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A Study of some the optical properties for (SnO_2) thin films prepared by Sol-Gel method

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Abstract

In this research a bilateral tin oxide (SnO_2) thin films was prepared by Sol-Gel method, flow coating technique which is considered a simple and cheap technique. The horizontal sample preparation with and without the use of installed, and also with installed to vertical sample. Results of optical spectroscopy that the biggest values of the transmittance T was for horizontal films with an installed, as for the absorbance A was the biggest values of the vertical sample. For the reflectivity R was value in the horizontal films with installed, less than a horizontal films without Sticky as well as for films vertical. The results of the energy gap Eg for that direct allowed and forbidden transitions and for the indirect allowed and forbidden transfers for the studied Samples were also calculated, and they showed that the highest value of Eg was (3.85eV) for the direct forbidden transfers in the horizontal sample with installer, while the lowest value of Eg was (3.65eV) for the indirect allowed transfers without installer. The vertical film with indirect showed the lowest value for the energy gap ever (3.45eV) for the indirect allowed transitions.

Keywords: optical properties, Sol-Gel method

دراسة بعض الخواص البصرية لغشاء SnO_2 المحضر بطريقة التغشية بالسكب

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الخلاصه

تم في هذا البحث دراسة تحضيرأغشية رقيقة ثنائي اوكسيد القصدير SnO_2 بتقنية المحلول الجيلاتيني (Sol–Gel) بطريقة التغشية بالسكب (Flow Coating)حيث تمتاز هذه التقنية بالبساطة وقلة التكلفة . تم تحضير عينة أفقية مع وبدون استخدام مثبت، وأيضا مع مثبت لعينة عمودية . أظهرت نتائج المطيافية الضوئية أن أكبر قيم للنفوذية T كانت للاغشية الأفقية التي أضفنا لها مثبت ، أما بالنسبة إلى الامتصاصية A فكانت أكبر قيم لها للعينة العمودية ، وبالنسبة إلى الانعكاسية R فقد كانت قيمها أقل في الأغشية الأفقية مع مثبت ، منها في الأغشية الأفقية بدون مثبت وكذلك لاغشية العمودية . كما بينت النتائج والحسابات في قيم فجوة الطاقة Eg في الانتقالات الالكترونية المباشرة المسموحة والممنوعة وفي الانتقالات غيرالمباشرة المسموحة والممنوعة للعينات المدروسة ، أن أكبر قيمة فجوة الطاقة للعينة الافقية مع مثبت هي (3.88eV) وذلك في الانتقالات المباشرة الممنوعة ، أما أصغر قيمة لعرض فجوة الطاقة للعينه الافقية بدون مثبت فهي (3.82eV)

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وذلك في الانتقالات غيرالمباشرة المسموحة. بينما أبدت العينة العمودية أصغر قيمة لفجوةا لطاقة على الاطلاق
حيث بلغت (3.38eV) وذلك في الانتقالات غيرالمباشرة المسموحة .

Introduction

The increased importance of this technology because of It is characterized by low its cost, low loss material, suitability Broad surfaces [1].

This method is used for Cover glass equipment for protection, but can be used on flat glass. This method works with any type of substrates and characterized Films prepared in this way as the most thickness as compared with other methods.

Where they were used this method for the preparation of many types of thin films, such as zinc oxide (ZnO) copper oxide(CuO) tungsten oxide(WO_3)etc.. Tin oxides films possess a wide use, especially in the field of solar cells, Calendar vector transparent and gas sensors [9 causes of high permeability and good conductivity in these films to the chemical composition and structure to the microwave [2].

This research aims to determine the best conditions for the preparation of thin-film deposition of tin oxide by Sol-Gel method, flow coating technique, and study the transmittance, absorption and energy gap .Tin oxide status of horizontal and vertical and the effect of the installer DEA on these values, The importance of thin films oxide in the growing applications, where Used in solar cells, Photo Detectors and Transistors [3-5].

Experimental part

Dual- tin oxide with a white color material, molecular weight ((150.69) gm / mol) density ((6.95) gm / cm^3) melting point ((1630 ˚C)) and boiling points (1800 - 1900) ^oC [1, 2].

Installation of dual- tin oxide are crystalline quartet installed and the lattice parameters are crystal size of the level (101) of the BRAC law was (d = 3.350Å) and the lattice constant (a = 4.736Å) [6-8].

A sol - gel, flow coating technique was used to prepared for prepare thin films of tin oxide deposited on the glass substrate, as it becomes tin chloride as a prefix , and the use of various organic solvent which is methanol, ethanol, propanol.

Abnormalities may occur in films where the substrates cleaned using ultrasound where we wash with a solution of a water and soap, then put it in the machine.

Ultrasound for a quarter of an hour, and then dried and make sure to get rid of the dust on the dry substrate.

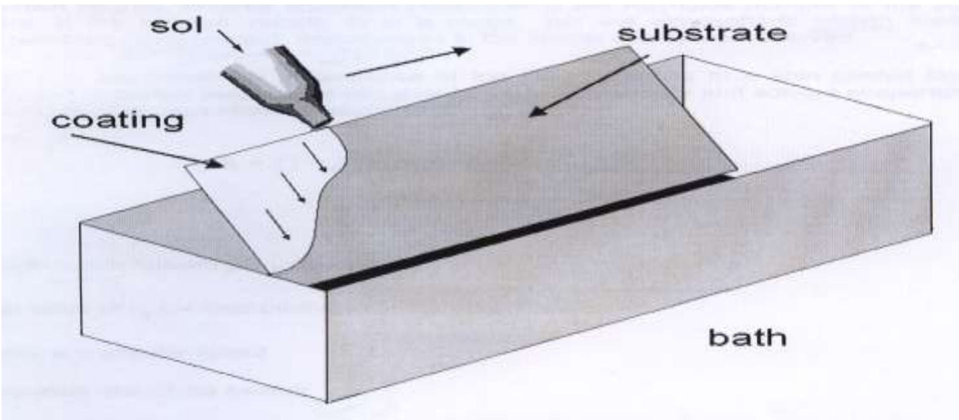


Figure 1- Flow Coating process

We then take three volumes of quad- tin chloride, And adding each one individually on each of ethanol , methanol , propanol then placed on a magnetic stirrer for one hour, we noticed This was the best melt with ethanol, so the dependence on ethanol in the preparation of the study samples.

Taken 5 g from the quad- tin chloride as a prefix, and resolves 20 ml and placed on the engine Magnetic for an hour, then left in the laboratory for a full day, and increase the accuracy of the

solution is filtered through a filter paper, and This becomes ready to use the flow of coating technology is divided into two parts with installer and without installer. And Samples set horizontal and vertical in three ways.
We poured the solution without the addition of installed on the glass slide placed diagonally around 5 degrees for detective table, and leave for 21 minutes and then put them horizontally on a table in the first sample.
Then pour the solution with the addition of installed on the glass slide placed diagonally around 5 degrees for laboratory table, and leaves for 21 minutes and then put them horizontally on a table, second sample.
And in third sample we pour the solution with the addition of installed on the glass slide , which tend angle of 5 degrees For plumb for 21 minutes , and after slopping keep slide vertically with the laboratory table.
After the slides are placed in the electric oven at 400 °C and leave for an hour, and then pass on the slide to a dryer temperature of 200 °C for an hour, then placed in an atmosphere Detective conducted by optical study.
It can be described what happened chemically according to the following equations:

$$SnCl_4 \rightarrow Sn_4 + +4Cl^- \quad \ldots\ldots(1)$$

$$C_2H_5OH \rightarrow C_2H_5O^- + H^+ \quad \ldots\ldots(2)$$

Then reacts

$$4H+ +4Cl- \rightarrow 4HCl \quad \ldots\ldots(3)$$

$$C_2H_5O- + Sn_4+ \rightarrow (C_2H_5O)4Sna \text{ solution(Sol-Gel)} \quad \ldots\ldots(4)$$

Then Heated to 400 °C

$$(C_2H_5O)_4Sn + O_2 \rightarrow SnO_2 + 10\, H_2 + C_2 \quad \ldots\ldots(5)$$

Reset and Dispassion

1- Structure measurements

In order to identify the crystalline structure of thin films SnO_2 X-ray diffraction technique (XRD) was used with source of (Cu. K) and a wavelength (0.015405Å).
It calculated the distance between the interplaner distains (d) using (Bragge Law) from the relationship: [10]

$$n\lambda = 2d\sin\theta \quad \ldots\ldots(6)$$

n : constant (rank diffraction) .
d : The interplaner distance.
λ: Wavelength of the incident beam .
θ :Diffraction angle with range about (20^o -60^o) .
Measurements of the optical properties of which include absorbance, transmittance, reflective and the energy gap for SnO_2 , this follows deposite on glass substrate using a spectrometer the UV- visible (UV / VIS - PV- 8800 spectroscopy photometer) processor from a company (Pye Unicom)and took the transmittance of the spectroscope, The absorbance was calculated from [11].

$$A = \log(1/T) \quad \ldots\ldots(7)$$

the reflectivity is given by[12]

$$R = 1 - (A + T) \quad \ldots\ldots(8)$$

Then the absorption coefficient is given by

$$\alpha = 2.303A/t \quad \ldots\ldots(9)$$

where (t) is the thickness of the membrane [12,13]
The subside coefficient is given by

$$Ko = \alpha\lambda/4\pi \quad \ldots\ldots(10)$$

where (λ) is the length of the photon wave incident. [14]
the Refractive index was determined of the equation [15,16]

$$no = \sqrt{\left(\left(\frac{1+R}{1-R}\right)^2 - (Ko^2+1)\right) + \left(\frac{1+R}{1-R}\right)} \quad \ldots\ldots(11)$$

Figures- 2, 3 and 4 show the XRD patterns for SnO_2thin film of horizontal and vertical Samples with and without installer. It is show that the films was Polycrystalline and the effect of installer was no upped that is agree with previous studies[1-4] ,There was no apparent effect for installer on the structure of the films. These results are consider with the (ASTM) (American Standard of Testing Materials [3- 6].

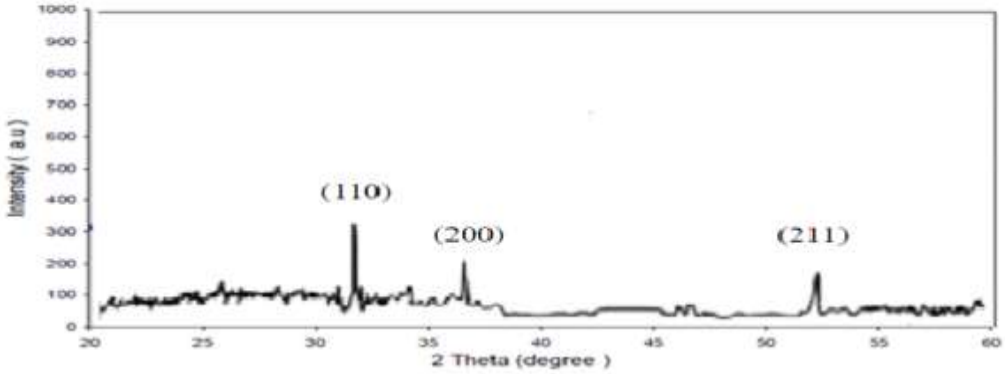


Figure 2- X-ray diffraction of (SnO_2) thin film of the horizontal sample without installer

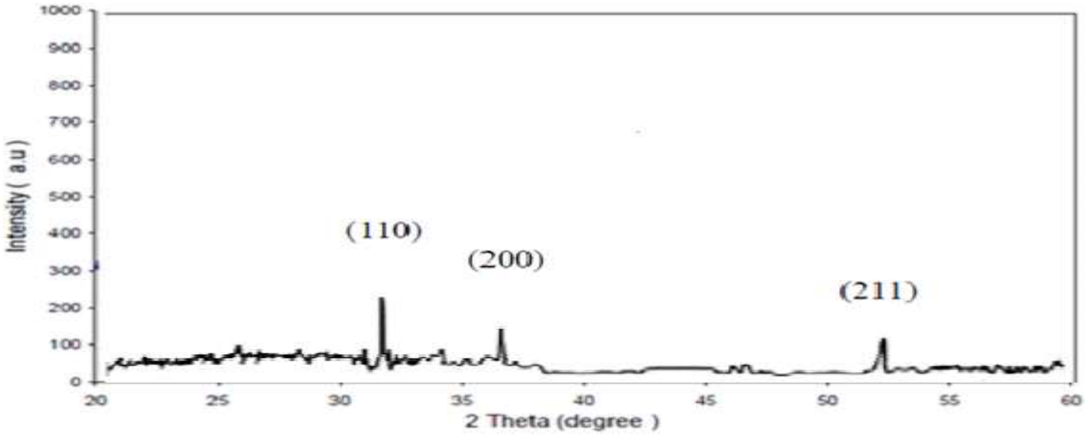


Figure 3- X-ray diffraction of (SnO_2) thin film of the horizontal sample with installer

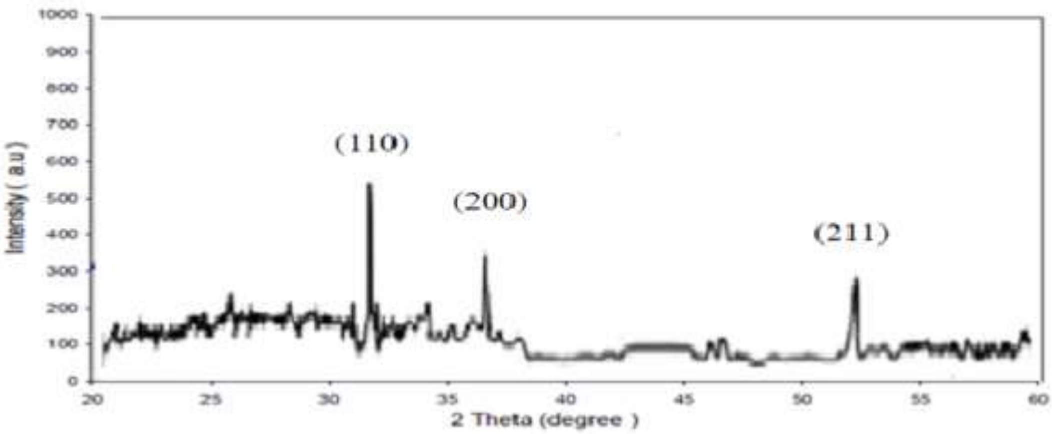


Figure 4-X-ray diffraction of (SnO_2) thin film of the vertical sample with installer

2-Optical Measurements

Figure- 5 and 6 show the Transmittance and Absorbance spectrum measured for SnO_2 thin films respectively. It is found the Transmittance increased with increasing wavelength. Between the phases (300-350nm) and reached to a high transactions values even greater than 90% toward the field of infrared.

It is found that the transmittance increased with increasing wave length in the rang (300-350) nm in all of samples but in the vertical samples it was smaller than horizontal samples of each wave length, as well as permeability values was the largest in horizontal sample which has been added the installer of the sample without installer, especially in the field between the phases (300-350) nm and the transmittance increased to a high values reached greater than 90% toward the field of infrared.

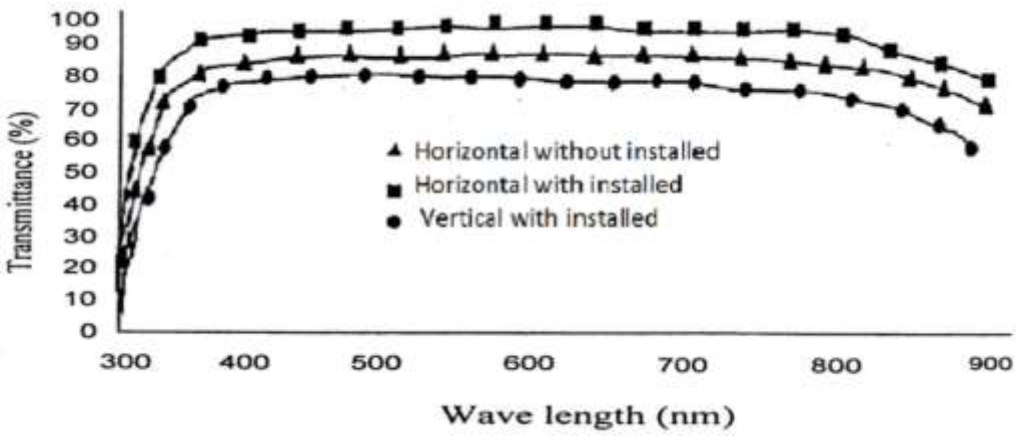


Figure 5- Transmission spectra of (SnO_2) thin film of horizontal and vertical Samples with and without installer.

Figure-6 represents the relation between absorbance and wave length of (SnO_2) thin film.

In general it can see that the absorbance decreases with increasing of wavelength and the absorbance of the vertical sample is greater than horizontal samples , clearly the absorbance of horizontal samples that without installer is smaller than the sample of horizontal which with an installer.

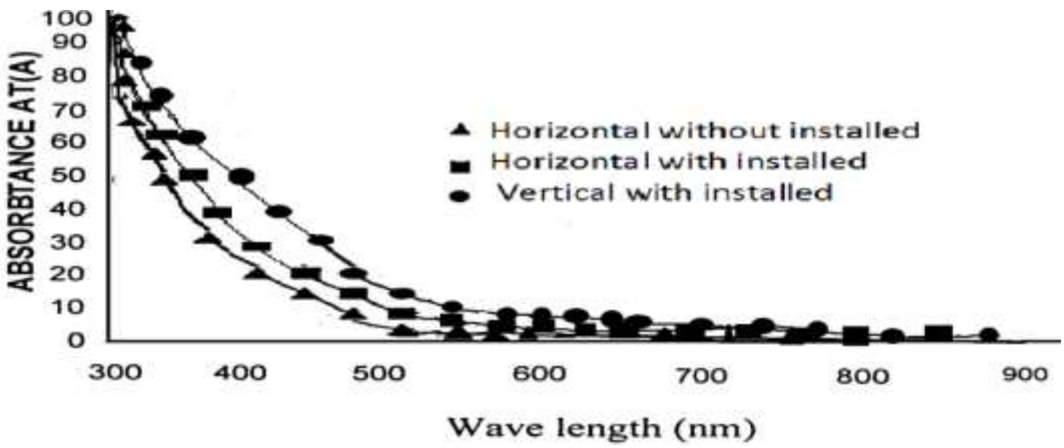


Figure 6-Absorbance spectra of (SnO_2) thin film of horizontal and vertical samples with and without installer.

Figure-7 shows that R as a function λ for SnO_2 , It is found that R decreases with increasing of wavelength in the rang (380-900) nm , and the value of R of the vertical samples is greater than

the horizontal samples as in Figure-7 ,But the summit has withdrawn from 300nm horizontal samples to 400nmvertical samples , where the reflectivity increase rapidly and abruptly and went to the value (20.3%) of the samples for horizontal and vertical , that all of the reflection and absorption was begun for horizontal sample at 300nm , while the vertical sample 400nm due crystalline structure according to the method deposition. As was the reflectivity values for horizontal sample with installed smaller than the horizontal sample without installed.
When wavelength 600nmtransmittance 79.81% vertical sample and absorbance 9.53% and reflectivity10.32 % for the same sample was which fulfilled the basic relationship $R = 1 - (A + T)$ At this wavelength the same 600nm horizontal sample with a fixed value of transmittance 95.16% and absorbance 2.12 % and reflectivity 2.63 % so also realized previous relationship. These values for each of the transmittance absorbance and reflectivity converge with the values contained in the previous global scientific studies.

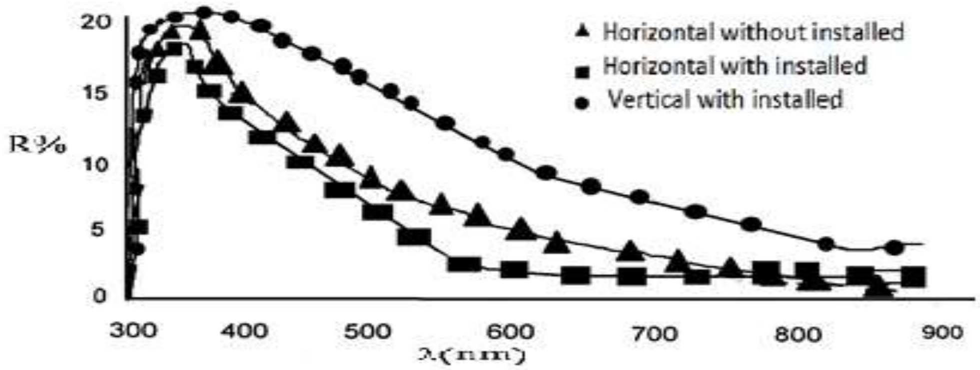


Figure 7- reflectivity spectra of (SnO_2) thin film of horizontal and vertical Samples with and without installer.

Figure- 8 represents the relation between K_o and hν of (SnO_2) thin film.
It is note from Figure-8 that the coefficient values which is found from relation(10)increase with increasing of photon energy, and that the value of coefficient of damping in the vertical sample is greater than the horizontal samples at the same energy values always, due to a difference form the crystalline structure between the horizontal and vertical modes. We also find that the damping coefficient values are almost identical in the two Horizontal samples, and this shows that the installer did not have an active role enough in damping coefficient values.

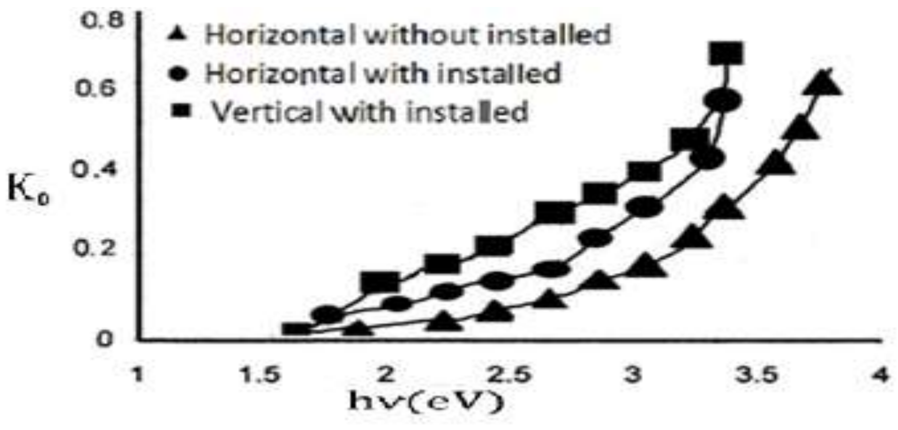


Figure 8-the absorption coefficient of (SnO_2) thin film of horizontal and vertical Samples with and without installer

Figure -9 represents the relation between n_o and hv of (SnO_2) thin film, This Figure shows that n_o as a function of hv that the refractive index values of vertical sample is greater than the horizontal values for samples, The values ranging between (1.53–2.17) which is the value of the refractive index of the tin oxide film moderation (1.85), and this is in line with the values, Calculated in the previous global scientific agenda [16], which was (1.80).

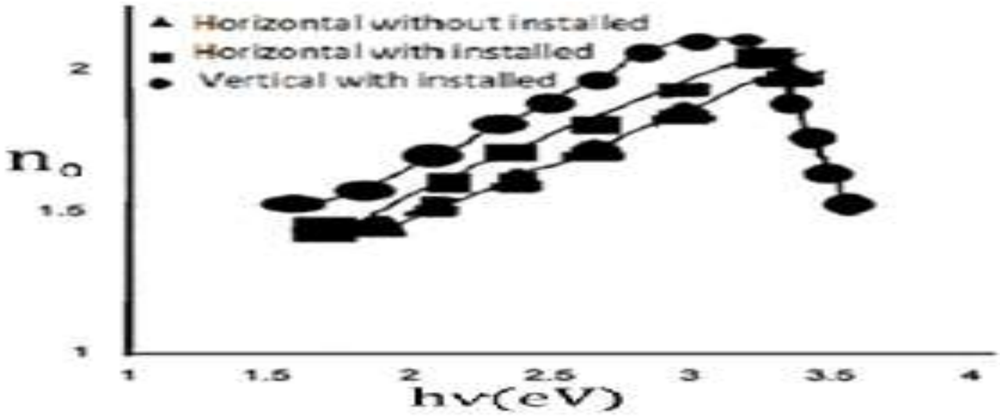


Figure 9- the refractive index of (SnO_2) thin film of horizontal and vertical Samples with and without installer.

Figures- 10,11and 12 shows that real dielectric constant and the imaginary dielectric constant as a function of hv , In the horizontal and vertical position there are similarity of the behavior of the refractive index with a real dielectric constant as for the section of the imaginary dielectric constant , the difference in the curves between the horizontal and vertical modes due The difference in absorption coefficient values , The imaginary dielectric constant is a measure of lost Radiation energy incident on the sample , It represents a contribution of charge carriers within the stated article in the absorption of the optical radiation energy. [17-19]

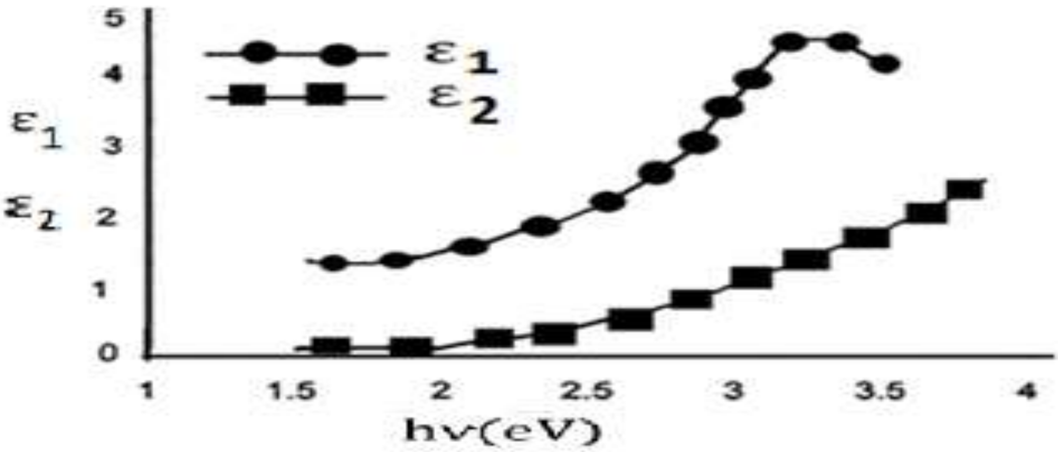


Figure 10-the real dielectric constant and the imaginary dielectric constant of (SnO_2) thin film of the horizontal sample without installer.

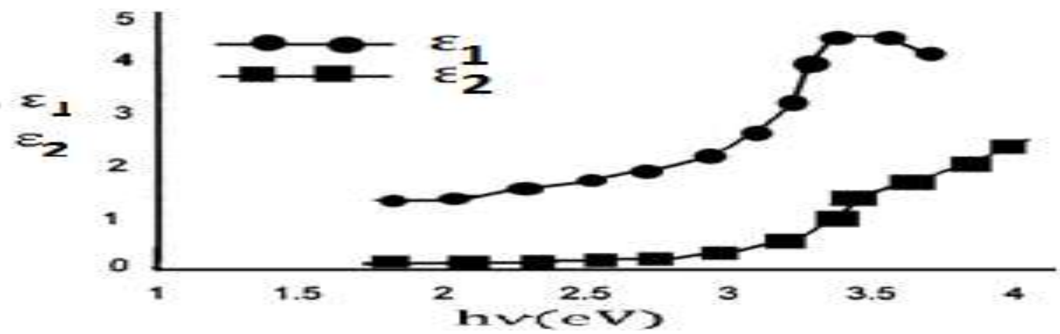


Figure 11- the real dielectric constant and the imaginary dielectric constant of (SnO_2) thin film of the horizontal sample with installer

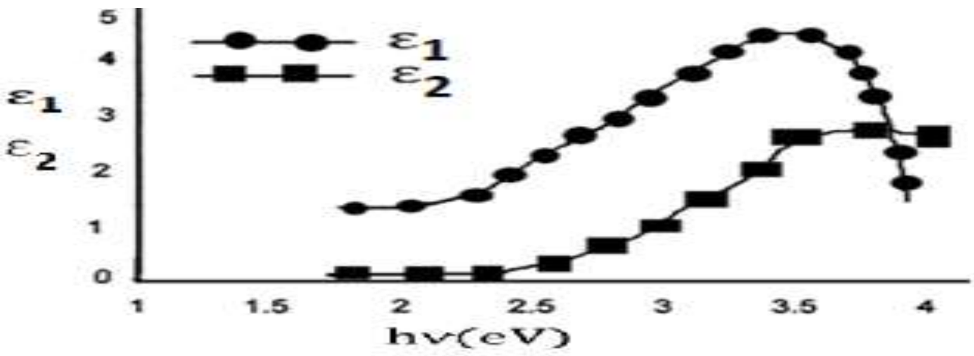
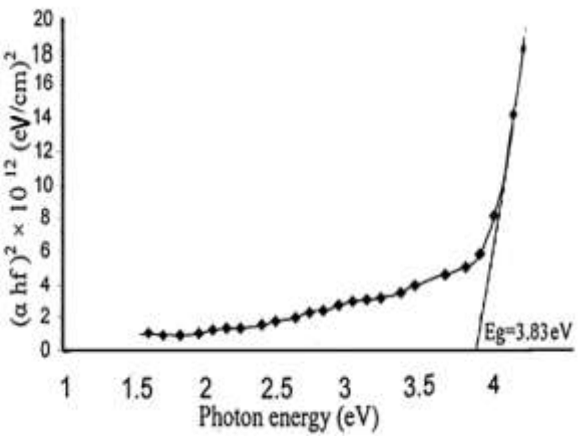


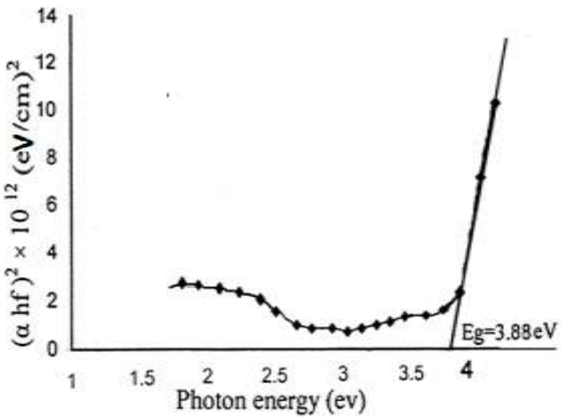
Figure 12- the real dielectric constant and the imaginary dielectric constant of (SnO_2) thin film of the vertical sample with installer.

Figures-13-18 show the direct and indirect transfer of both types of allowed and, forbidden and the energy gap which found from the figure conclude the following:

For vertical sample energy gap decreased for each transfer compared to horizontal samples, and arrived at (3.38ev) in the transfer of indirect allowed either in horizontal samples were smaller value in the transfer of indirect allowed and which were (3.68eV), The largest value gap energy of all samples (3.88eV), The horizontal sample with installer and these results are comparable with research [20,21].

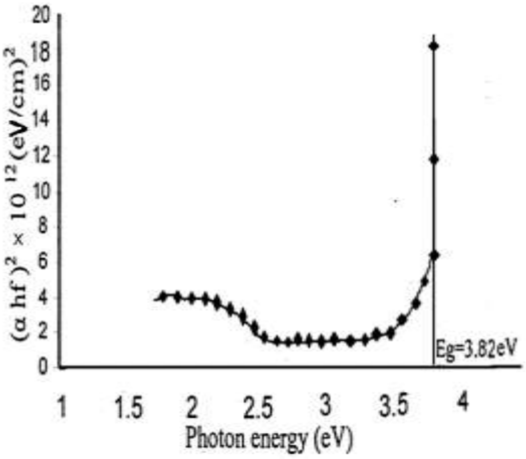


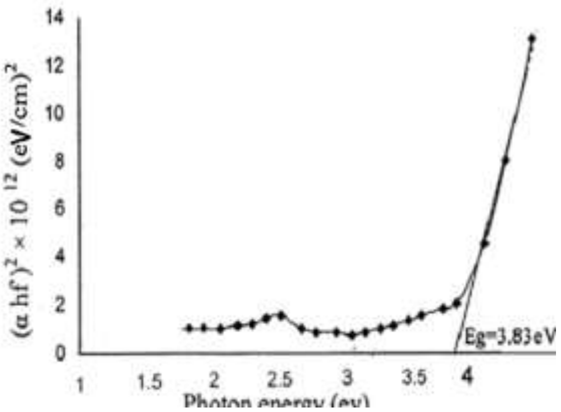
a- allowed



b- is forbidden

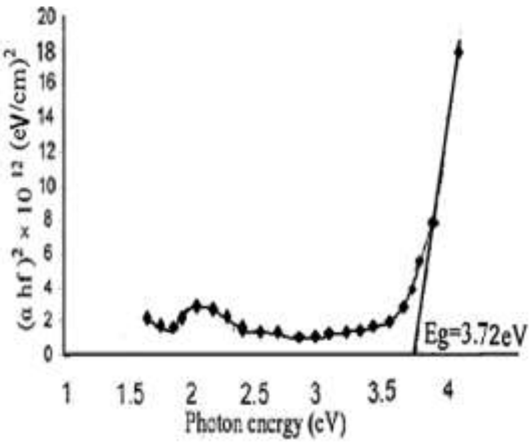
Figure 13- the energy gap of (SnO_2) thin film of the horizontal sample with installer of direct transitions a- allowed b- is forbidden.

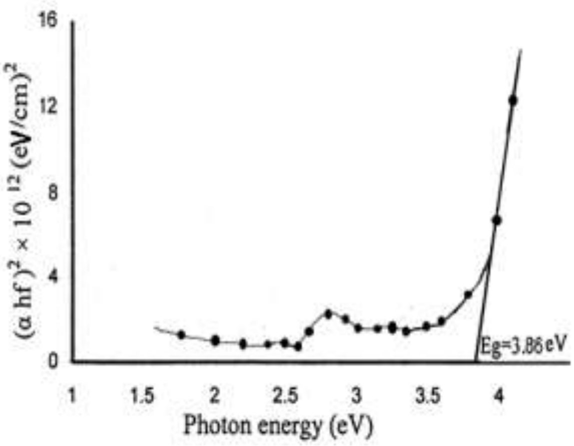




a- allowed b- is forbidden

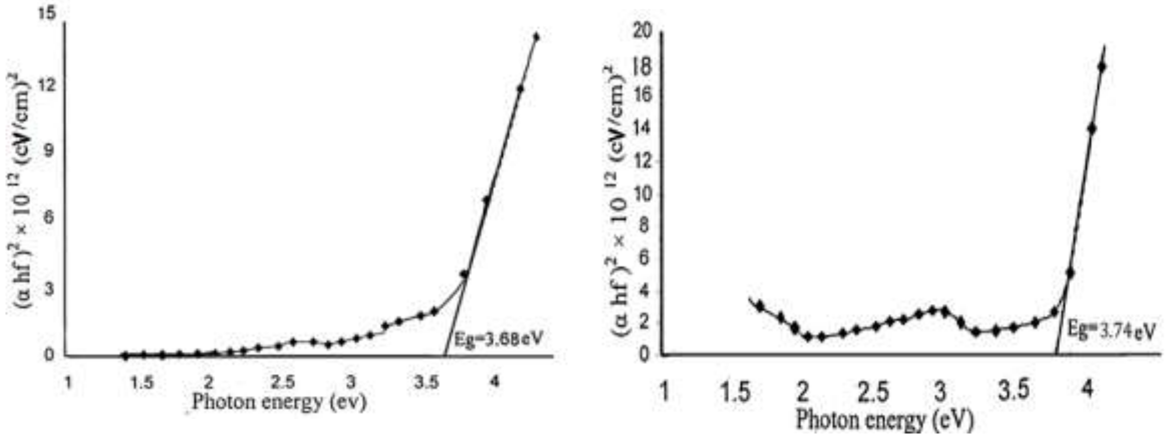
Figure 14 - The energy gap of (SnO_2) thin film of the horizontal sample without installer of direct transitions a- allowed b- is forbidden.





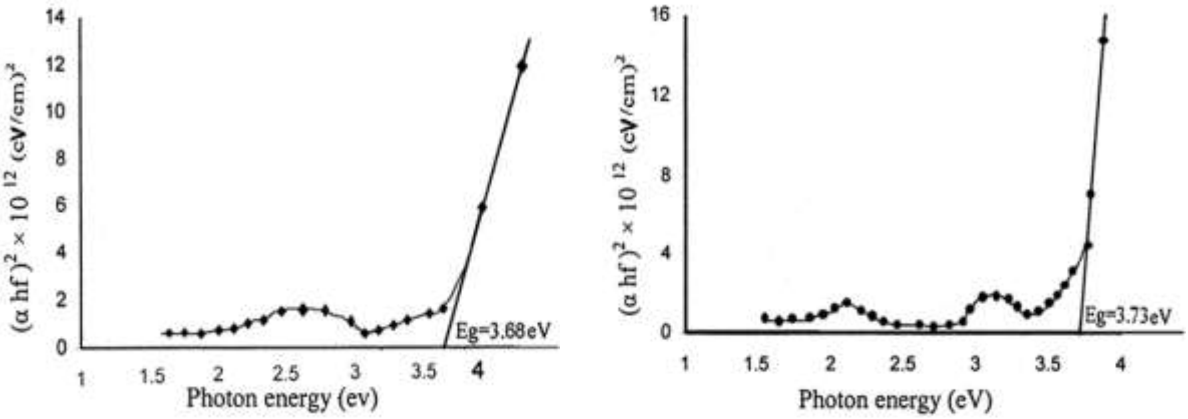
a- allowed b- is forbidden

Figure 15- the energy gap of (SnO_2) thin film of the vertical sample with installer of direct transitions a- allowed b- is forbidden



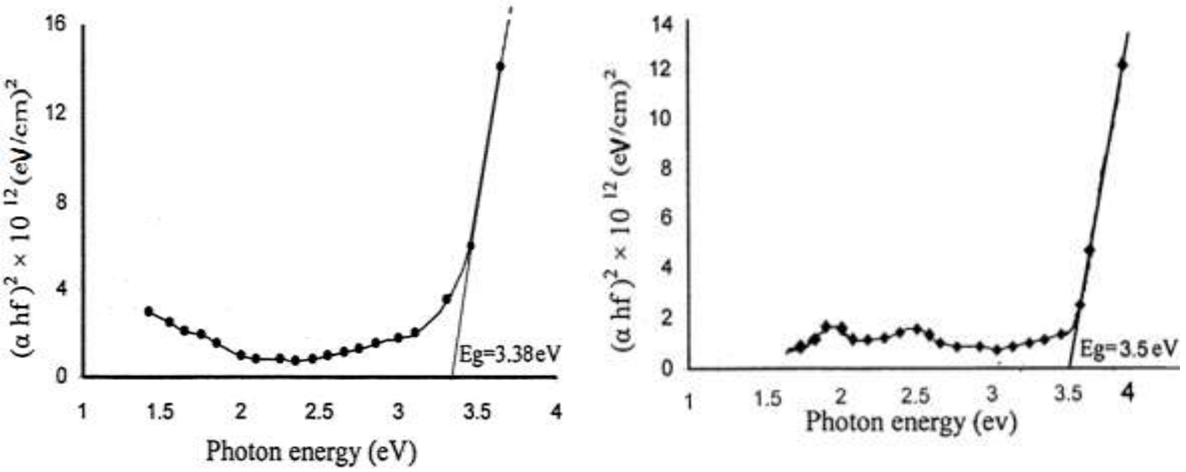
a- allowed b- is forbidden

Figure 16- the energy gap of (SnO_2) thin film of the horizontal sample with installer of indirect transitions a- allowed b- is forbidden.



a- allowed b- is forbidden

Figure 17- the energy gap of (SnO_2) thin film of the horizontal sample without installer of indirect transitions a- allowed b- is forbidden



a- allowed b- is forbidden

Figure 18- the energy gap of (SnO_2) thin film of the vertical sample with installer 0f indirect transitions a- allowed b- is forbidden

Conclusions

We found that the high transmittance ranging from (80-95)% within the wavelength (600-900)nm, The absorbance ranging (10-20)% from the same field, means we have a film with a weak absorbency, The results indicate that the tin oxide film is high absorbance only in a narrow field is the field of UV rays.

Transmittance become better with installer of horizontal samples, and a few improve the absorbance of the sample vertical, vertical samples gave lower transmittance and upper Absorption coefficient compared with the horizontal samples.

The results show that the biggest value of the energy gap in the direct transitions allowed (3.88eV), while the smaller the value of the energy gap in the transfer of indirect allowed (3.82eV).

The vertical sample has a smaller value of the energy gap (3.38eV) in the transfer of indirect allowed. However, the vertical position gave lower values for the energy gap of the four transitions, thus the biggest values of the refractive index.

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