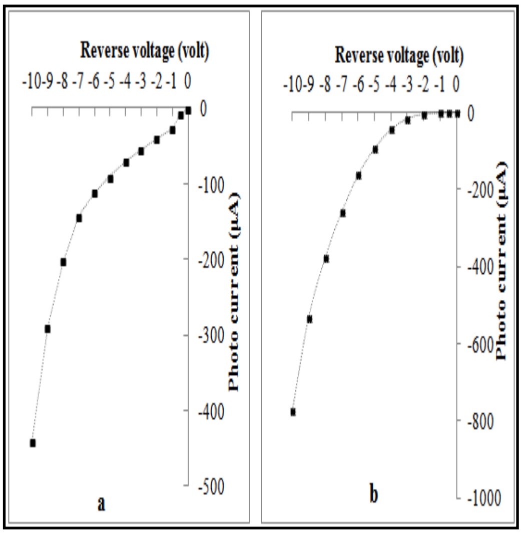

Fig.6.I-Vcharacteristic under forward reverse bias of the Al /MnS /Si/Al for (a)MnS as prepared and (b) MnS 150°C)

Figure (7) and Table (2) Show the I-V,characteristics for for Al/MnS /Si/Al (as prepared and 150)° C the measured short-circuit current, open -circuit voltage , fill factor and Efficiency .

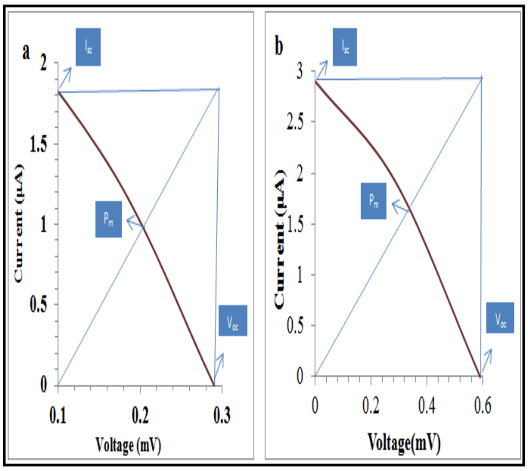

Fig. 7: I-V characteristics for Al/MnS/Si/Al heterodiode for (a. MnS as prepared and b. MnS 150°C) .

Table (2) show The values of each of the Voc, Isc, Pm, F.F and η solar cell for the Al /MnS/Si /Al for (a)-MnS as prepared and (b) MnS 150°C

Samples	V_{oc} mV	I_{sc}μA	P_m	F. F %	η%
MnS as prepared	0.215	2.5	0.232	40.46	1.066
MnS 150°C	0.59	2.9	0.48	28.05	1.7

Conclusion

The Al/P-MnS/n-Si/Al heterojunction was successfully fabricated by using thermal evaporation technique at different temperature (as prepped and 150 °C). The I-V characteristics of heterojunction (as prepped and 150 °C) MnS are strongly dependent on the structure .The Silicon improves the performance the MnS heterojunction solar cell to be very efficient materials for solar cell applications

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