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Influence of the Zinc Tin Oxide Nanoparticle proportions on the Optical properties prepared by the laser Method

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ABSTRACT

In this research, the pulse laser deposition method was used by the PLD Nd:YAG wavelength laser nm1064λ = to precipitate thin films of pure zinc oxide and tin-like oxide with different weight ratios (0.2 , 0.4)kg were deposited on glass bases in order to study the effect of annealing at a degree 573k and deformation of some physical properties of zinc nanoparticle oxide films. X-ray diffraction measurements of pure and tainted oxide films of different proportions (0.2, 0.4)kg in tin indicated that these films possess a multi-crystal line structure, of hexagonal type. The topographical properties of the prepared membrane surfaces were studied using the Atomic Force Microscope (AFM) and showed that the ZnO membrane has a smooth and uniform surface in composition.
The results of the optical properties also showed a sharp increase in the optical transmittance spectrum until it reaches 90% after annealing, and the deformation reduces the optical transmittance. It also found that the optical energy gap of the ZnO membrane (3.2)eV (before annealing and 3.3eV)) after annealing and the energy gap decreased with increasing mixing ratios.

Introduction

Thin films receive great attention for use within multiple areas where they fall into Manufacture of many components of thin electronic devices and detectors Interference filters are used in a wide range of optical fields, such as mirror manufacturing, also involved in the manufacture of microelectronic circuits is the study of the properties of matter, which is in the form Thin films that have attracted physicists attention since the second half of the seventeenth century as they were conducted Many important research in this field [1].
The thin films in its preparation have revolutionized the field of applications, because it has become the alternative Successful for Bulk materials in achieving their properties as well as potential The physical and chemical properties of these substances change. Membranes are known as the substances they prepare In the form of one or several thin layers of controlled sedimentation of molecules or atoms or Ions are based on Substrate), and their thickness must not exceed one micron. [2].

Previous studies

Surry, Saleh , and Sabah(2017)[3] investigated the effect of tin deformation on the structural properties of thin ZnO membranes prepared by chemical vapor deposition at atmospheric pressure or by impurity ratios (5,3,1%) of thickness nm (20±400), And deposited on glass bases with a temperature of 400 ° C. The results of X-ray examinations (XRD) showed that all the membranes of the preparation have a multi-crystalline structure of the hexagonal type, and the prevailing direction of growth is (002). In crystalline size, which indicates improvement in the crystalline structure of the prepared films.[3].
And The researcher (yousif) studied (2013) [4] the structural and optical properties of the ZnO membranes prepared by the pulsed laser method, and the study showed through X-ray diffraction (XRD) that the degree of crystallization of the membranes depends on the amount of magnesium in the layers, and that all membranes possess Level (101) is a dominant reflection and is of a multi-crystalline hexagonal structure.[4]
The practical Side Experimental Details:-

A zinc oxide powder with sizes ranging from 10-30 (nm) with a high purity of 99.99%) was used and manufactured by the American company Sky Spri nanomaterial's with other models of tin dioxide (SnO 2) nanoscale 50-70nm). (Its high purity is 99.99%)) The factory is also "by the same company with weight ratios of (0.2 , 0.4,) where a weight of 3gm has been weighed. Tin is the added substance after which the samples were taken according to the formula and as follows:-

$ZnO\ (1-x) + SnO_2\ (X) \rightarrow ZnSnO_3$...... (1)

After obtaining mixed powders of different proportions, they are pressed forcefully to obtain zinc oxide tablets before and after deformation with tin dioxide according to the value of x

Then sintering the discs resulting from mixing in the tube electric oven at a temperature ((700oC) in the presence of oxygen gas for a period of two hours, then the tablets were left to cool after turning off the oven and after preparing the glass bases the sedimentation is where .

The process of sedimentation of models prepared from zinc dioxide tablets before and after deformation with tin oxide according to the value of x) and obtaining thin and homogeneous films within the discharge chamber of the laser system and under a discharge pressure of (10-3 Torr). The sedimentation process includes three basic steps.

1- Interacting the falling laser radiation with the target, which is a powder and pressed disc.

2 - Plasma is formed inside the chamber towards the glass slide on which the film is deposited and caused by lasers.

3. The film is deposited on the glass slide at room temperature and at a low discharge pressure (10-3 Torre).

Figure (1) The figure shows the membrane precipitation device (PLD) and how to fix the glass slide above the target and the distance between them is (2.5 ± 1) cm. As for the distance between the target and the starting point of the laser beam (15 Cm). The best distance between the target and the base is (2cm) and the appropriate laser energy for deposition is (500m.J), frequency (6Hz), and the number of pulses (200) pulses. The angle between the falling laser beam and the target surface is (45^o).

Fig.1: The figure shows the membrane precipitation device (PLD)

The annealing is one of the preferred methods to improve the properties of the membrane as it is exposed to a heating process

Regular for a specified period of time, up to the thermal homogeneity of all the sample intended to remove the generated stresses

In the material or the removal of the heterogeneity that arises from the impurity diffusion process in order to increase the electrical efficiency

As well as "to reduce the structural defects caused by manufacturing [5].

Results and discussion

This research includes presenting the practical results of zinc oxide and tin oxide films and their mixture in different proportions and their interpretation of each of the structural properties and surface topography and the optical and electrical properties

1- structural properties

A faience board for drawing, electrical and study was obtained.

Figure (2) X-ray diffraction of zinc powder. Copyright in Fig. 14, 11, 14, 11, 14, 11, 14, 14, 14 ,,,,,, concerned with the polycrystalline structure. The Prague diffraction angles were at 31.736 °, 34.338 °, 36.230 °, 47.505 °, 56.5330 °, 62.761 °, 66.309 °, 67.8470 °, 69.029 °, 72.459 °, 76.874 ° (101), (102), (110) and (103, (200), (112), (201), (004) and (202) respectively. These results are identical to those reported by Nagayasamy and others. [6]

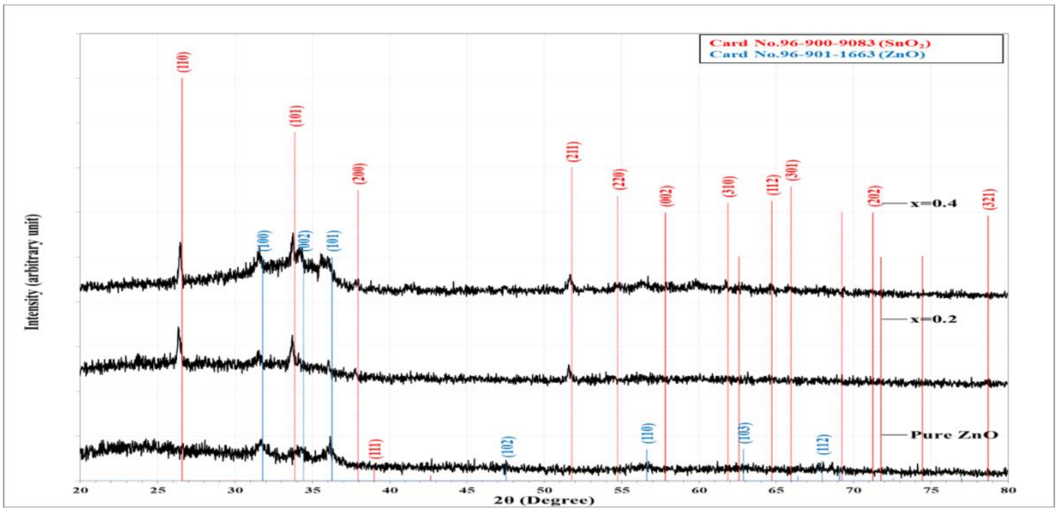

Fig. 2: X-ray diffraction curves for pure thin films and mixture films before annealing.

Table 1: X-ray diffraction parameters for pure thin films and mixture films before annealing.

Sample	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	hkl	d_{hkl} Std.(Å)	Phase	Card No.
	31.7122	0.5596	2.8193	14.8	(100)	2.8137	Hex. ZnO	96-901-1663
ZnO	34.3105	0.8394	2.6115	9.9	(002)	2.6035	Hex. ZnO	96-901-1663
	36.1892	0.9194	2.4801	9.1	(101)	2.4754	Hex. ZnO	96-901-1663
	47.5416	0.4397	1.9110	19.8	(102)	1.9110	Hex. ZnO	96-901-1665
	26.3158	0.3198	3.3839	25.5	(110)	3.3498	Tet.SnO_2	96-900-9083
	31.5123	0.4397	2.8367	18.8	(100)	2.8137	Hex. ZnO	96-901-1663
0.2	33.7109	0.3997	2.6566	20.8	(101)	2.6439	Tet.SnO_2	96-900-9083
	36.0293	0.3997	2.4908	20.9	(101)	2.4754	Hex. ZnO	96-901-1663
	37.7482	0.2798	2.3812	30.0	(200)	2.3686	Tet.SnO_2	96-900-9083
	51.5789	0.3998	1.7705	22.1	(211)	1.7642	Tet.SnO_2	96-900-9083
	26.4357	0.2798	3.3688	29.2	(110)	3.3498	Tet.SnO_2	96-900-9083
	31.5123	0.3998	2.8367	20.7	(100)	2.8137	Hex. ZnO	96-901-1663
	33.7508	0.2399	2.6535	34.6	(101)	2.6439	Tet.SnO_2	96-900-9083
0.4	34.2705	0.4398	2.6145	18.9	(002)	2.6035	Hex. ZnO	96-901-1663
	36.0293	0.5197	2.4908	16.1	(101)	2.4754	Hex. ZnO	96-901-1663
	37.9081	0.3598	2.3715	23.4	(200)	2.3686	Tet.SnO_2	96-900-9083
	51.6589	0.3998	1.7680	22.1	(211)	1.7642	Tet.SnO_2	96-900-9083

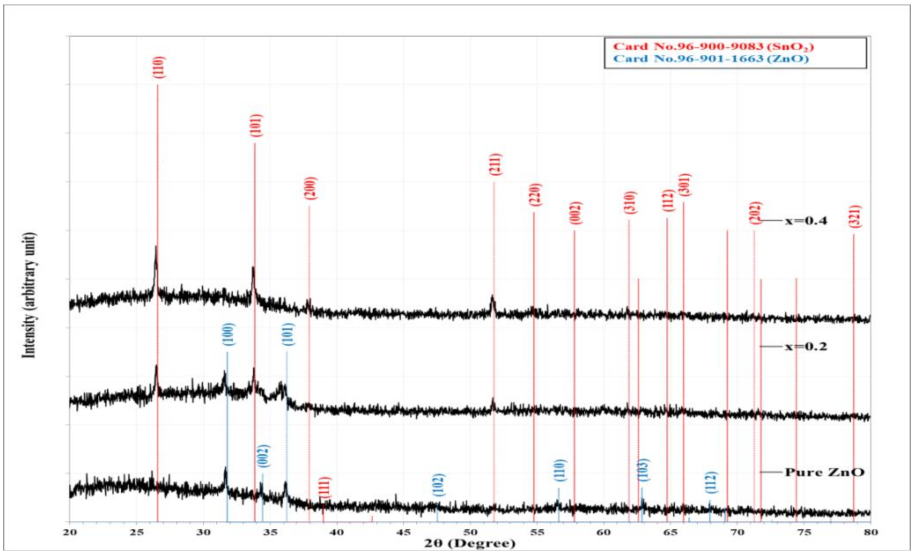

Fig. 3: shows the X-ray diffraction curves of zinc oxide films, tin oxide films and mix samples in different proportions after annealing.

Table 2: X-ray diffraction parameters for pure thin films and mixture films after annealing.

Sample	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp. (Å)	G.S (nm)	hkl	d_{hkl} Std. (Å)	Phase	Card No.
	31.6505	0.2200	2.8247	37.6	(100)	2.8137	Hex. ZnO	96-901-1663
	34.3366	0.3942	2.6096	21.1	(002)	2.6035	Hex. ZnO	96-901-1663
ZnO	36.2136	0.2912	2.4785	28.7	(101)	2.4754	Hex. ZnO	96-901-1663
	56.5049	0.3560	1.6273	25.3	(110)	1.6245	Hex. ZnO	96-901-1663
	26.4725	0.2913	3.3642	28.0	(110)	3.3498	Tet.SnO_2	96-900-9083
0.2	31.6181	0.2913	2.8275	28.4	(100)	2.8137	Hex. ZnO	96-901-1663
	33.7864	0.2266	2.6508	36.7	(002)	2.6035	Hex. ZnO	96-901-1663
	36.0841	0.3560	2.4871	23.5	(101)	2.4754	Hex. ZnO	96-901-1663
	51.6505	0.2913	1.7683	30.3	(211)	1.7642	Tet.SnO_2	96-900-9083
	26.4725	0.1942	3.3642	42.0	(110)	3.3498	Tet.SnO_2	96-900-9083
0.4	33.7540	0.2265	2.6533	36.7	(002)	2.6035	Hex. ZnO	96-901-1663
	37.9612	0.4207	2.3683	20.0	(200)	2.3686	Tet.SnO_2	96-900-9083
	51.6828	0.3560	1.7672	24.8	(211)	1.7642	Tet.SnO_2	96-900-9083

Through our study, it was found that the granular size changes from 23.01 to 23.5 nm for the non-annealed samples and from 29.3 to 31.87 nm for the annealed samples. The annealed samples also appeared with a larger grain size than the samples before annealing.

2- Surface topography

Three-dimensional images of Atomic Force Microscopy (AFM) and the statistical particle size distribution of the mixture films at different mixing ratios before annealing. The following figures show that the particle size increases with an increase in the ratio x and the distribution becomes homogeneous and has a narrower distribution as shown in the statistical distribution of particle size corresponding to each sample, the three-dimensional images of the atomic force microscope and the statistical distribution of the particle size for the surfaces of the pure thin films and the mixture films before annealing.

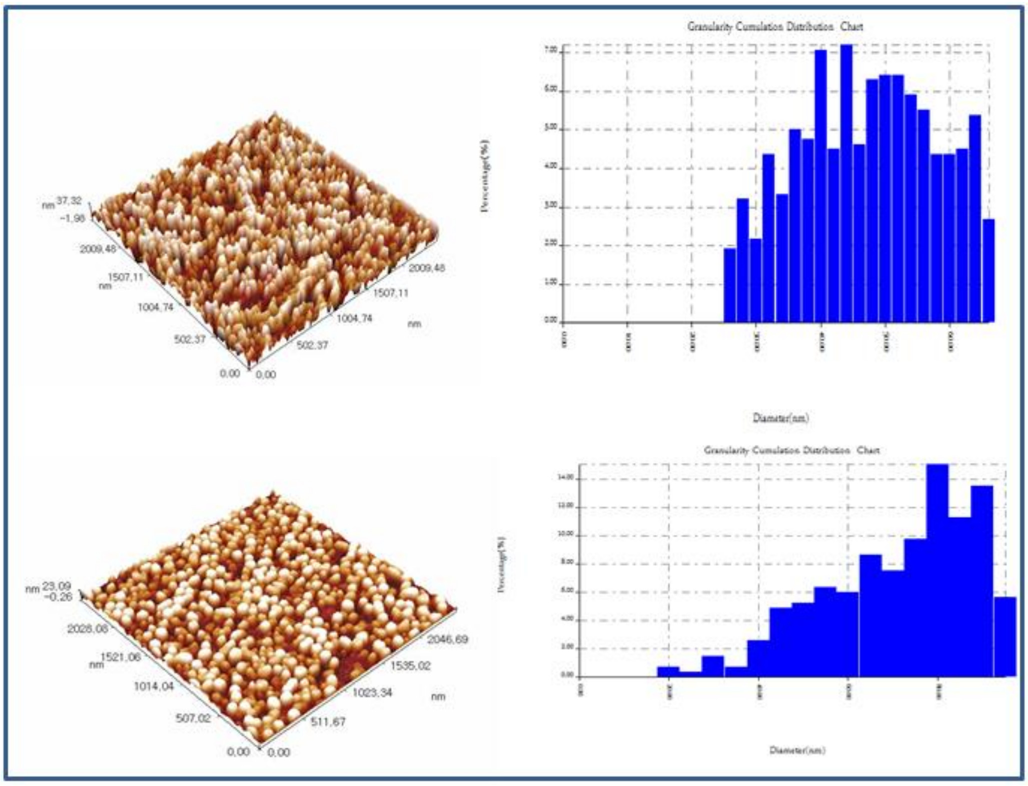

Fig. 4: shows the statistical distribution of the particle size corresponding to each of the ratios 0.2 and 0.4, respectively

3- Optical properties

From the UV-visible absorption spectrum - near infrared (in the wavelength range of 300-1000 nm), the optical properties of ZnO and SnO_2 membranes and their mixtures have been studied in different proportions which were prepared by pulsed laser on glass substrates before and after annealing.

Absorption spectrum:-

The following figures show the absorption spectra of pure ZnO membranes and membranes before and after annealing. In general, it can be seen that the absorbance decreases with increasing wavelength λ of all samples prepared. Since at high wavelengths there is not enough energy to raise the electrons from the valence beam to the conduction beam, while at the lower wavelengths with energy greater than the prohibited energy gap the electrons rise to the conduction beam and form a pair The electron gap that contributes to the electrical conduction process, Absorbability increased with an increase in SnO_2.

There is a sharp decrease in the absorbance of the annealed films, especially in the ZnO sample at a wavelength of approximately 400 nm, due to the fact that the absorbance possesses a sharp edge indicating an increase in the degree of crystallization and the removal of crystal defects near the edge of the absorption after annealing, while the membranes tend to be more transparent in the area of long wavelengths (That is, absorbance is the opposite of permeability) as shown in the following figures(2)(3).

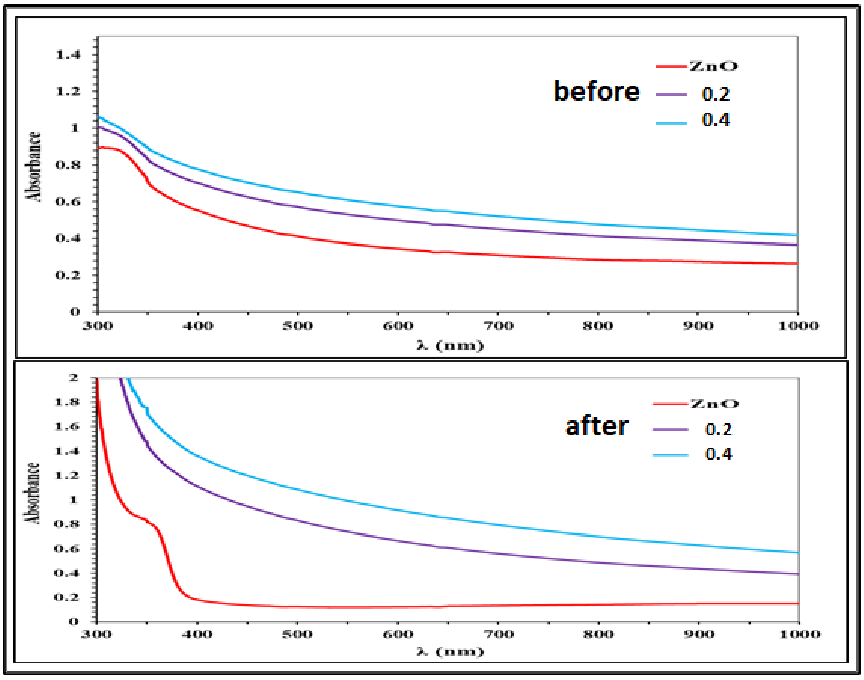

Fig. 5: shows Absorbance before and after annealing

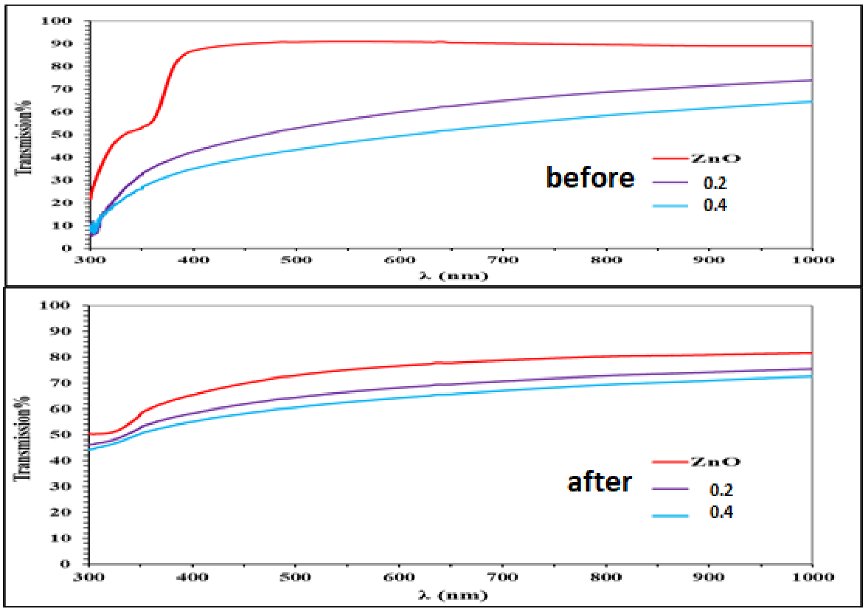

Fig. 6: shows Permeability before and after annealing

Absorption coefficient

The following diagrams show the absorption coefficient spectra for pure ZnO and SnO2 films and for compound films before and after annealing. In general, it can be seen that the absorption coefficient decreases with increasing wavelength and increases with increasing SnO2 ratio. It appears from the following figures that the absorption coefficient values are within the 104 range, which indicates that the direct type transition [7] This result is consistent with previous research, as both ZnO and SnO_2 have a permissible direct transmission [8] [9]. The tables below the following figures show the values of the permeability of the absorption coefficient of the energy gap before and after annealing.

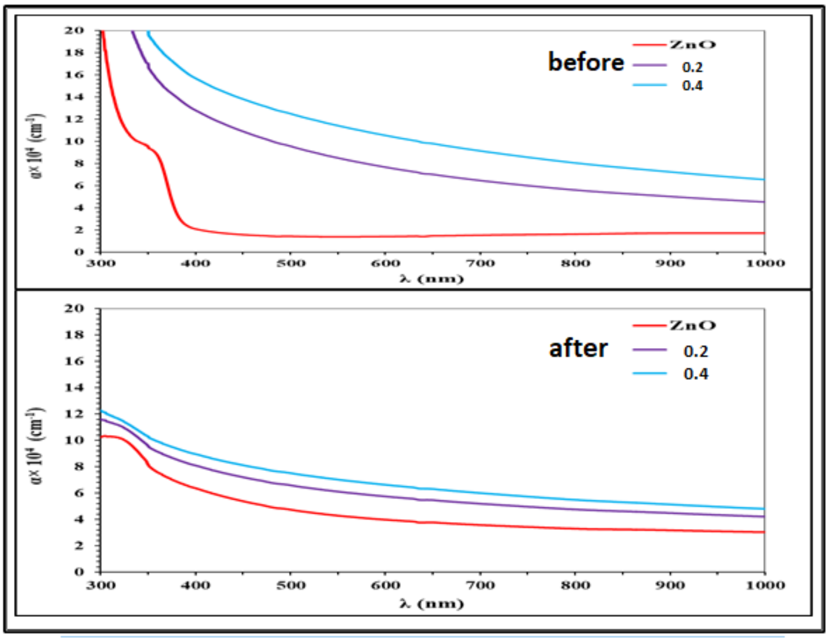

Fig. 7: absorption coefficient before and after annealing

The Optical Energy gap

The figure shows the characterization of the permissible direct-transmission Taos relationship [6] (the relationship between (αhυ) 2 on the y-axis versus hυ on the x-axis) of the pure membranes ZnO and SnO2 and the membranes before and after annealing. Find the energy gap values from the tangent intersection of the linear region of the curve with the x-axis. In non-annealed films, the value of the optical energy gap was 3,20 electron volts for the zinc oxide films (which are within the range of values in previous research) [8] and gradually decreased by increasing the tin oxide until it reached 2.90 electron volts in the only tainted film (0.4) while it was The value of the optical energy gap in the annealed films is 3.30 electron volts for the zinc oxide films, and it is gradually reduced by the proportion of tin oxide until it reaches 2.80 electron volts in the only tainted films (0.4).

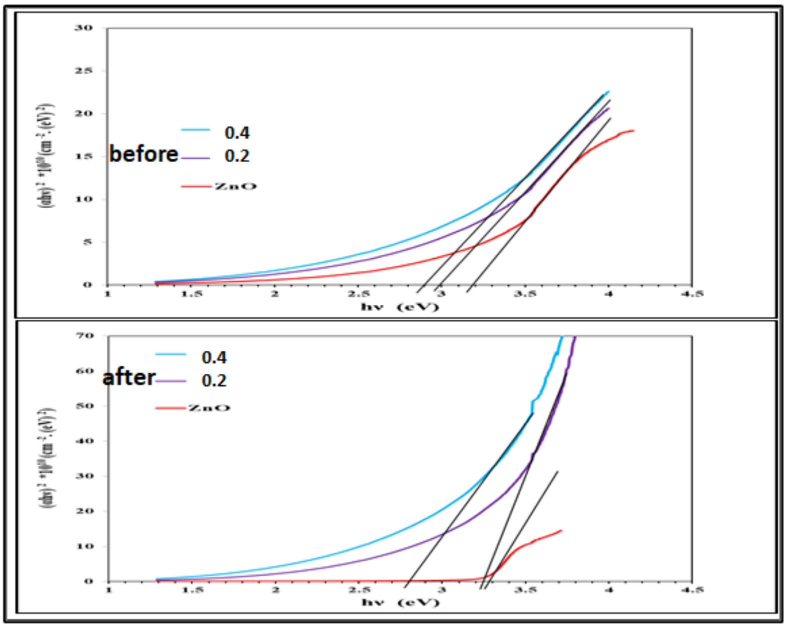

Fig. 8: shows energy gap before and after annealing.

The following tables below represent the values shown in the aforementioned figures for permeability, absorption coefficient, and energy gap, before annealing in Table No. 1 and after plasticization in Table No. 2 .

Table 3: represents the permeability; absorption coefficient and energy gap values before annealing.

Sample	T%	α (cm^{-1})	Eg (eV)
ZnO	75.17	42813	3.20
0.2	66.55	61076	3.00
0.4	62.62	70207	2.90

Table 4: represents the values of permeability; absorption coefficient and energy gap values after annealing

Sample	T%	α (cm^{-1})	Eg (eV)
ZnO	91.13	13933	3.20
0.2	56.71	85096	3.00
0.4	46.68	114286	2.80

Conclusions

Some conclusions can be made about the physical properties of zinc oxide and tin-like films through the results shown in our research These are as follows:

1. The possibility of obtaining ZnO nanoparticles by means of the pulse laser technology (PLD).
2. The results revealed the X-ray diffraction that the compound's membrane (ZnO) is in the form of a multi-crystalline substance with a hexagonal phase.
3. Scanning electron microscopy (AFM) measurements showed that tin denaturation significantly affects the shape and size of the particles forming the surface of the membrane.
4. The energy gap of tainted membranes decreases by increasing the proportion of vaccination.
5. The tin vaccination improves the optical properties of the membranes by reducing the energy gap.
6. ZnO film has a high optical transmittance rate of (90%) and its value decreases by increasing the percentage of tin distortion.
7. The pure ZnO membrane possesses a large energy gap that decreases by increasing the percentage of tin distortion and reduces after annealing when increasing the percentage of the deformation as well.

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تأثير نسب تشويب أوكسيد الخارصين النانوية بالقصدير على بعض الخواص البصرية المحضرة بطريقة الليزر النبضي

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الملخص

تم في هذا البحث استخدام طريقة الترسيب بالليزر النبضي PLD بواسطة ليزر Nd:YAG ذي الطول الموجي λ=1064 nm لترسيب أغشية رقيقة من أوكسيد الخارصين النقية و المشوبة بالقصدير وبنسب وزنية مختلفة (0.2 , 0.4) تم الترسيب على قواعد زجاجيه وذلك لدراسة تأثير التلدين عند درجه حراره 573k والتشويب على بعض الخصائص الفيزيائية لأغشية أوكسيد الخارصين النانوية .

بينت قياسات حيود الأشعة السينية لأغشية أوكسيد الخارصين النقية والمشوبة بنسب مختلفة (0.2 , 0.4) بالقصدير بان هذه الاغشية تمتلك تركيب متعددة التبلور، من النوع السداسي .

ودرست الخصائص الطبوغرافية لسطوح الأغشية المحضرة باستخدام مجهر القوة الذرية(AFM) وبينت أن غشاء ZnO يمتلك سطحاً ناعماً ومتجانساً في التركيب.

كما وأظهرت نتائج الخصائص البصرية وجود زيادة حادة في طيف النفاذية البصرية حتى تصل إلى 90%بعد التلدين, وإن التشويب يقلل من النفاذية البصرية.

كما وجدت أن فجوة الطاقة البصرية لغشاء ZnO(3.2eV) قبل التلدين و(3.3 eV) بعد التلدين وتقل فجوة الطاقة بزيادة نسب الخلط.