Electrical and Optical Properties of Lead Sulfide Thin Films

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ABSTRACT. Polycrystalline PbS thin films were prepared by spray pyrolysis techniques. The starting solution was prepared from equal molarities (0.1M) of lead acetate (Pb $(CH_3COO)_2$, $3H_2O$), and thiourea $SC(NH_2)_2$ in distilled water which are added to each other in the volume ratio 1/3. The mixture obtained is immediately sprayed onto a cleaned heated glass substrate. Clean compressed air at a flow rate of 20 L/min was used as carrier gas with volumetric solution flow of 100 mL/h. The effect of substrate temperature on the structure features were investigated suggesting that films are polycrystalline with cubic microcrystalites. The diffractograms of films prepared at different substrate temperatures from 175°C to 400°C with step 25°C show the presence of well-defined peaks that indicate the films are polycrystalline in nature. The overall intensity of refraction increased as the substrate temperature increased without the appearance of any new peaks. Optical measurements were carried out on films deposited on glass substrate at 200°C, 250°C, 300°C, 350°C,and 400°C and 30 minutes spray time. The films show homogeneity and high absorption coefficient more than $3 \times 10^5 cm^{-1}$. The optical energy gap of PbS thin films was estimated from the optical measurements. The intercept of the extrapolations to zero absorption with photon energy axis are taken as the values of the direct energy gap with average value of about 0.55±0.02eV for the films. The electrical measurements show an extrinsic semiconducting behaviour with activation energy of about 0.247,0.234,0.23,0.22, and 0.21eV for films deposited on glass substrate at 200°C, 250°C, 300°C, 350°C, and 400°C respectively.

1. Introduction

Solar energy is an extensive low-intensity energy source whose economic feasibility relies on efficient collection, retention, and utilization. Efficient power generation based on photo-thermal conversion of solar energy requires panels that absorb strongly in the solar spectral region while emitting very weakly at operating temperature that may be as high as 573K[1]. Lead sulfide is very versatile material which find wide applications. So PbS thin films have been used as ideal selective surfaces for photothermal conversion applications[2][3]. It is important as electronic and optoelectronic devices[4][5], in infrared photography[6], optoelectronic devices, photoconductive cells, photovoltic cells, contactless thermometers[2], and high absorption coefficient continuously increasing from the infrared

through the visible region[7]. PbS is black semiconductor with a band gap of 0.4 eV, and a relative cut—off wavelength of 3 μm[8]. It is used in infrared detectors since the mid 1940s[9], for photodetector applications. Later in solar energy research, PbS thin films have been used as selective surfaces for photothermal conversion applications, either independently on metallic substrates[3.10] or in multi layers stacks of PbS-CdS-PbS[11], $(PbS)_{1-x}(CdS)_x$[12] compositions. Also used as solar control coating applications in the region with warm climates of thin films of 0.05—0.15μm thick deposited on glass substrates in single layer. Lead sulfide is a very versatile material and has been studied extensively due to their wide application as near infrared detectors[13]. M.M.Rahman[14] prepared $CuS_{1-x} PbS_x$ coating by spray and screen printing method, and showed that good solar selective coating of $CuS_{1-x} PbS_x$ with about 10% PbS may be obtained by Spray method. George *et al.*[15] have prepared PbS films by reactive evaporation in sulfur atmosphere for the first time and showed that these films are P-type, and the mobility is temperature activated, and have high thermoelectric power. Robert *et al.*[16] have studied theoretically and experimentally the dependence of the absorpetivity and emissivity of PbS films on thickness. Both results predict optimum absorpetivity/emissivity (a/e) values for thickness range 300—800 Å. PbS selective coatings with a solar absorptance of 0.9—0.95 and a normal emittance of 0.1—0.3 were prepared by spray pyrolsis on commercial aluminum substrates[17]. Mohammad shows that the use of SnO_2 : F and PbS coating will improve the stagnation temperature by about 10°C and that use of SnO_2 : F on glass plate will further improve the stagnation temperature especially in the case of high operating temperature collectors where radiation losses are greater[18].

The aim of this work is to investigate the effect of the preparation parameters of the spray pyrolysis technique (substrate temperature, spray time (thickness), solution concentration, gas and solution flow rates) on PbS thin films. Physical properties of PbS thin films prepared by spray pyrolysis technique (inexpensive cost) are studied to optimize the fabrication parameters to use as solar absorber or in solar collector or for solar cell fabricate.

2. Experimental Details

Spray pyrolysis technique is a chemical deposition technique in which fine droplets of desired material solution are sprayed onto a heated substrate. This system is easy and simple, it allows a continuous deposition of large area with thin solid films on different substrate[19]. The starting solution was prepared from equal molarities (0.1 M) of lead acetate (Pb $(CH_3COO)_2$. $3H_2O$) and thiourea, $SC(NH_2)_2$ in distilled water added to each other by the volume ratio 1/3. The mixture obtained is immediately sprayed onto a heated glass substrate. These substrates were cleaned by HCl, then washed by distilled water followed by cleaning with acetone, methanol and isopropanole respectively in ultrasonic cleaner. Then the substrates are rinsed by bi-distilled water and dried by filtered air just before spraying. Clean compressed air at a flow rate of 20 L/min,. was used as carrier gas, with volumetric solution flow of 100 mL/h. one set of films were deposited at substrate temperature of 175°C to 400 °C step 25°C where the deposition time was kept constant at 30 min. deposition time. The spray process gives optically brownish stable and good adhesion polycrystalline film on glass according to the chemical reaction[17]. The film thickness was measured by a mechanical stylus method.

$$\overset{\displaystyle S}{\underset{\displaystyle |}{|}}$$

$$NH_2\text{---}C\text{---}NH_2 + 2H_2O \text{ -------------- } CO_2 + 2NH_3 + H_2S$$

$$Pb(CH_3COO)_2 + H_2S \text{ -------------- } PbS + 2CH_3COOH$$

(Talysurf Stylus measuring instrument with an experimental error ±3.5 %) and it is about 0.25 μm.

3. Measurements

The structure of the thin films were investigated by using an x-ray diffractometer Phillips model PW/1710 with Ni filter and CuKα radiation of wavelength 1.542 Å. The x-ray tube was operated at 40KV and 30mA. The condition of the recorded X-ray diffraction patterns were obtained using scanning speed 2° per minute and scanning angular range 2θ = 4° to 90°.

The spectral distribution of transmittance and reflectance of each film were measured using JASCO V-570 UV/VIS/NIR spectrophotometer. The transmittance and reflectance of the films were measured at room temperature using un-polarized light at normal incidence in the wavelength 200-2500 nm.

Ohmic contacts with Au were made to the ends of the PbS thin films by thermal evaporation. The specimens were mounted in a vacuum cell which was evacuated to a pressure of 10^{-3} Torr. The samples heated in the dark from the ambient temperature (300 K) to 473 K. D.C. potential difference of 20 V from Power Supply Model 1030 A was applied at the two electrodes (the areas of the films were about 5mm x10 mm). The current was measured by electrometer type 160B Digital Multimeter; K-Keithley with a sensitivity of ± 0.3%.

4. Results and Discussions

4.1. *Structure*

Figure (1) shows diffractograms of films prepared at different substrate temperature from 175°C to 400°C step 50°C and at a constant deposition time of 30 min. The x-ray diffractograms show that the samples under test are crystalline all over the covered temperature range. The overall intensity of reflection peaks increased as the substrate temperature increased with no new reflections. This means that the substrate temperature 175°C, which is the lowest one, is high enough to allow the appearance of all probable crystalline phases. So the main features of the diffraction patterns are the same but only the peak intensity is varied. This indicates a preferential orientation on the microcrystalline with the (200) and (111) direction perpendicular to the substrate. The diffraction peaks observed at 2θ equal 26, 30, and 43° corresponding respectively to (111), (200), and (220) planes of cubic PhS as confirmed by ASTM card. In all cases the intensity of the peak (200) is the highest one, except the 400°C the intensity of plane decreases and the intensity of plane (111) increase, this may be due to a type of crystal modification of the PbS. At 350°C the intensity of (111) appears equal to that at (200). The intensity of (200) plane decreased slightly as the temperature increased from 200 to 250°C, then it tends to decrease at the higher temperature. The intensity of the peak (111) is increased by high rate as the temperature increases from175°C to 200°C. This rate becomes slight till 350°C, but

the highest intensity was detected at 400°C, i.e. as the temperature increases from 200°C to 400°C. The intensity of (200) decreases while the intensity of (111) increases. The intensity of (220) peak was extremely low in comparison with the (200) and (111). This indicates a preferential orientation on the microcrystalline with the (200) and (111) direction. The high symmetry of the structure and the best crystalline of the film were formed in the temperature range from 200°C to 300°C. Phases identification revealed that only cubic PbS is formed. The lattice parameter of PbS thin films were calculated by PDP computer program[20], change from 5.96 Å to 5.93 Å as the substrate temperature increased from 175°C to 400°C. Table (1) shows the observed I/Io ratio for films prepared at different substrate temperature, and the ratio I/Io of ASTM card.
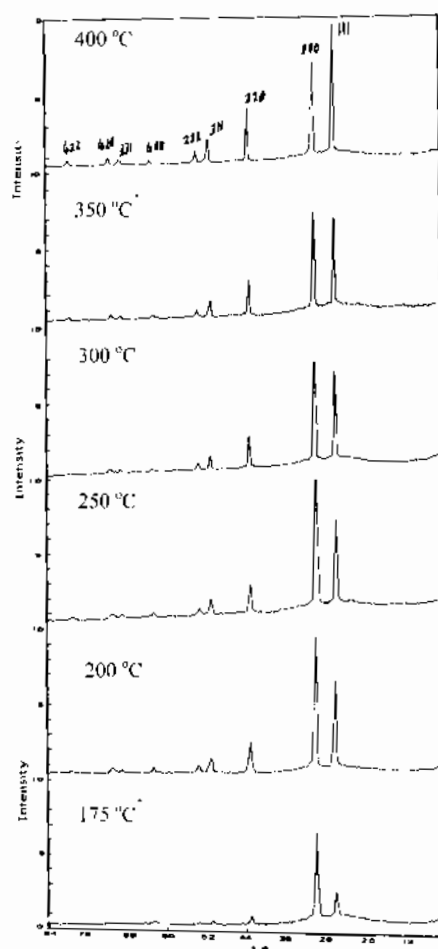

Fig. 1. X-ray Diffraction of PbS Thin Films Prepared by Spray Pyrolysis Technique at Different Substrate Temperature Range From 175°C to 400°C Step 50°C and During Constant Deposition Time of 30 min.

Table 1. I / Io ratio for films prepared at different substrate Temperature and the I / Io of ASTM card.

Stander Data			Observed Data						
" ASTM"			Substrate Temperature ; °C						
Plane	D	I/Io	d	175	200	250	300	350	400
111	3.429	84	3.4503	27.3	59.4	66.9	89	95.1	142.4
200	2.969	100	2.9957	100	100	100	100	100	100
220	2.099	57	2.1017	09.2	21.2	23.4	34.4	35.9	55.6
311	1.790	35	1.7909	04.6	10.3	11.8	15	17.6	24.8
222	1.714	16	1.7173	2.98	04.7	05.3	06.9	08.5	14.1
400	1.484	10	1.4859	03.5	04.3	04.3	3.75	04.3	05.1
331	1.362	10	1.3651	000	01.7	2.66	03.4	03.9	6.4
420	1.327	17	1.3305	000	3.4	04.1	04.4	06.2	09.4
422	1.212	10	1.2142	000	02.35	02.4	04.1	03.9	05.7
511	1.1424	6	1.1445	000	000	000	000	000	000

Tahle (1) shows that PbS films prepared at different substrate temperatures have different intensity from that reorded in the ASTM card for PbS powder while there is no change in their positions. This could be explained by the existence of some kind of preferential orientation of crystallites or in other words, by the formation of texture in the prepared films. Also the sharpness of the peaks indicate the good crystallenity of the obtained films.

Although broadening of x-ray line profiles is also due to strain, it is not possible to separate these effects by an integral breadth method, because of the abscnce of higher order reflections. So the mean grain size of the grown up crystallities was calculated using the Scherrer's formula[21]; Equ.(1), and the strain between them was calculated using Equ.(2)

$$D \ = K\lambda / \ (\Delta (2\theta) \ cos(\theta)) \tag{1}$$

$$S \ = \ \Delta(2\theta)/(2tan(\theta)) \tag{2}$$

Where,

D   is the mean dimension of the crystallite perpendicular to the diffraction plane.

$\Delta(2\theta)$ is the full width at half maximum of the diffraction line in radian

λ is the X-ray wavelength equal to 1.542 Å

K   is the shape factor ~ 0.94

θ is the diffraction angle for diffraction line position

S   is the maximum propability of strain

Figure (2) shows, the variation of the grain size and strain, as a function of substrate temperature for the two planes (111) (200), as the preferred planes of PbS thin films prepared by spray pyrolysis technique at different substrate range from 175°C to 400°C step 50°C and a constant deposition time of 30 min. The grain size increases as the substrate temperature increases and the strain decreases in the same sense. The increase of the grain size may increase the surface area of each grain, which lead to the increase of the pores between grains and reduce the force per unit area on each two adjaeent grains[22], i.e. reduce the strain. The grains of plane (200) are higher than that of plane (111). Figure (2) also confirms the point of view of improving the crystallite quality as the grain size

increases while the strain in between them decreases, i.e. the crystallites improved in relaxed media[23].

4.2. Scanning Micrograph

Figure (3) shows the surface morphology of PbS thin films prepared by Spray pyrolysis technique. The films prepared at different substrate temperature 175°C, 250°C, and 400°C and at constant deposition time of 30 min.. At different temperatures the morphology of the polycrystalline PbS films have a continuous spongy weaves. At the lowest temperature the crystals are poorly orderly distributed while at higher temperature the crystals are well in order. On the other hand, at the highest temperature the crystals become in optimum ordering condition and with bigger grain sizes as shown in Fig. (3a,b,c) (magnification of 500 x)[23].
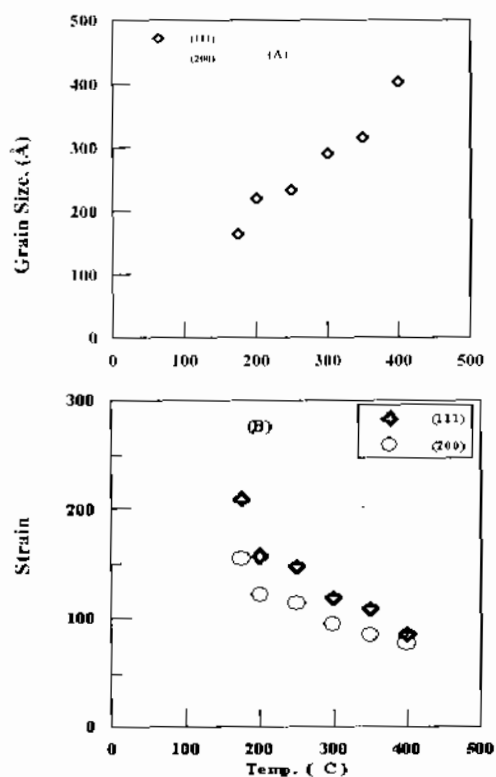

Fig. 2. The grain size (A) and strain (B) of PbS thin films prepared by spray pyrolysis technique at different substrate temperature from 175°C to 400°C step 50°C and 30 min. deposition time.
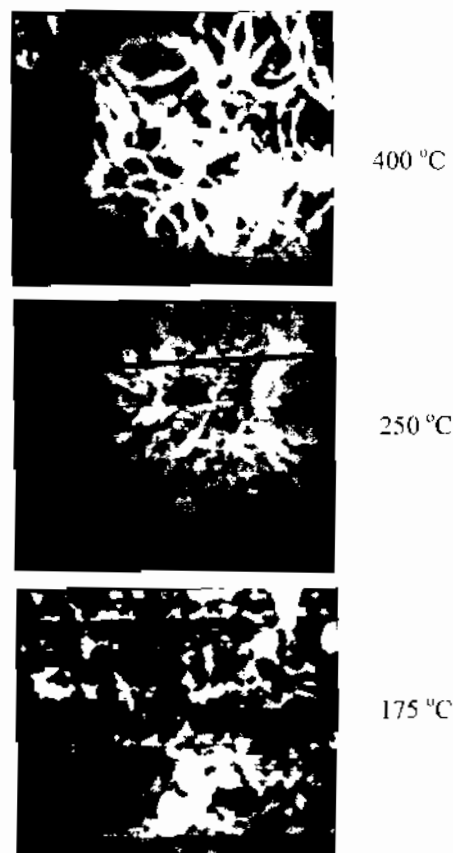

Fig. 3. Thin films prepared at 30 min. deposition time and at different substrate temperature.

4.3. Optical Properties

Figure (4) shows the optical spectra of the reflectance of PbS thin films versus the wavelength from 200 nm to 2500 nm. The PbS thin films deposited at different substrate temperature from 200 to 400 °C step 50 °C and at constant deposition time of 30 min. This figure shows that the reflectance has the same behaviour at different substrate temperature. The reflectance increases gradually in the visible region from about 16.0 % to 19.0 % (200

ºC) and from about 21.9 % to 24.0 % (400 ºC). At 810 nm very small peak was detected, then the reflectance increased steadily in the near infrared region and reached about 31.7 % (250 ºC) and 36 % (400 ºC) at the wavelength 2500 nm. The reflectance increases as the substrate temperature increases from 200 to 400 ºC. This could be attributed to the compactness of the film at higher temperature. This behaviour means that the reflectance depends on two parameters, the first is surface function while the second is a wavelength function. As the radiation falls on any surface in controlled manner short wavelength will fall first and then increases gradually. At short wavelength that will be in the order of the grain size or less the reflection will be sensitive and representing the surface topology, and the reflectance vibrates between minimum and maximum. This behaviour will continue till the wavelength (λ) becomes greater than the grain size of the given sample, i.e. the sensitivity changes and the reflectance attains the maximum value[24]. The effect of temperature is to increase the reflectance since the grain size is a function of temperature, i.e. PbS thin films have minimum reflection in the visible region which may mean that this material is suitable to be used as solar absorber applications[3,25].
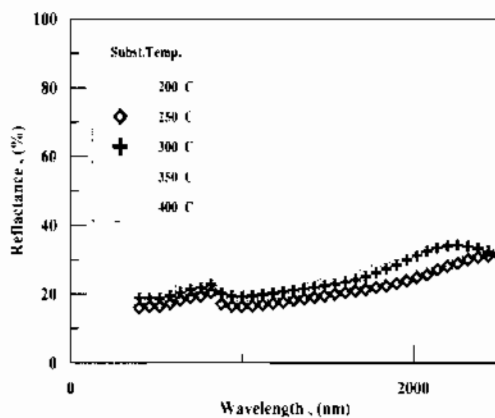

Fig. 4. Reflactance vs. wavelength for pbs thin films prepared by spray pyrolysis technique at different substrate temperature from 200ºC to 400ºC, and 30min. deposition time.
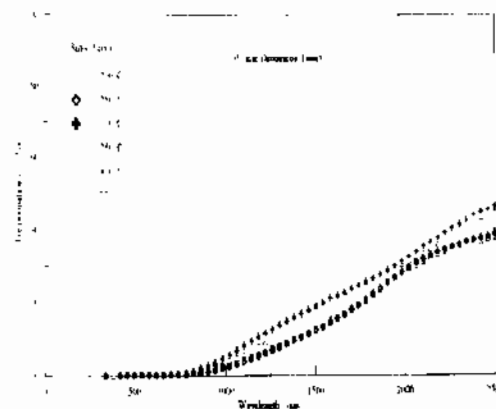
Fig. 5. Transmittance vs. wavelength for PbS thin films prepared by spray pyrolysis technique at different substrate temperature from 200ºC to 400ºC, and 30min. deposition time.

Figure (5) shows the wavelength dependence of the transmittance of PbS thin layers deposited at 200, 250, 300, 350, and 400ºC substrate temperature during constant deposition time 30 min in wavelength range 200 nm to 2500 nm. The general behaviour of this spectrum is the increase of transmittance as wavelength increases keeping in mined that the effective increment starts nearly at 850nm, while in the law wavelength range the transmission was nearly zero. From our previous point of view the grain size is a function of substrate temperature, the transmittance will decrease as substrate temperature increases. In other words the prepared thin film becomes more opaque as substrate temperature increases. The noticed is anomalous at substrate temperature 300 and 350 ºC and may be due to time mistake or due to the change of the deposition rate to be slow than the rest of substrate temperatures. Also from the figure the maximum transmittance was at about 47%, while the minimum transmittance was about 37% which mean that the transmittance decreases by about 10% as the substrate temperature increases to 400ºC. The algebraic sum of the reflectance and transmittance at any substrate temperature and at any given wavelength illustrates that PbS layers are suitable to be employed as absorber in different solar applications[18]. The absorption coefficient (α) can be calculated using Equ. (3)[26]

$$\alpha = \frac{1}{d} \ln \{ \frac{(1-R)^2}{2T} + [\frac{(1-R)^4}{4T^2} + R^2]^{0.5} \} \qquad (3)$$

Where,

α = Absorption coefficient ($4\pi k / \lambda$)   (cm^{-1})

k = Extinction coefficient   (non)

R = Reflection   (%)

T = Transmission   (%)

λ = Wavelength   (nm)

d = Film thickness   (nm)

Figure (6) shows the ealculated absorption coefficient (α) versus the wavelength from 200 nm to 2500 nm of PbS thin films, for films deposited at different substrate temperatures ranging from 200°C to 400°C step 50°C and at a eonstant deposition time of 30 min. Generally, the absorption coefficient α decreases as the wavelength increases. The maximum value of α for all such temperatures was in the visible region with an average value of about 3.5×10^5 cm^{-1} and the minimum value was at 2500 nm (near IR)[8]. The increase in the absorption coefficient could be related to the increase of the degree of crystallinity and the size of crystallite as the substrate temperature increases. The optical band gap is defined as the minimum energy needed to excite an electron from the valence band to the conduction band. The optical band gap was determined from the analysis of the spectral dependence of the absorption in the vicinity of the fundamental absorption edge. In this case, the interband absorption theory shows that the absorption coefficient can he obtained using Equ.(4)[27].

$$\alpha h v = A(h v - E_g)^b \qquad (4)$$

Where,

E_g = is the optical band gap

v = is the frequency

A = is a constant, depends on the transition probability

b = is a constant determines the type of transition

It is known that, PbS has a direct band gap, therefore the constant b is equal to ½ (for an allowed direct transition). In our case this is confirmed by drawing α against hv where the fundamental absorption edge is due to the allowed direet transition at wavelength of about 2400nm (0.55eV). The optical energy gap of PbS thin films were estimated from the intersect of tbe extrapolation to zero absorption with the photon energy axis.

Figure (7) shows the variation of $(\alpha h v)^2$ versus the photon energy (h v) of PbS thin films prepared by spray pyrolysis technique, deposited at different substrate temperature from 200 °C to 400 °C step 50 °C and at deposition time of 30 min. At different substrate temperature the energy gap of PbS thin films are 0.545, 0.55, 0.57, 0.543, and 0.54 eV as the substrate temperature increases. These results are similar to the results given by Reddy[28]. So PbS thin film with its narrow bandgap is a good material used as solar absorber.
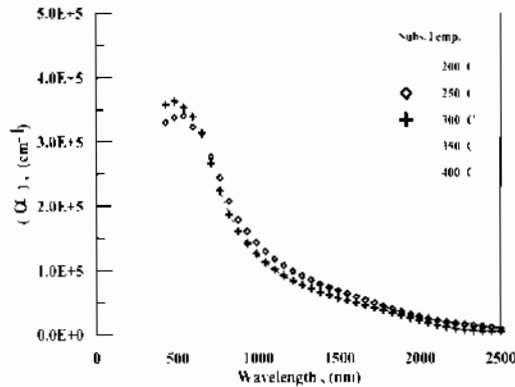
Fig. 6. Absorption coefficient vs wavelength for PbS thin films prepared by spray pyrolysis technique at different sub substrate temperature from 200°C to 400°C step 50°C, and 30 min. deposition time.
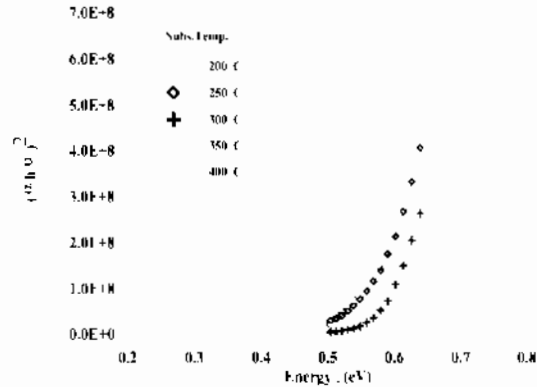
Fig. 7. $(\alpha h v)^2$ vs Photon energy for PbS thin films prepared by spray pyrolysis technique at different substrate temperature from 200°C to 400°C step 50°C, and 30 min. deposition time.

The extinction coefficient (k) can be considered as a result of the bsorption of light by the atoms in the bulk material. While in the case of the thin films, it is not fully due to the absorption of the atoms but depends on the surface roughness, polycrystallinity, grain size, impurity, etc. All these factors change the attenuation of light in the thin film and hence cause a change in the apparent value of the extinction coefficient (k). The extinction coefficient (k) was related to α as given in Equ. (5)

$$\alpha = 4 \pi k / \lambda \tag{5}$$

Figure (8) shows the wavelength dependence of the calculated extinction coefficient of PbS thin films prepared by spray pyrolysis technique in the wavelength range from 200 nm to 2500 nm. The general behaviour of extinction coefficient versus wavelength is the increase of extinction coefficient in part (a-b), till maximum value around range 700-800 nm, then the extinction coefficient decreass again reaching minimum value as the wavelength becomes maximum. This behaviour can be explained by the degree of smoothing of the thin film surface. As the degree of surface non-uniformity is high, the extinction coefficient will be high. The value of k increases in low wavelength region (a—b) due to the high senstivity of reflected part of radiation. In the range (b—c) where the wavelength increases the senstivity of the reflected radiation decreases and as a result the extinction coefficient decreases. The refractive index n can be calculated using Equ. (6).

$$R = \{ (n-1)^2 + k^2 \} / \{ (n+1)^2 + k^2 \} \tag{6}$$

Figure (9) shows the energy dependence of the calculated refractive index of PbS thin films in the energy range from 0.5 eV to 3 eV at the substrate temperature 200,250,300,350, and 400 °C and deposition time of 30 min.. The general behaviour of the refractive index versus energy is the sharp decrease of refractive index from a to b and then slight increase to c, and finally constant around 1.5 as the energy increases for all the substrate temperatures. This may be explained on the basis of the degree of the surface smoothing and sensitivity of reflectance of radiation. Accordingly PbS is a suitable material to employ as absorber of the visible radiation.
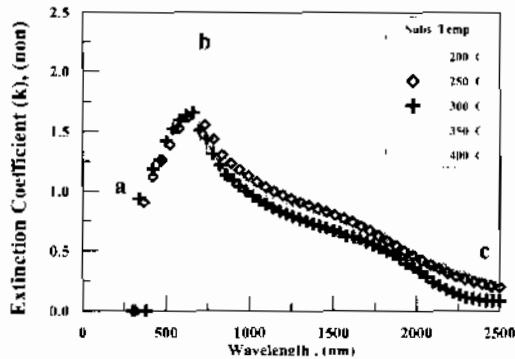
Fig. 8. Extinction Coefficient Vs Wavelength for PbS thin films prepared by pray pyrolysis technique at different sub substrate temperature from 200°C to 400°C step 50°C, and 30 min. deposition time.
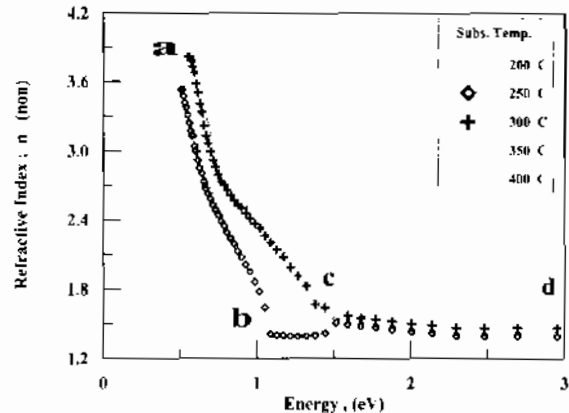
Fig. 9. Refractive Index Vs Wavelength for PbS thin films prepared by spray pyrolysis technique at different substrate temperature from 200°C to 400°C Step 50 °C, and 30 min. deposition time.

4.4. D.C. Conductivity

Electrical measurements of PbS thin films prepared at different substrate temperatures were studied. The measurements of dark conductivity were recorded from the room temperature (300 k) to 473 K under vacum. The temperature dependence of the dark conductivity is given by[29]

$$\sigma = \sigma_0 \, \exp(E_\sigma / KT) \tag{7}$$

where:

σ is dark conductivity,

T   is the absolute temperature of the sample,

K   is the Boltzmann constant,

E_σ is the activation energy of the temperature, dependence of electrical conductivity,

σ_0 is constant depends on the conduction mechanism.

Figure (10) shows the variation of the dark conductivity with temperature for PbS thin films prepared at different substrate temperatures from 200 °C, 400 °C in step of 50°C and during a constant deposition time of 30 min. All the curves have the same behavior. The conductivity increases as the temperature increases, and the activation energy varies between 0.2466 eV to 0.2085 eV as the substrate temperature increases from 200 °C to 400 °C. Table (2) shows the activation energy as well as the optical energy. Comparing the activation energies E_σ and E_g, the main results showed that the activation energy is narrow and E_σ nearly half the value of E_g. This confirms that PbS is a material lies within the range of solar radiation absorber and may be used in solar thermal applications.

Table 2. The activation energy of conduction and the optical energy for PbS thin films prepared at different substrate temperature.

Substrate Temp. °C	Activation Energy of Conduction eV	Optical Energy Gap eV
200	0.2466	0.545
250	0.234	0.55
300	0.2296	0.57
350	0.2195	0.543
400	0.2085	0.54

5. Conclusion

The effect of substrate temperature on the physical properties of PbS thin films prepared by spray pyrolysis technique were investigated. The spray pyrolysis technique has its own merits over the other techniques. A satisfactory, homogeneity, durability, and reproducibility are obtained after many tested tries. The results show that, The prepared PbS thin films are polycrystalline single phase cubic. The crystallinity, grain size, and preferred orientation are improved with increasing temperature. PbS thin films prepared by spray pyrolysis technique have a high absorption coefficient of ordered about 3.5×10^5 cm^{-1} in the visible light. The optical band gap of PbS thin films prepared is about 0.55 ± 0.02 eV. The refractive index range from 4 to 1.5 and the extinction coefficient reached to a maximum value of 2. The D.C. conductivity increases as the temperature increases. The activation energy of PbS thin film is about 0.234 eV, which is approximately half the optical band gap. This value with the other properties confirms that PbS thin film is a material lies within the range of solar radiation absorber. The result shows that all the thin films prepared by spray pyrolysis technique are p-type, and their room temperature conductivity is of the order of 10^{-3} (Ω m)$^{-1}$.

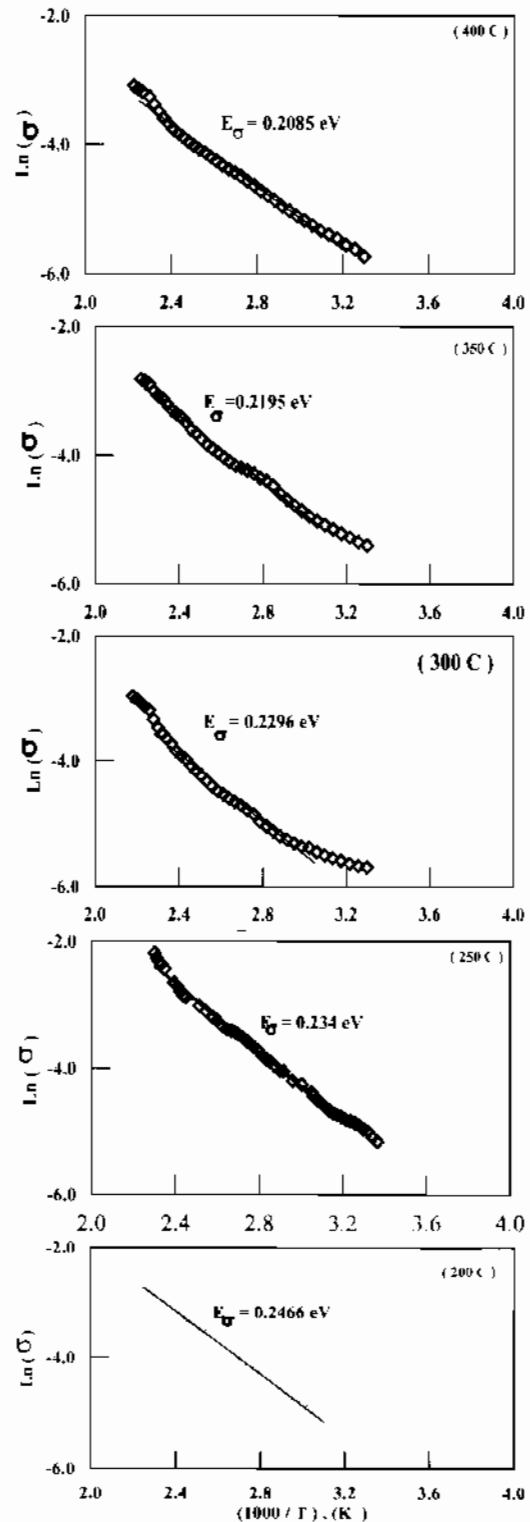
Fig. 10. Variation of Ln(σ) Vs. 1000/T for PbS thin films prepared by spray pyrolysis technique at different substrate temperature from 200°C to 400°C step 50°C, and 30 min. deposition time.

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الخواص الضوئية و الكهربية لأغشية رقيقة من كبريتيد الرصاص

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المستخلص. يتناول هذا البحث دراسة الخواص الفيزيقية لأغشية رقيقة من كبريتيد الرصاص لاستخدامه فى مجال تطبيقات الطاقة الشمسية حيث يستخدم كغشاء ماص للأشعة الشمسية في السخانات الشمسية والخلايا الشمسية. تم تحضير أغشية رقيقة من مركب كبريتيد الرصاص بطريقة الرش الحراري على شرائح زجاجية عند تدرج درجة حرارة التحضير حيث تتراوح بين ١٧٥مْ إلى ٤٠٠ مْ وعند زمن ترسيب ثابت ٣٠ دقيقة. استخدم محلول بتركيز ٠,١ مول مكون من خلات الرصاص والسيوريا بنسبة ٣:١. تم ترذيذ (رش) المحلول بمعدل ١٠٠مم لتر/ساعة مع الهواء الجاف بمعدل ٢٠ لتر/ دقيقة.

ولتوضيح الخصائص الفيزيقية لهذه الأغشية أجريت بعض الاختبارات التركيبية والضوئية والكهربية حيث أوضحت النتائج أن جميع الأغشية الرقيقة المحضرة بطريقة الرش الحراري بلورية التركيب لمركب كبريتيد الرصاص المكعب التبلور فقط وذات تبلور جيد تحت معظم ظروف التحضير. كما أوضحت دراسة الخواص الضوئية للشرائح الرقيقة عند درجة حرارة الغرفة وذلك بقياس النفاذية والانعكاسية لأطوال موجية تتراوح بين ٢٠٠–٢٥٠٠ نانومتر وجود نهايات عظمى فى منحنيات النفاذية يقابلها نهايات صغرى في الانعكاسية، وتتوقف هذه النهايات على ظروف النماء للشرائح. ومن سلوك هذه المنحنيات وجد أنها تتمتع بنفاذة صغيرة جدا تصل إلى حوالي ١٠% في حالة الضوء المرئي، وحوالي ٥٠% في المنطقة NIR، كما أنها تتمتع بانعكاسية صغيرة تصل إلى حوالي ٢٢% في الضوء المرئي وحوالي ٣٤% في المنطقة NIR. كذلك تتمتع هذه الشرائح بمعامل امتصاص (α) عالي يزيد على ٦٠٣×١٠⁵ سم⁻¹ وبذلك فهي مناسبة لعمل شرائح ماصة تستخدم في الخلايا الشمسية والسخانات الشمسية، كذلك أوضحت حسابات معامل الامتصاص الناتجة من

منحنيات النفاذية والانعكاسية عند طول موجي مختلف على وجود فجوة طاقة مباشرة قيمتها حوالي ٠,٥٥±٠,٠٢ إلكترون فولت لجميع ظروف التحضير ، وعليه فان طريقة الرش الحراري تعتبر من الطرق الجيدة في تحضير هذا المركب وبتكلفة قليلة لأمكانية استخدامها كأغشية ماصة للأشعة الشمسية. تم تعيين الموصلية الكهربية في مدى درجات الحرارة من درجة حرارة الغرفة إلى ١٥٠مْ وأوضحت النتائج أن الموصلية الكهربية لها نفس السلوك الكهربي تقريبا وتختلف في مدى التغير طبقا لظروف التحضير، وأن طاقة التنشيط لها حوالي ٠,٢٤٧، ٠,٢٣٤، ٠,٢٣، ٠,٢١، إلكترون فولت بالنسبة للشرائح المحضرة عند درجات حرارة تتراوح بين ٢٠٠مْ الى ٤٠٠مْ . كما أوضحت النتائج أن جميع الأغشية الرقيقة المحضرة بطريقة الرش الحراري لها حوامل تيار من النوع الموجب (P-Type).