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Study of Changes in Structural and Electrical Properties of Thin Film After Irradiation It by Laser

Mohammed A. Mahdi*, Shams B. Ali* & Farah Samir*

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Abstract

This research studied the effective of irradiation by laser on structure and electrical properties of thin film such as lead sulphid PbS, so in the beginning the film has amorphous structure and when irradiation by laser (annealed) the structure properties would change and the no. of peak appeared with different modes but the mode(200) still has large intensity compared with another modes, and the grain size increased with increased the time of irradiation to become (7.5 to 16)nm, and for the electrical properties the film has linear ship between voltage and current, and the conductivity increased when the time of irradiation.

Keywords: annealing, electrical properties.

دراسة التغير في الخواص التركيبية و الكهربائية لغشاء مشعع بالليزر

الخلاصة

يتناول البحث دراسة تأثير التشعيع بالليزر على الخصائص التركيبية و الكهربائية لغشاء مثل كبريتيد الرصاص حيث يظهر تركيب عشوائي لكن يأخذ بالتبلور و ظهور المادة و بروز عدد من القمم بعد التعرض إلى أشعة الليزر و يلاحظ ظهور النمط (200) بالشدة الأكبر بين القمم , و يلاحظ أيضا أن متوسط الأحجام الحبيبية تزداد تدريجياً بزيادة زمن التعرض إلى الليزر لتزداد من nm (7.5 – 16) إضافة إلى إن الغشاء يمتاز بخصائص خطية مابين التيار و الفولتية و يزداد مقدار التيار المار بزيادة زمن التعرض إلى الليزر حيث تزداد التوصيلية الكهربائية على حساب المقاومية الكهربائية.

Introduction

As is well known laser light has many applications[1] in different fields such as (cutting,drilling,welding, annealing,….) so annealing by laser is easily comparison with ordinary methods that used ovens because it's not need selection suitable temperature less[2] than melt point or vapor point so this type of annealing called cold annealing. We used annealing process to change the structure properties of materials[3] such as thin films like (CdS, PbS, PbO,MnS,…), so this method effects on electrical properties because the heat help electron to move from valance band to conductive band so that the electrical conductivity increased and in the same time the resistance decreased.

***Laser and Opto-Electronic Engineering Department, University of Technology/Baghdad**.

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

In this paper we used semiconductors films called (galena)[4,5] with narrow band width equaled (0.38)eV[6] it's preparation by three different methods chemical bath deposition, thermal evaporation and electrical deposition but chemical deposition(C.B.D) used in most because we can get The of large areas of films, can deposition in room temperature, the film has photo-conductivity in the region IR[5,7] (800-3000)nm, the applications of PbS films as detector of Infrared region with wavelength cutoff equals 3100nm[8],the film has high dielectric constant leads to relatively slow detectors (compared to silicon, germanium, InSb or HgCdTe)[7]

Experimental:

a. Deposition PbS film

To prepare PbS we used chemical bath deposition (C.B.D)and it's need to require ions of lead and ions of sulphed so used lead nitrate $Pb(NO_3)_2$ source of lead ions Pb^{+2} and Althauoria $SC(NH_3)_2$ source of sulphed ions S^{-2} and require a base medium so used sodium hydroxide NaOH and a complex (hydroxylamine chlorhidrole) also Bi-salt to control the course of interaction, especially during phases of growth and nucleation and growth show table(1). PbS films deposition on different substrates like (glass, polymer, Si…). We deposited PbS films on glass with dimensions (2.5X2) cm. the interaction can take these steps:

$$Pb(NO_3)_2 + NaOH \rightarrow PbOH + Na(NO_3) \quad .....(1)$$

$$PbOH + SC(NH_2)_2 \rightarrow PbS + H_2O \quad ....(2)$$

Show fig (1).

b. X-Ray diffraction spectra.

To determine the nature of the growth films and structural characteristics of PbS films, X-Ray diffraction measurement has been done and compared with ASTM (American Society of Testing Materials) cards, using Phillips PW 1840 X-Ray diffractometer of λ = 1.54A^o from Cu-Kα. The average grain size (GS)of polycrystalline material can be calculated from the X-Ray spectrum by means of Full Width at Half Maximum (FWHM) method (Scherer relation)[9]

$$G.S = \lambda * A/(\Delta\theta \cos\theta) \quad ......(3)$$

Where:

θ= diffraction angle

λ= 1.54A^o from Cu-Kα.

$\Delta\theta$ =full-width at half maximum of XRD peak appearing at the diffraction angle θ, A the shape factor, the value of which depends on the crystalline shape and ganerally it is 1.

c. annealing Process.

After the preparation of the samples are irradiated them by green laser (CW) with wavelength 532nm and 80mW, before irradiation it we increase the spot size of beam from 1.5mm to 20mm by using beam expander, to cover the sample as show as fig (2), with varying periods of time. Table (2) shows the properties of laser and the time irradiation.

d.Electrical Properties

1. I-V Charistics:

In order to measure the electrical properties we need ohmic contacts. it was obtain by under vacuum of Aluminum wire of high purity on the surface of film from fig (3) you can show the shape of electrodes. We would use just forward base. To measure the resistance of film we measure the slop and apply equation (4):

$$R = (slop)^{-1} \quad ..(4)$$

$$Slop = V/I \quad ...(5)$$

e. Electrical conductivity

To measure the electrical conductivity we measure the electrical resistivity of the deposition films was determined by equation(6):

$\rho = R(x*y/l)$ .....(6)

Where:

R :resistance of film.

x,y: length and width of film.

t: the thickness of film.

later we can determine the conductivity by equation(7):

$\sigma = 1/\rho$ ..... (7)

Results and discussion:

- **Structure Properties**

When deposition any film we must made test of X-Ray diffraction to known the natural of film if it amorphous or crystalline and later determine the grain size of it, so from show fig(4) the film has amorphous structure but it began crystalline when it radiation by laser and the intensity of peaks increased with increased in the time of radiation and the peak of material appeared in different planes(200,220,111) but the plane (200)has higher intensity than that another planes show fig(5,6,7), and the grain size increased with increasing the time of irradiation show fig(8) because the heat that came from laser led to unite the grain between them in addition the edges of grain smooth. And from the same shape we didn't find any bend in diffraction angles of films this led to the films hadn't any defects in structure of film.

- **Electrical properties**

PbS film had conductivity p-type because the film deposited without vacuum system from fig (10) we found the film has linear relation between current and voltage so when voltage increased the current that cross in the film increased too, in addition we found the electrical conductivity increased with increased in irradiation time because the united of grains execute to increase the free path of electron so that collision between electrons decreased therefore the conductivity increased show fig(11).

Conclusions1.PbS films have polycrystalline structure,but the no. of plans appeared when made annealing process.

2.Increasing in the grain size with increasing in the time of radiation.

3.Omic properties appeared on the film.

4.The electrical conductivity increased when the time of irradiation increased.

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Table (1)

Contact of chemical Bath	Quantity	PH	Time of Deposition hr	Temperature K
Pb $(NO_3)_2$	0.5M	12	2	300 Room temp.
SC $(NH_3)_2$	1M			
NaOH	0.5M			
hydroxylamine chlorhidrole	1ml			
Bi-salt	0.5M			

Table (2)

Laser type	Mode	Power	Intensity Before expand beam	Intensity after expand beam	Time of Irradiation
Semiconductor	CW	80mWatt	45.29 mW/mm^2	0.255 mW/mm^2	10 min
					20 min
					30 min

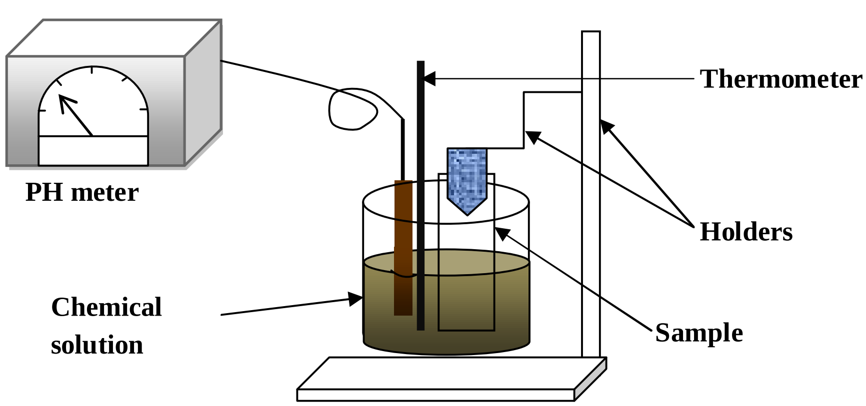

Figure (1) show the setup of deposition system

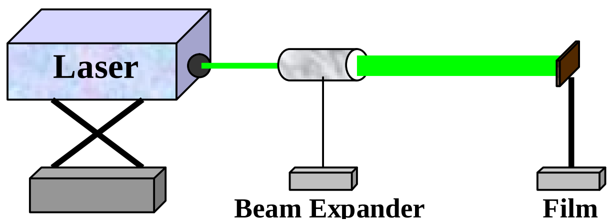

Figure (2) Show the setup of process of annealing

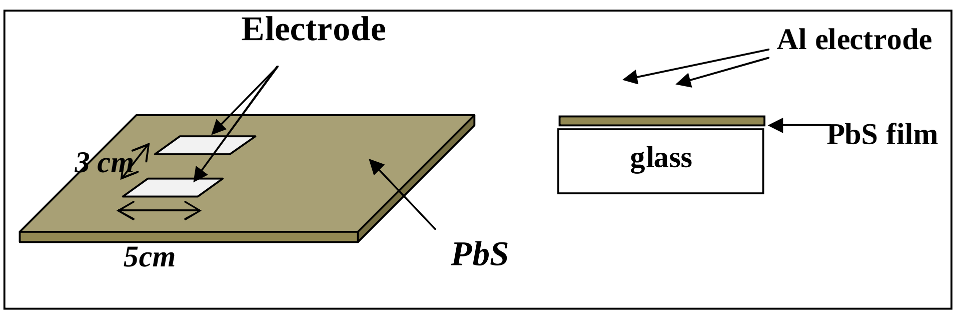

Figure (3) Show the shape of electrodes in the thin film

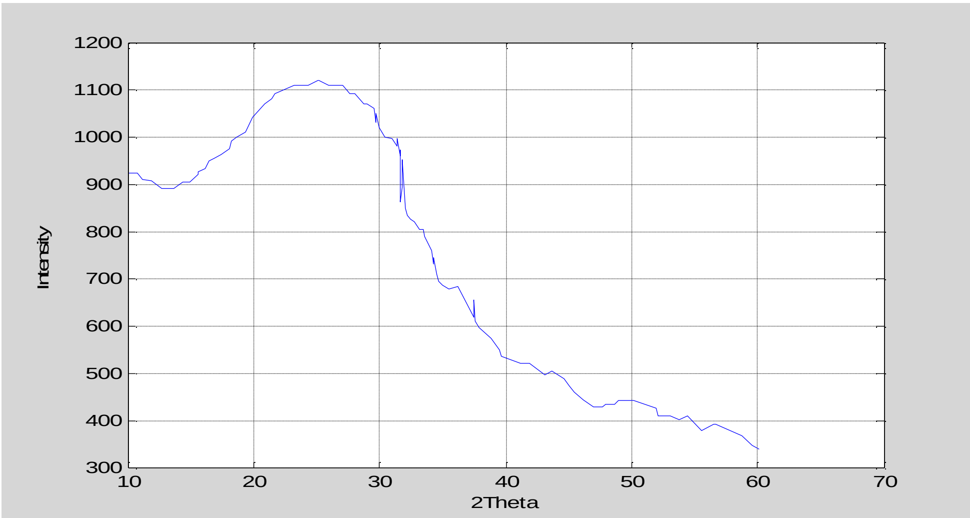

Figure (4) show the amorphous structure of PbS film before irradiation

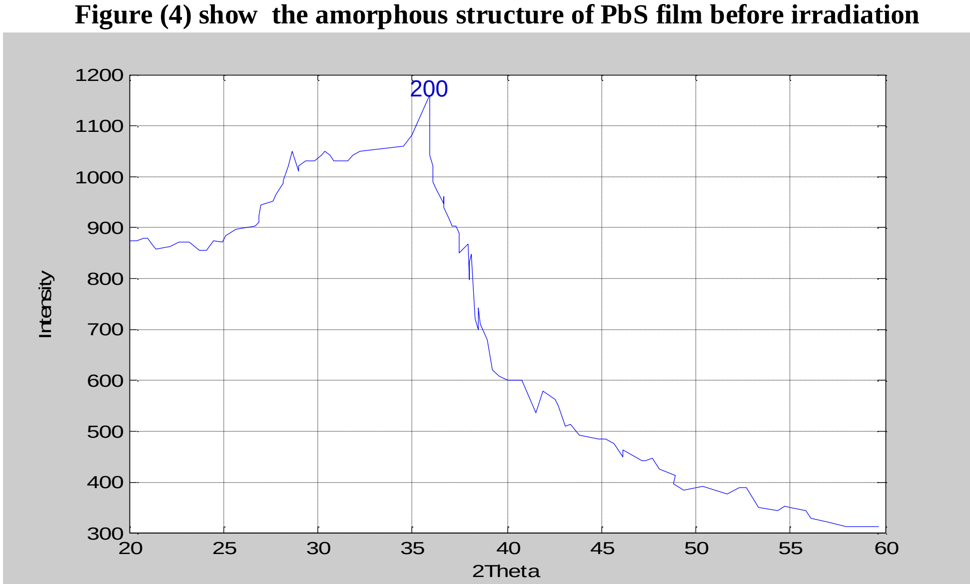

Figure (5) Show the crystalline structure of film after 10 min from irradiation

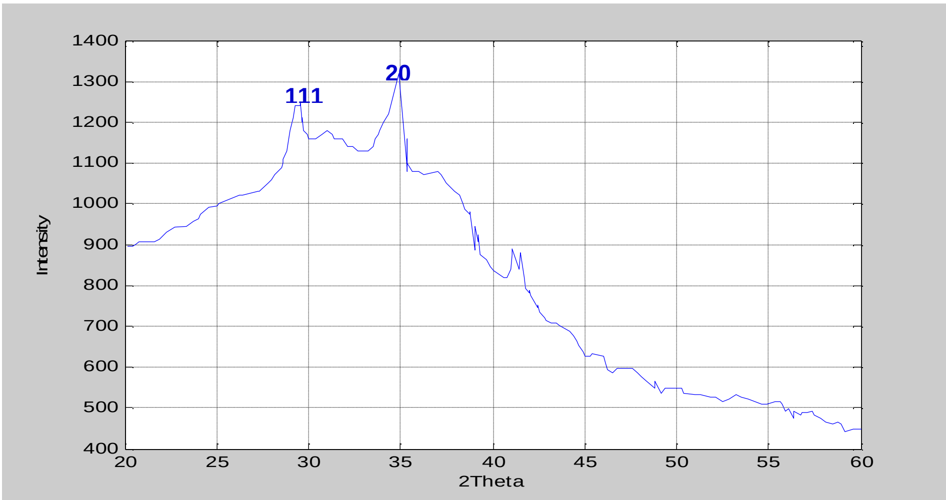

Figure (6) Show the crystalline structure of film after 20 min from irradiation

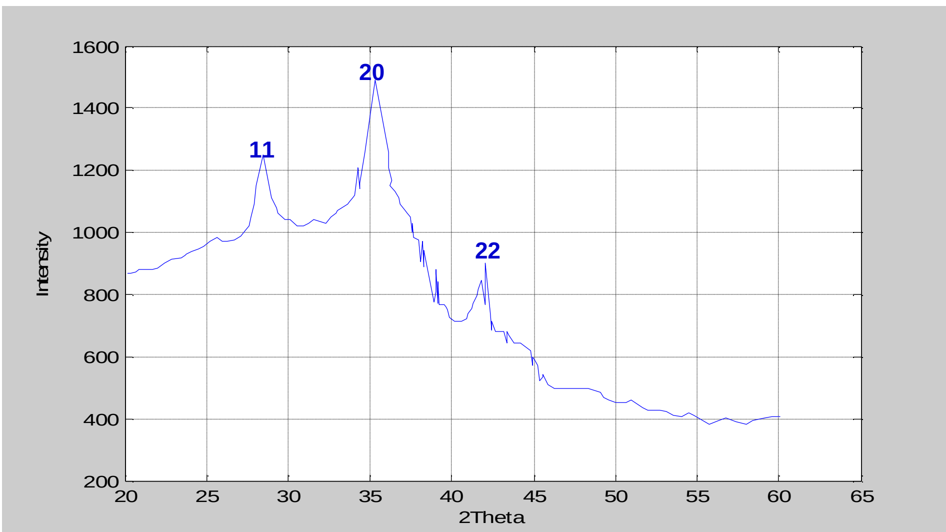

Figure (7) Show the crystalline structure of film after 10 min from irradiation

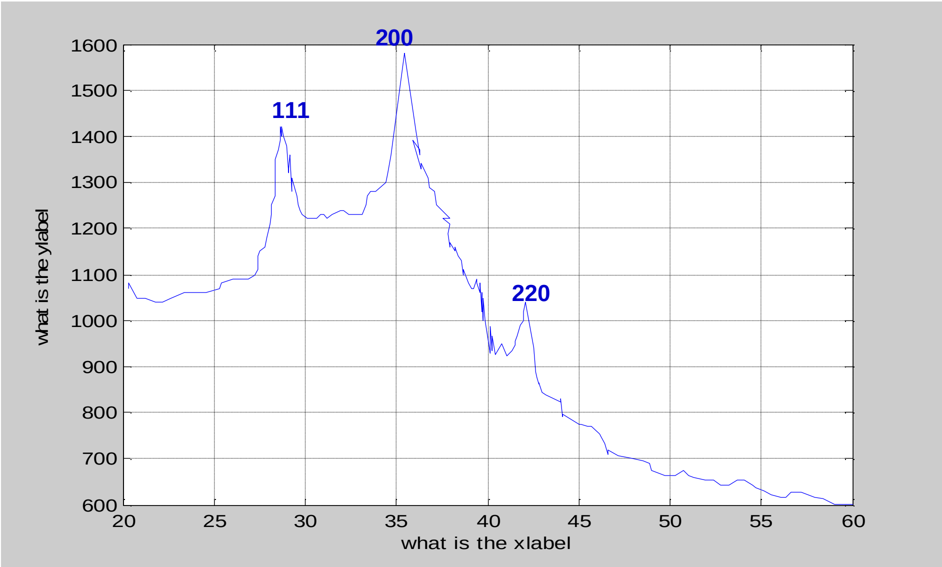

Figure (8) Show the crystalline structure of film after 40 min from irradiation

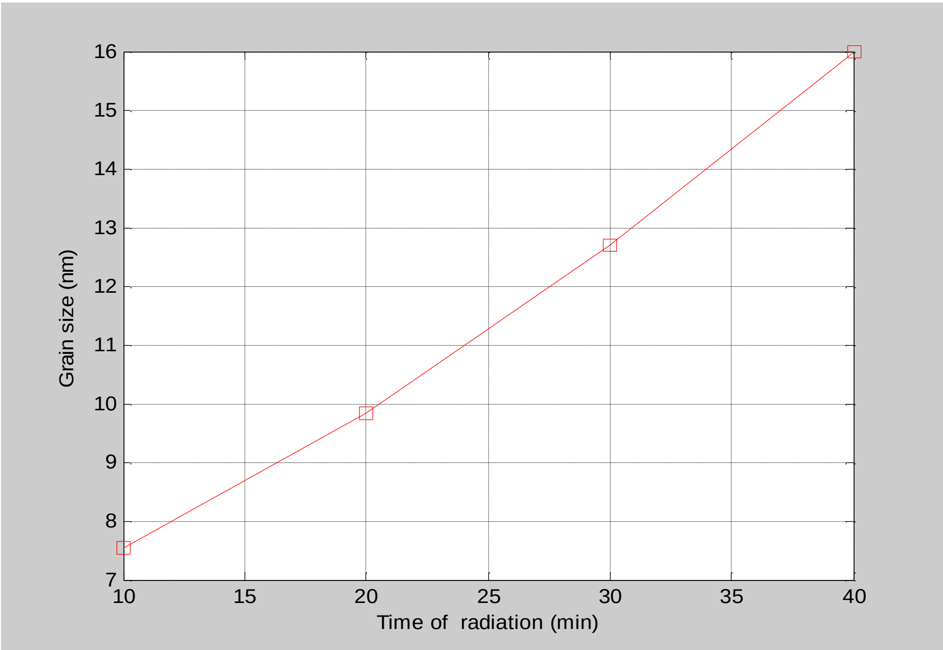

Figure (9) show the change in average of grain size in different time

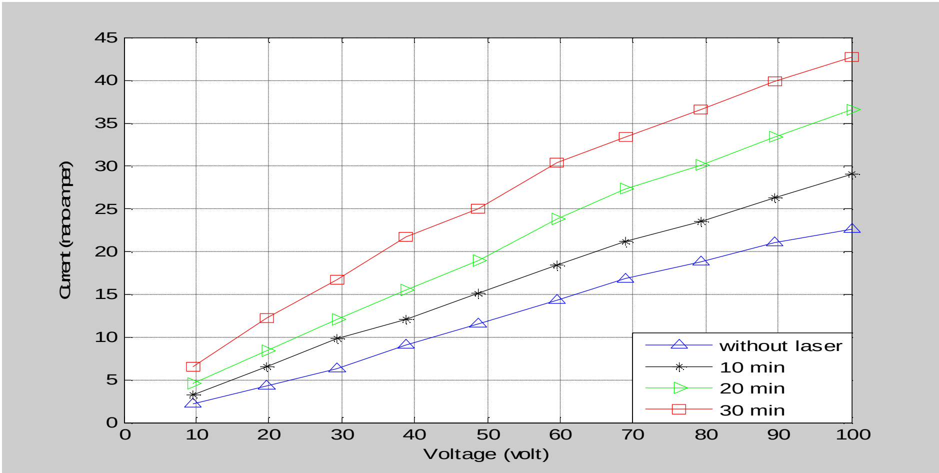

Figure (10) Show the change in electro conductivity before and after annealing