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Study The Effect of Thickness on Zno Thin Films prepared by Spray Pyrolysis Method

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Abstract: Zinc oxide thin films ZnO were prepared by spray pyrolysis method with different thickness from(247.35,342.4,437.6)nm onto glass substrate at 350◦c .The concentration is 0.3 Molary,X-ray diffraction patterns confirm the proper phase formation of the material.The optical properties of ZnO were determined through the optical transmission method using ultraviolet-visible spectrophotometer with wave length (300-1100)nm. The energy gap increases with the increase of thin film thickness and ranges from (3.0,3.2,3.25)eV.

Keywords: ZnO ;thin films ;spray pyrolysis .

Introduction

Zinc oxide is an n-type semiconductor of wurtzite structure .Researchers studied the science of thin films and for importance of these films and their uses in various electronic devices and solar cells,There are different methods available to prepare thin films as (Evaporation ,decay, sputtering ,spray pyrolysis and other). We recall some of the researchers who were interested in preparing the Zno pure thin films [1].In 1997.N.Golego and others using the method of chemical spray to temperatures(180-360) c◦ Ts and the result was that the energy gap fixed and equal (3.30)eV [2].

In 1999 ,the Majin [3] and others using Zn metal and oxidized with O2 by thermal evaporation method in temperature(250-500)c◦ and the result that the transmittion is 80%.The searcher Enas[4] used thermal evaporation method to prepare Zno thin films and measurement of structural properties and found it with installation of multi-type shape of hexagons and got a high transmittance in the region UV/INR and the value of the substrate temperature at350◦c [5,6].ZnO-based devices have attracted significant interest since they present senseitivity to various gases,non toxicity ,high chemical stability for dopping ,and low cost .ZnO have many applications such as liquid crystal display ,solar cells ,optoelectronic devices ,transparent electrodes ,varistors ,planer optical wave guides, heat mirrors for saving energy ,sensers for gases ,and others[7,8].The aim of The present work is to study the structural and optical properties of ZnO thin films which prepared by The Spray Pyrolysis Method at different thickness.

Experimental

Zinc oxide films were deposited on heated glass substrate at 350◦c by chemical spray pyrolysis method using 0.3M aqueous solution of Zinc acetate Zn(CH3Co2)2.2H2O purity (99.5%) in eathanol and deionized water with ratio(3:1)and the final solution was sprayed at rate of (5) ml/minutes for 20 minutes .as the following equation:

$$Zn(CH3COO)2+2CH3OH \longrightarrow 2CH3COOCH3+Zno+H2 +O2$$

compressed air is used as carrier gas for the deposition .The nozzle substrate separation used of 30cm .Then the thickness of the thin films was calculated by using a gravimetric method [9]:-

$$t=\Delta m/A\rho f \qquad =m2-m1/A \qquad \rho f \quad \ldots\ldots\ldots\ldots(1).$$

Where:
m2:weight after deposition(gm)
m1=weight before deposition (gm)
A=substrate area (cm2)
ρf =the thin film density (gm/cm3).the result is shown in table (1).

The structure of the thin films was studied using X-ray diffractometer.
Target:Cu
Wave length:1.5406A◦
Voltage:40(Kv)
Current:30(mA)
Silt
Divergence:1.0000(deg)

Scatter:1.0000(deg)
Receiving:0.01500(nm)
Measure
Axis: Theta -2Theta
Step: 0.0500(deg)
Speed: 5.000(deg/min)

The reflectance R has been calculated from absorption and transmittion spectra using the relation :

$$R=1-A-T \quad \ldots\ldots \quad (2)$$

The absorption coefficient has been calculated using equation :

$$\alpha = 2.303\ A/t \quad (3)$$

where

α :Absorption coffeicent (cm-1).
A :Absorption
t: thin film thickness(nm).

The extinction coefficient K◦ which is defined as the amount of loss in energy due to the interaction between light and charges of the medium was calculated for all the thin films prepared from the following relationship :

$$K_\circ = \alpha * \lambda / 4\pi \quad .. \quad (4)$$

Where:

λ :wavelength (nm) .

Dielectric constant of the constants within the two branches was calculated by the real $\varepsilon1$ and imaginary $\varepsilon2$ according to equations:

$$\varepsilon 1 = n2- K_\circ 2 \quad \ldots. \quad (5)$$

$$\varepsilon 2 = 2nk_\circ \quad \ldots \quad (6)$$

Refractive index of the important constants have been calculated using the following equation [10].

$$n = [(1+R/1-R)2-(k_\circ 2+1)] 1/2+(1+R)/(1-R) \quad \ldots\ldots\ldots\ldots\ldots(7)$$

Results and Discussion

The investigation of (XRD) indicates that the Zno thin film is polycrystalline type of Hexagonal .as Fig(1).The effect of thickness on the optical properties of Zno thin films has been studied .The absorption spectra and transmittance spectra of Zno thin films are shown in Fig (2,3) all these thin films demonstrate good optical transmittance and find top transmittance which is equal to (90%) in the visible and near-infrared range .This high transmission is used in solar cell .The transmission of ZnO thin films decreased as the thickness increased .

Fig.4 shows variable of reflectance as afunction of wavelength .Their high reflaction and transmission in the VIS/NIR make these thin films for good material .

Fig.5 shows variable of absorption coefficient as a function of photon energy

Fig (6) shows where change extinction coefficient as a function of photon energy for ZnO thin film to note that it behaves similar to the absorption coefficient curve because of its association with it as the relationship above, and that decreases with an increase of thickness, this can be a good advantage by which to conserve energy by reducing the thickness of the thin film.

Fig(7,8)show that thereal and imaginary Dielectric constant as function of photon energy.

Fig (9) ,show that the refractive index increases with the increase thickness of thin film until it reaches to the highest value is 1.999 .

The energy gap was calculated as in Fig (11,12) where the energy gap increases with the increase of thickness of thin film and ranges from (3.0,3.2,3.25)eV an approach to the theoretical value which is equal to 3.37 eV . Crystal the wurtzite structure deviates from the ideal arrangement by changing the c/a ratio or u parameter [11].The c/a ratio and u parameter for the films deposited are computed and given in table (1).

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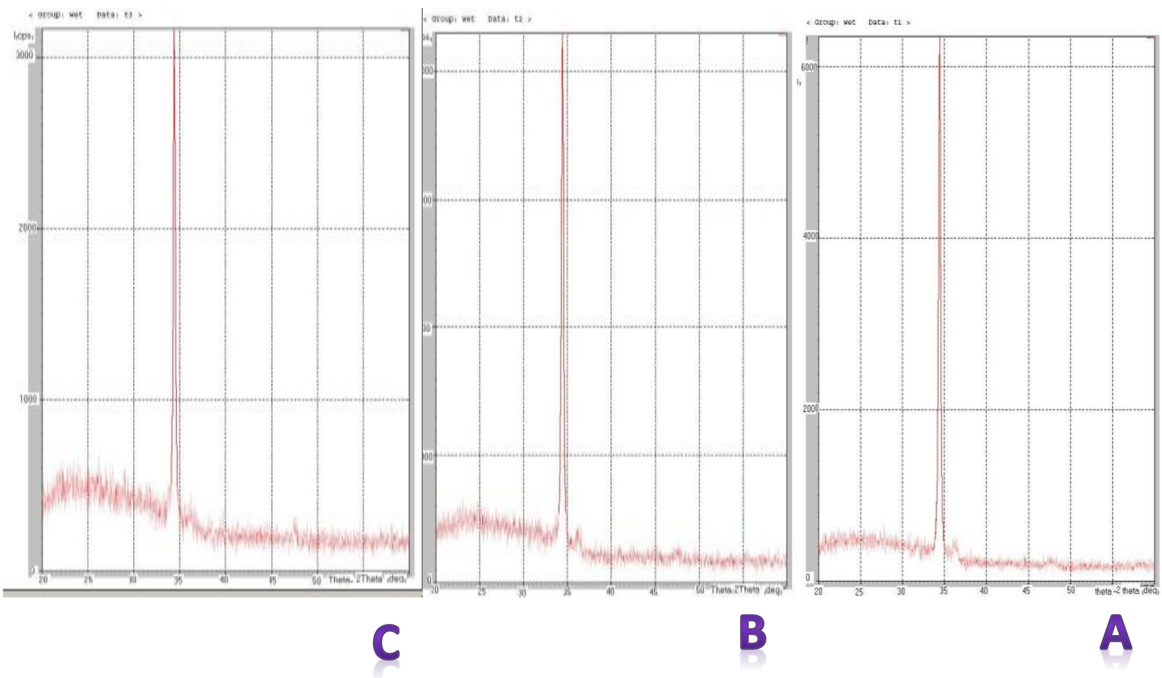
Table 1.Lattice parameters of Zno films prepared by spray pyrolysis

Thickness t nm	(a) A°	C A◦	c/a	u =1/3a^2/c^2+1/4	Ideal value c/a	u
247.35	3.453	5.353	1.550	0.388	1.633	0.375
342.4	3.467	5.358	1.545	0.389		
437.6	3.489	5.358	1.535	0.391		



Fig(1).XRD spectrum of Zno films with different thickness A)247.35nm,(B)342.4nm and(C)437.6nm.

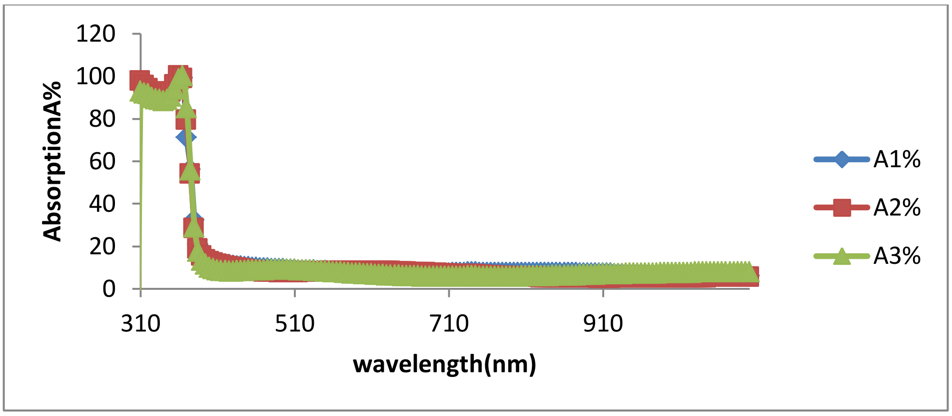
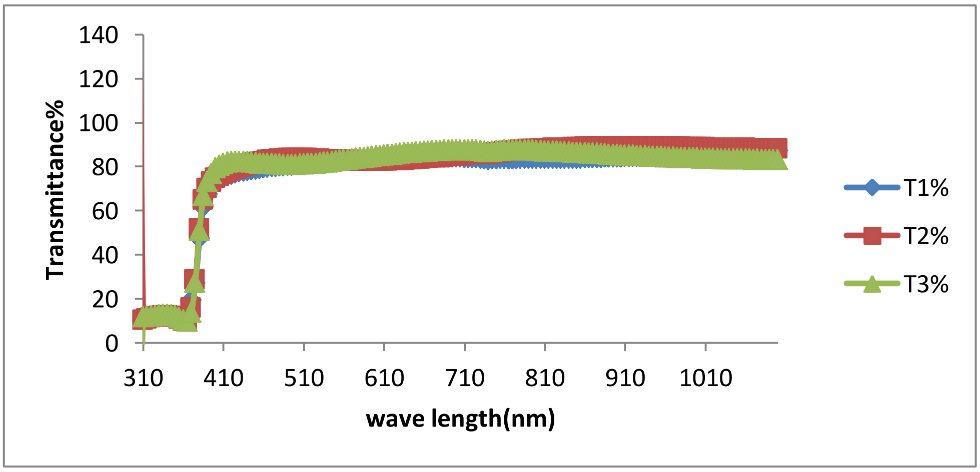
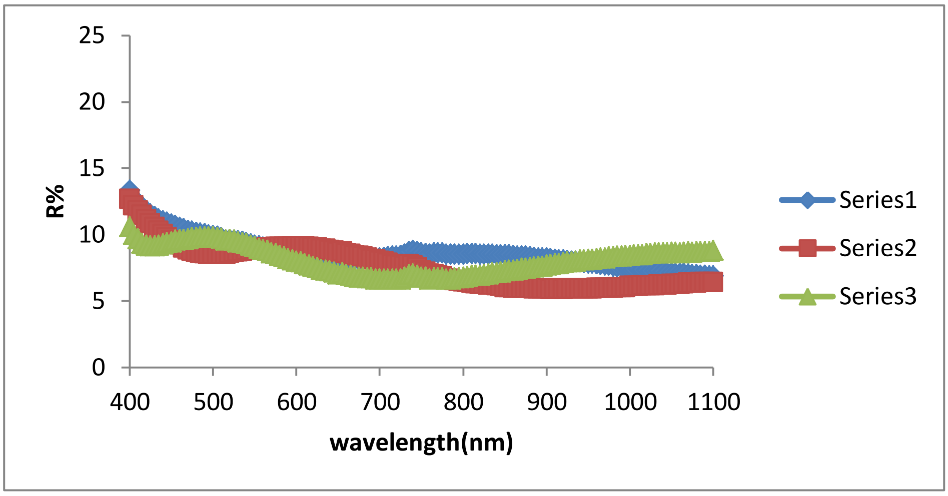


fig.(2) Absorption as function of wavelength for Zno films.



Fig(3)Transmission as function of wavelength for Zno films



fig(4)Change Reflactance as function of wavelength .

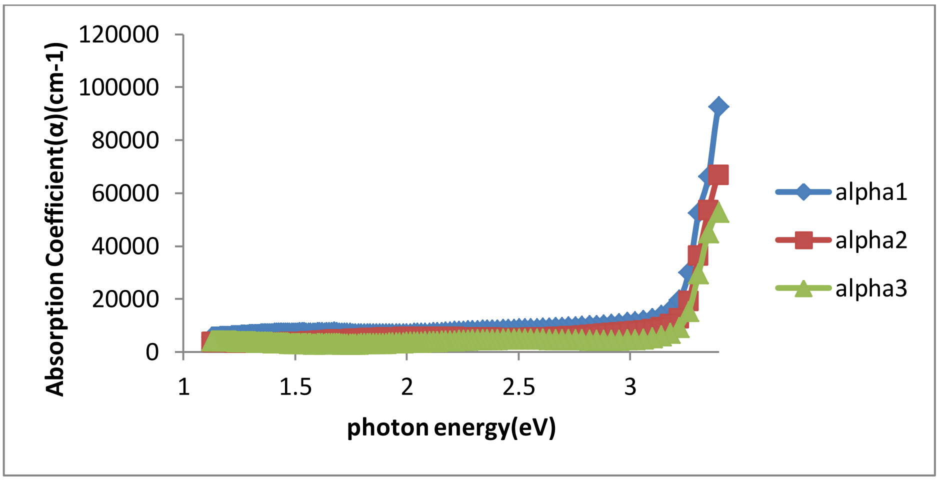


Fig (5).shows change of absorption coefficient as a function of photon energy

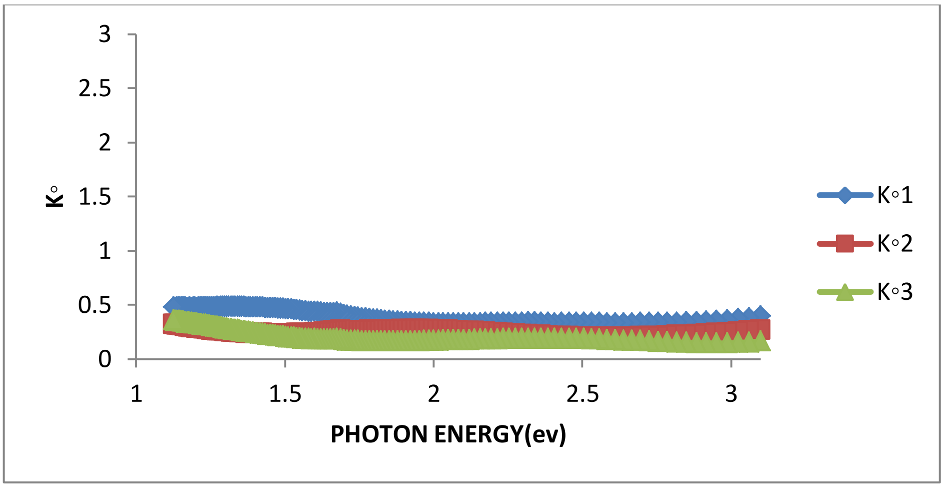


Fig (6).change extinction coefficient as function of photon energy for Zno films .

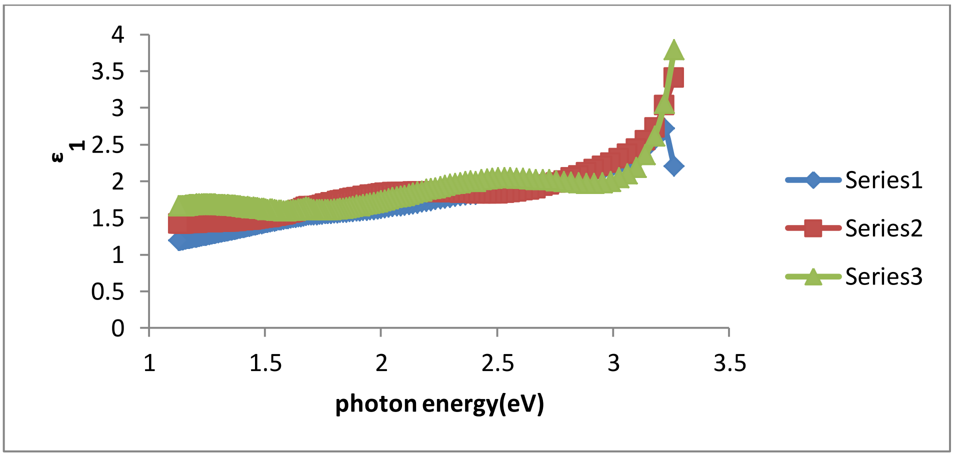


Fig (7).Dielectric constant ε1 as function of photon energy .

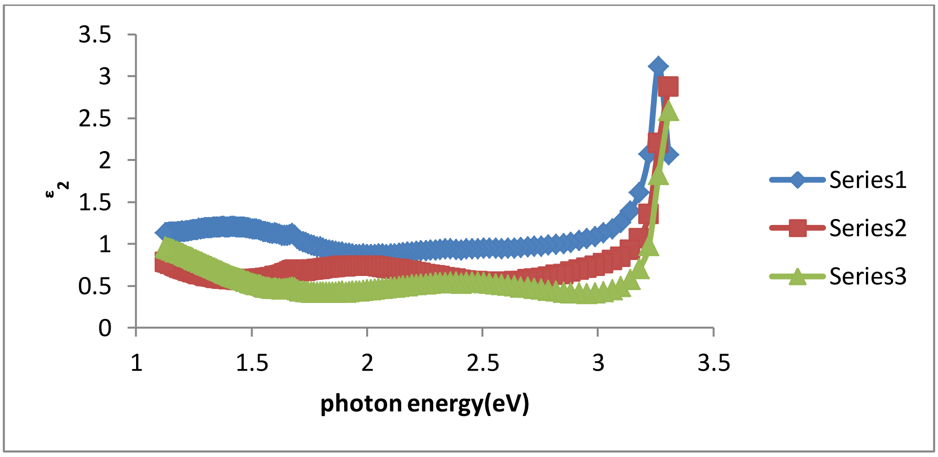


Fig (8). Dielectric constant ε2 as function of photon energy .

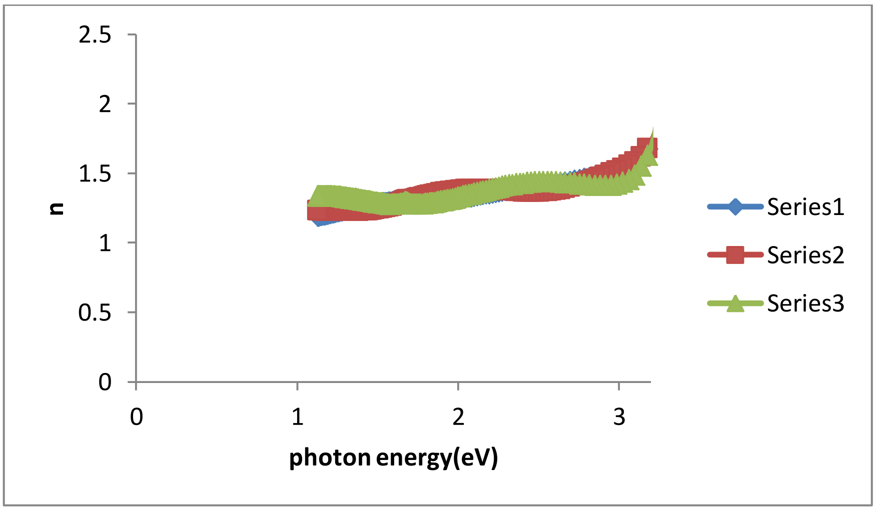


Fig (9).Refractive index as function of photon energy .

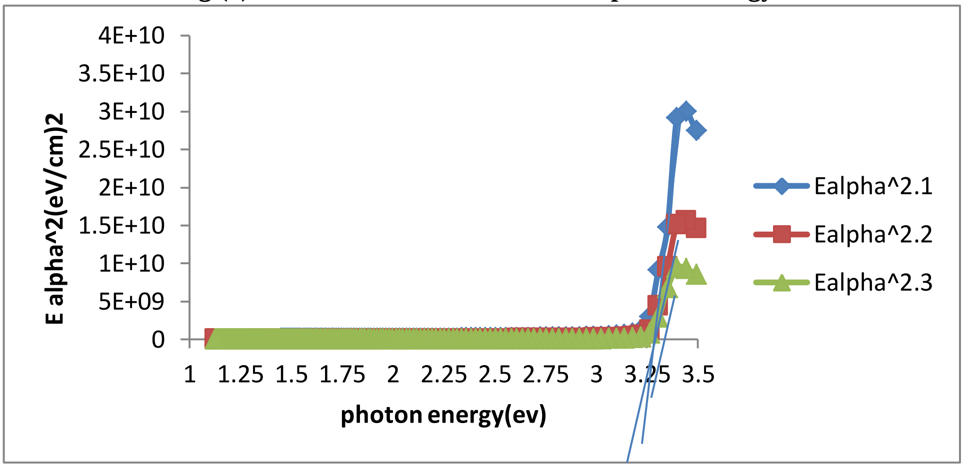


Fig (10). Aplot of (αhv)2 as function of photon energy with different thickness

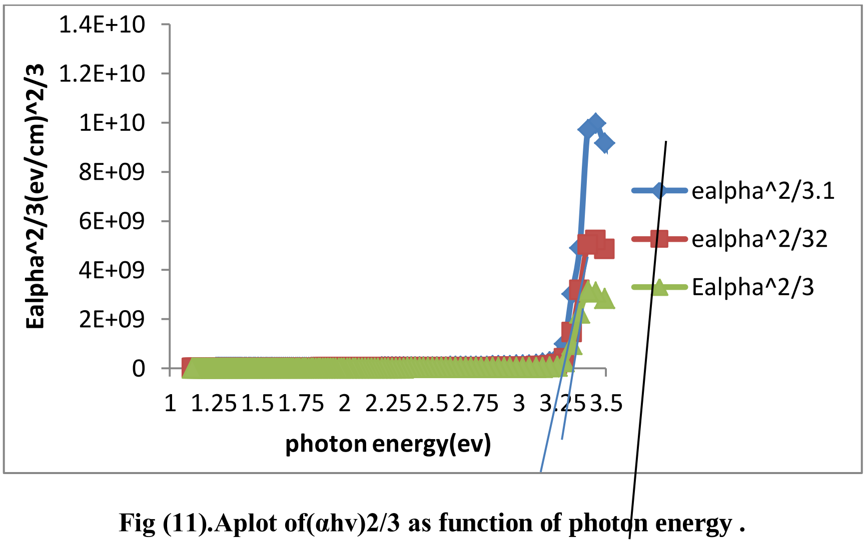


Fig (11).Aplot of(αhv)2/3 as function of photon energy .

دراسة اختلاف السُمك لأغشية أوكسد الزنك المحضرة بطريقة الرش الكيميائي

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الخلاصة

حُضرت اغشية رقيقة لأوكسيد الزنك المحضرة بطريقة الرش الكيميائي ولسُمك مختلف منه وبمعدل رش (m5نانومتر على قواعد زجاجية بدرجة حرارة 350 ,437 ,247 وبتركيز 03مولاري .ان حيود الاشعة السينية بين بان الغشاء ذو تركيب متعدد التبلور .حُددت الخــواص البصــرية للاغشــية عــن طريــق النفاذيــة البصــرية بأســتعمال مطيــاف ضــمن الاطــوال الموجيــة Ultra Violet –Visible.(1100−300)