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Structural and Morphological Studies for $ZnO:SnO_2$ Composite Thin Films

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Abstract: In the present work, structural properties have been studied for ZnO, SnO_2, ZnO: SnO_2 composite thin film prepared by spray pyrolysis technique deposition at substrate glass with different deposition conditions, volume ratios(50%:50%,70%:30%,90%:10%), Substrate temperature (400 and 450°C), incident angle spray (0 and 45)degree. The X-ray diffraction technique has showed that all prepared films are polycrystalline structure type of hexagonal with preferred orientation of plan (002) direction for all prepared thin films (ZnO, $ZnO:SnO_2$ composite) except SnO_2 thin films are polycrystalline structure type of tetragonal with preferred orientation of plane (110), the results obtained by X- ray diffrograms show that the thin film structure has an average grain size between (2.4 to 46 nm) and uniform homogeneity by added tin oxide to zinc oxide , the results show high crystalline with deferent conditions deposition. Surface analysis by SEM and AFM has been used to understand the effect of the different conditions deposition on morphology properties of the samples. the SEM micrographs show needle – like, fiber – like, hexagonal nano rods, rich particles (high growth) and homogeneity, uniform distribution, high growth. The results showed an increase of the average grain size with roughness increasing, and this leads to obtain a high surface area.

Keywords: Composite thin films; ZnO: SnO2 thin films; Structural properties; Morphological studies.

Introduction

Zero and one dimensional nanostructures of binary metal oxides such as $_{SnO2}$, ZnO and TiO_2 have attracted great interest owing to their unique properties and potential use in different diverse applications [1]. ZnO and SnO_2 belong to wide direct band gap semiconductors, and their band gaps are 3.4 and 3.6 eV respectively [2, 3]. Zinc and tin oxides have attracted considerable attention and many investigators exploited various synthesis methods to couple and to obtain nano composites of ZnO and SnO_2 [4].

Composite materials are engineered or naturally occurring materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct at the macroscopic within the finished structure composite thin films are a new area of study with many applications, e.g. metal oxide thin films in high density magnetic recording media. Engineering the processing, microstructure and properties of these thin films is of great importance Surface diffusion and self-shadowing effects are found to play an important role in determining various film microstructures under different processing conditions [5].

The conductometric semiconducting metal oxide gas sensors currently constitute one of the most investigated groups of gas sensors. They have attracted much attention in the field of gas sensing under atmospheric conditions due to their low cost and flexibility in production, simplicity of their use and large number of detectable gases possible application fields. In addition to the conductivity change of gas-sensing material, the detection of this reaction can be performed by measuring the change of capacitance, work function, mass, optical characteristics or reaction energy released by the gas/solid interaction [5].

Experimental Work

A. Films Preparation

The ZnO pure, SnO_2 pure and ZnO: SnO_2 composite thin films were deposited by spray pyrolysis technique using homemade equipment as illustrated in *the F*igure (1) with different parameters show in the table (1).

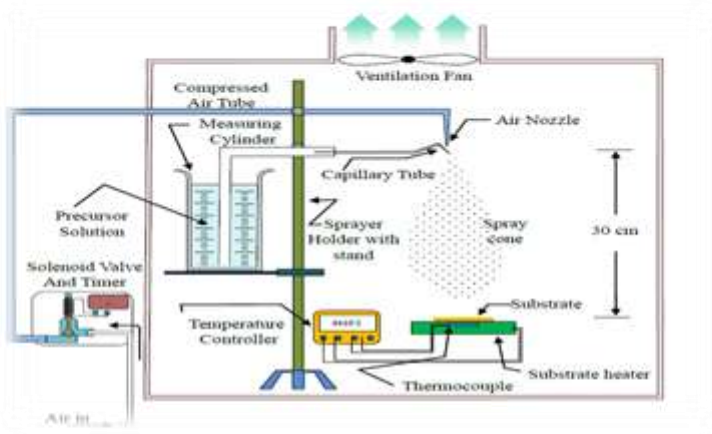


Fig. (1) The diagram of spray pyrolysis equipment.

Table (1) Spray pyrolysis process parameters for the deposition Of ZnO:SnO2 composite thin films.

Spray parameters	**Optimum value/Item**
Nozzle diameter	0.3 mm
Nozzle-substrate distance	32 cm
Precursor solution concentration	0.1M
Solvent	Distilled water
Solution flow rate	3 ml/min
Carrier gas	Nitrogen
Gas pressure	4 bar
Substrate temperature	(400,450)^{o}C
Incident spray angle (for nozzle)	(0,45) degree

ZnO: SnO_2 thin films composite were prepared by using a mixing of an aqueous solution of Zinc Chloride ($ZnCl_2.5H_2O$) with concentration (0.1) M andTin Chloride ($SnCl_4.2H_2O$)with concentration (0.1) according to the different conditions illustrated in the table (2), dissolved in 100 ml of distilled water. The mixture was stirred by (magnetic stirrer) for 30 min.

Table (2) Conditions of deposition ZnO:SnO2 thin film composite by spray pyrolysis.

Volume ratio	Incident angle	Substrate temperature
ZnO(100%),SnO_2(0%)	0^o&45^o	400 &450 ^{o}C
ZnO(0%), SnO_2(100%)	0^o&45^o	400 &450 ^{o}C
ZnO (50%), SnO_2 (50%)	0^o&45^o	400 &450 ^{o}C
ZnO(70%), SnO_2 (30%)	0^o&45^o	400 &450 ^{o}C
ZnO(90%), SnO_2 (10%)	0 ^{o}&45^o	400 &450 ^{o}C

B. Material Characterizations

X- Ray Diffraction (XRD)

The structure analysis and lattice parameters of films were carried out by analyzing the x-ray diffraction patterns obtained via diffractometer of target Cu K_α, with wavelength of 1.5406 Å and glansing angle (2θ) in the range of 10 to 60 degrees.

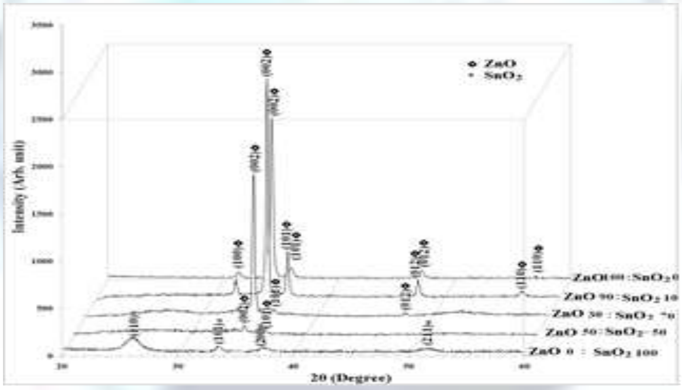
Figures (2to5) show the XRD patterns for (ZnO:SnO_2) composite thin films with different deposition conditions (volume ratio, substrate temperature, incident angle for spray pyrolysis), the resultant patterns give an indication about the structure crystallenity, the films have polycrystalline structure of the hexagonal ZnO standards peaks with preferred orientation at (002) plane for ZnO ratio of (100%, 50%, 70% and 90%) and the tetragonal structure of SnO_2 with preferred orientation at (110) plane, thegrowth as well as the crystallizationofzincoxidemuch higher thanthetin oxide, especially after adding the tinoxidetozincoxideat different rates.Theoptimum ratio was (ZnO90%: SnO_2 10 %),at the incident angle of sprayerof (45^o) degree. Figure (5) showsthatthe this ratio representsthehighest average grain size(highest crystallization) inprepared thin film andthis confirmsthattheadditiontin oxidebysimple andspecificleadstoanincreaseofcrystallization, the adding of SnO_2 will affect the crystallization, new peakswill appear by increasing incident angle to 45 degree this led to increase of crystallization and reveal new planes of directions. The preferred orientations data and average grain size for thin films prepared by spray pyrolysis with different conditions tabulated in the tables (3) to (7).

X-ray diffraction could be used to define the preferred orientation, and from the diffrograms one can calculate the average grain size and determine whether the deposited films suffer from stress or not.
The average grain size calculated using Debye-Scherrer formula was nano structure, The single line method is one of the several line profile analysis methods based on a Voigt function to determine the size–strain parameters (microstrains and crystallite sizes), The average grain size (g), which can be estimated using the Scherrer's formula[6] :

$$g = (0.94 \lambda) / [\Delta (2 \theta) \cos\theta] \quad \ldots\ldots(1)$$

where:
λ : is the x-ray wavelength (Å) .
$\Delta (2 \theta)$: FWHM (radian) .
θ : Bragg diffraction angle of the XRD peak (degree) .
The micro strains are caused during the growth of thin films , and will be raised from stretching or compression in the lattice to make a deviation in the c-lattice constant of the hexagonal structure from the ASTM value. So the strain broadening is caused by varying displacements of the atoms with respect to their reference lattice position [6]. This strain can be calculated from the formula:

$$\delta = [| C_{ASTM} - C_{XRD} | / C_{ASTM}] * 100\% \quad \ldots\ldots(2)$$



Fig(2). XRD pattern for $ZnO:SnO_2$ films with different ratio at $T=400^oC$ and $\alpha=0$.

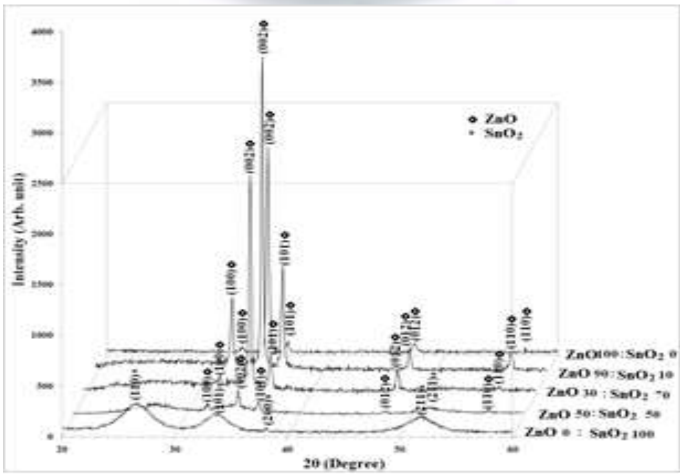


Fig.(3). XRD pattern for $ZnO:SnO_2$ films with different ratio at $Ts=400^oC$ and $\alpha=45°$.

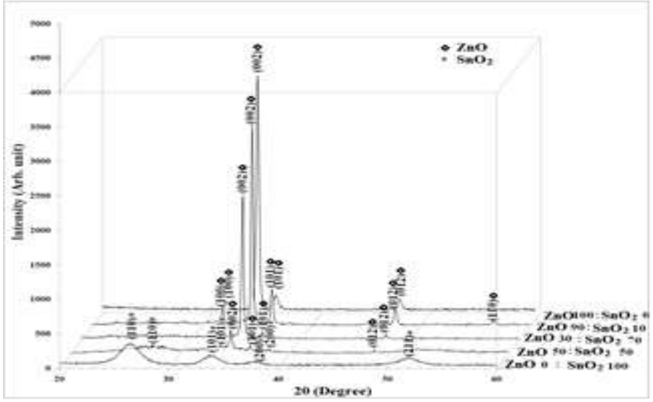


Fig (4). XRD pattern for SnO_2: ZnO films with different ratio at Ts=450^{o}C and α=0.

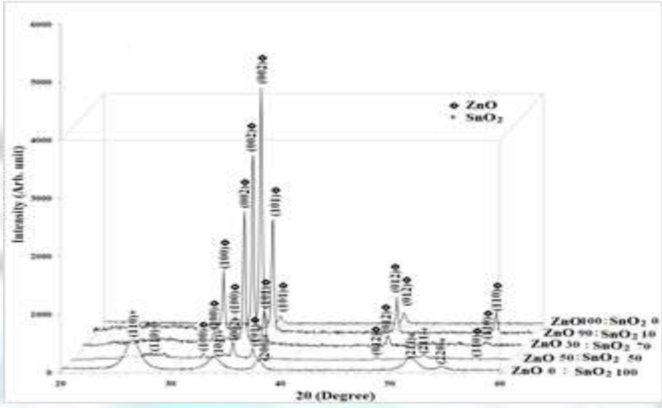


Fig.(5). XRD pattern for ZnO: SnO_2 films with different ratio at Ts=450^{o}C and α=45°.

Table (3) XRD data for100%ZnOat T = 400 and 450^{o}C and α = 0 & 45^o

Ts (C°)	α (Deg)	2θ $_{exp.}$ (Deg.)	β (Deg.)	Int. (Arb.U.)	(hkl)	d $_{Exp.}$ (A^o)	d $_{Std.}$ (A^o)	G.S (nm)	Strain *10^{-3}
400	0	31.247	0.419	56	(100)	2.8602	2.8009	18.5	21.17
		34.087	0.293	1750	(002)	2.6281	2.5886	26.7	15.26
		35.761	0.546	90	(101)	2.5089	2.4635	14.4	18.43
		47.073	0.420	72	(012)	1.9290	1.9010	19.4	14.73
	45	31.381	0.356	35	(100)	2.8481	2.8009	21.8	16.85
		34.221	0.251	2088	(002)	2.6182	2.5886	31.1	11.43
		35.977	0.334	70	(101)	2.4941	2.4635	23.4	12.42
		47.263	0.418	88	(012)	1.9222	1.9010	19.5	11.15
450	0	31.298	0.399	113	(100)	2.8557	2.8009	19.4	19.57
		34.138	0.279	3406	(002)	2.6243	2.5886	28.0	13.79
		35.812	0.520	182	(101)	2.5054	2.4635	15.1	17.01
		47.124	0.400	144	(012)	1.9270	1.9010	20.4	13.68
	45	31.432	0.339	74	(100)	2.8438	2.8009	22.9	15.32
		34.272	0.239	4077	(002)	2.6143	2.5886	32.7	9.93
		36.028	0.318	144	(101)	2.4909	2.4635	24.7	11.12
		47.314	0.398	178	(012)	1.9197	1.9010	20.5	9.84

Table (4) XRD data for100% SnO_2 at T=400and 450°C and α = 0 & 45°

Ts (C°)	α (Deg)	2θ exp. (Deg.)	β (Deg.)	Int. (Arb.U.)	(hkl)	d Exp. (A°)	d Std. (A°)	G.S (nm)	Strain *10^{-3}
400	0	26.114	1.438	177	(110)	3.4096	3.3487	5.3	18.2
		33.586	0.520	54	(101)	2.6662	2.6442	15.0	8.3
		37.502	0.919	40	(200)	2.3963	2.3679	8.6	12.0
		51.608	1.398	31	(211)	1.7696	1.7640	5.9	3.2
	45	26.480	2.120	325	(110)	3.3633	3.3487	3.6	4.4
		33.880	1.640	132	(101)	2.6437	2.6442	4.8	0.2
		37.880	1.440	45	(200)	2.3732	2.3679	5.5	2.2
		51.920	2.000	101	(211)	1.7597	1.7640	4.2	2.4
450	0	26.635	3.199	264	(110)	3.3441	3.3487	2.4	1.4
		33.705	2.479	166	(101)	2.6570	2.6442	3.2	4.8
		38.169	1.020	31	(200)	2.3560	2.3679	24.7	5.0
		51.860	2.840	144	(211)	1.7616	1.7640	2.9	1.4
	45	26.584	1.621	511	(110)	3.3504	3.3487	4.7	0.5
		33.971	1.459	220	(101)	2.6368	2.6442	5.4	2.8
		38.067	0.771	173	(200)	2.3620	2.3679	10.3	2.5
		51.926	1.337	211	(211)	1.7595	1.7640	6.2	2.6
		54.727	0.891	58	(220)	1.6759	1.6743	9.5	1.0

Table (5) XRD data for ZnO 90% and SnO2 10% % ZnOat Ts=400 and 450°C and α=0 and 45°

Ts (C°)	α (Deg)	2θ exp. (Deg.)	β (Deg.)	Int. (A.U.)	(hkl)	Phase	d Exp. (A°)	d Std. (A°)	G.S (nm)	Strain *10^{-3}
400	0	32.090	0.321	197	(100)	ZnO	2.7870	2.8009	24.3	4.96
		34.750	0.224	2400	(002)	ZnO	2.5795	2.5886	35.0	3.52
		36.420	0.267	488	(101)	ZnO	2.4650	2.4635	29.5	0.61
		47.820	0.324	183	(012)	ZnO	1.9006	1.9010	25.3	0.21
		56.750	0.375	72	(110)	ZnO	1.6209	1.6171	22.7	2.35
	45	31.860	0.221	588	(100)	ZnO	2.8066	2.8009	35.2	2.04
		34.550	0.189	2650	(002)	ZnO	2.5940	2.5886	41.5	2.09
		36.360	0.189	851	(101)	ZnO	2.4689	2.4635	41.7	2.19
		47.640	0.253	202	(012)	ZnO	1.9073	1.9010	32.3	3.31
		56.700	0.323	142	(110)	ZnO	1.6222	1.6171	26.3	3.15
450	0	31.950	0.311	198	(100)	ZnO	2.7989	2.8009	25.0	0.71
		34.640	0.215	2500	(002)	ZnO	2.5874	2.5886	36.5	0.46
		36.440	0.236	432	(101)	ZnO	2.4636	2.4635	33.4	0.04
		47.750	0.315	208	(012)	ZnO	1.9032	1.9010	26.0	1.16
		56.740	0.356	45	(110)	ZnO	1.6211	1.6171	23.9	2.47
	45	32.100	0.192	983	(100)	ZnO	2.7861	2.8009	40.6	5.28
		34.800	0.177	2850	(002)	ZnO	2.5759	2.5886	44.3	4.91
		36.590	0.181	1841	(101)	ZnO	2.4539	2.4635	43.5	3.90
		47.870	0.224	559	(012)	ZnO	1.8987	1.9010	36.6	1.21
		56.810	0.296	338	(110)	ZnO	1.6193	1.6171	28.7	1.36

Table (6) XRD data for ZnO 70 % and SnO_2 at Ts = 400 and 450°Cand α = 0 and 45°

Ts (C°)	α (Deg)	2θ exp. (Deg.)	β (Deg.)	Int. (A.U.)	(hkl)	Phase	d Exp. (A°)	d Std. (A°)	G.S (nm)	Strain *10^{-3}
400	0	34.600	0.299	1500	(002)	ZnO	2.5903	2.5886	26.2	0.66
		36.360	0.394	68	(101)	ZnO	2.4689	2.4635	20.0	2.19
		47.750	0.419	34	(012)	ZnO	1.9032	1.9010	19.5	1.16
	45	31.990	0.360	117	(100)	ZnO	2.7955	2.8009	21.6	1.93

		34.700	0.250	2200	(002)	ZnO	2.5831	2.5886	31.4	2.12
		36.540	0.360	368	(101)	ZnO	2.4571	2.4635	21.9	2.60
		47.760	0.400	205	(012)	ZnO	1.9028	1.9010	20.5	0.95
450	0	34.780	0.271	2100	(002)	ZnO	2.5773	2.5886	28.9	4.37
		36.550	0.322	96	(101)	ZnO	2.4565	2.4635	24.5	2.84
		47.900	0.311	65	(012)	ZnO	1.8976	1.9010	26.3	1.79
	45	32.040	0.283	227	(100)	ZnO	2.7912	2.8009	27.5	3.46
		34.760	0.234	2400	(002)	ZnO	2.5788	2.5886	33.5	3.79
		36.550	0.281	602	(101)	ZnO	2.4565	2.4635	28.0	2.84
		47.820	0.283	62	(012)	ZnO	1.9006	1.9010	28.9	0.21

Table (7) XRD data for ZnO 50% $SnO_2$50%Ts=400 and 450^oCandα=0 and 45^o.

Ts (C^o)	α (Deg)	2θ exp. (Deg.)	β (Deg.)	Int. (A.U.)	(hkl)	Phase	d Exp. (A^o)	d Std. (A^o)	G.S (nm)	Strain $*10^{-3}$
400	0	26.720	3.144	51	(110)	SnO_2	3.3336	3.3487	2.4	4.51
		32.120	0.357	49	(100)	ZnO	2.7869	2.8009	21.8	5.00
		33.920	0.832	72	(101)	SnO_2	2.6431	2.6442	9.4	0.42
		34.800	0.297	120	(002)	ZnO	2.5777	2.5886	26.4	4.21
		36.620	0.297	69	(101)	ZnO	2.4539	2.4635	26.5	3.90
		52.100	1.664	11	(211)	SnO_2	1.7540	1.7640	5.0	5.67
		56.970	0.357	14	(110)	ZnO	1.6165	1.6171	23.8	0.37
	45	26.760	3.126	76	(110)	SnO_2	3.3313	3.3487	2.5	5.20
		31.940	0.416	75	(100)	ZnO	2.8018	2.8009	18.7	0.32
		34.010	0.357	81	(101)	SnO_2	2.6360	2.6442	21.9	3.10
		34.660	0.254	250	(002)	ZnO	2.5885	2.5886	30.9	0.04
		36.460	0.297	128	(101)	ZnO	2.4644	2.4635	26.5	0.37
		47.790	0.535	42	(012)	ZnO	1.9031	1.9010	15.3	1.10
		52.180	2.556	41	(211)	SnO_2	1.7529	1.7640	3.3	6.29
		56.880	0.357	22	(110)	ZnO	1.6187	1.6171	23.8	0.99
		26.760	3.126	76	(110)	SnO_2	3.3313	3.3487	2.5	5.20
450	0	26.890	2.685	65	(110)	SnO_2	3.3153	3.3487	2.9	9.97
		31.990	0.335	63	(100)	ZnO	2.7980	2.8009	23.2	1.04
		33.870	0.297	89	(101)	SnO_2	2.6463	2.6442	26.3	0.79
		34.690	0.297	300	(002)	ZnO	2.5862	2.5886	26.4	0.93
		36.460	0.238	102	(101)	ZnO	2.4644	2.4635	33.1	0.37
		38.100	0.178	44	(200)	SnO_2	2.3623	2.3679	44.5	2.36
		47.790	0.178	29	(012)	ZnO	1.9031	1.9010	46.0	1.10
		51.750	2.556	31	(211)	SnO_2	1.7667	1.7640	3.3	1.53
		56.965	0.238	25	(110)	ZnO	1.6153	1.6171	35.8	1.11
	45	26.840	2.912	66	(110)	SnO_2	3.3190	3.3487	2.6	8.87
		32.020	0.357	91	(100)	ZnO	2.7956	2.8009	21.8	1.89
		33.920	0.357	100	(101)	SnO_2	2.6426	2.6442	21.9	0.61
		34.720	0.237	400	(002)	ZnO	2.5839	2.5886	33.1	1.82
		36.520	0.297	177	(101)	ZnO	2.4603	2.4635	26.5	1.30
		38.180	0.357	35	(200)	SnO_2	2.3574	2.3679	22.2	4.43
		47.880	0.475	39	(012)	ZnO	1.8998	1.9010	17.2	0.63
		52.100	2.080	38	(211)	SnO_2	1.7556	1.7640	4.0	4.76
		56.840	0.524	29	(110)	ZnO	1.6199	1.6171	16.2	1.73

Figure (6) show comporting betweenthe volume ratio and average grain size for all preferred orientation with temperature substrate (T) and incident angle (α), as it's can be seen the increasing in the volume ratio with the average grain size.

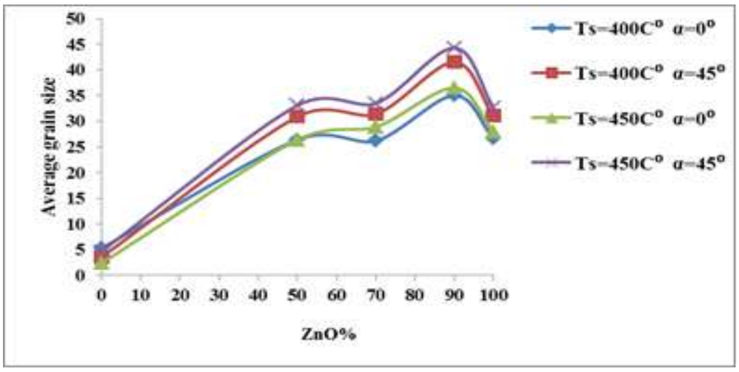


Fig. (6). Effect of ZnO wt.% on the average grain size.

C. Surface Morphology

Atomic Force Microscopy (AFM)

The surface morphology of ZnO, SnO_2 and ZnO:SnO_2 composite thin films were analyzed using an atomic force microscopy (AA-3000). It is known that the surface morphology of the films influences their properties as an important factors for applications like gas sensing, the increasing in surface roughness of the films leads to increase in sensing properties, therefore it is very important to investigate the surface morphology of the films, the surface morphology of the ZnO:SnO_2 composite thin films with different deposition condition at specific substrate temperature measured by AFM are illustrated in the figures (7 to 11). The analysis of the results can give an excellent value for average grain size and the surface roughness, these results are tabulated in the table (8). Surface roughness ofthe samples shows score of heights and bottoms (brightness and darknesscolor) as shown in the images, the increase of the number ofdips andriseswithin thespace give rise of roughness and it can be noticedthrough the sample image as well as thehomogeneity of the thin film surface.

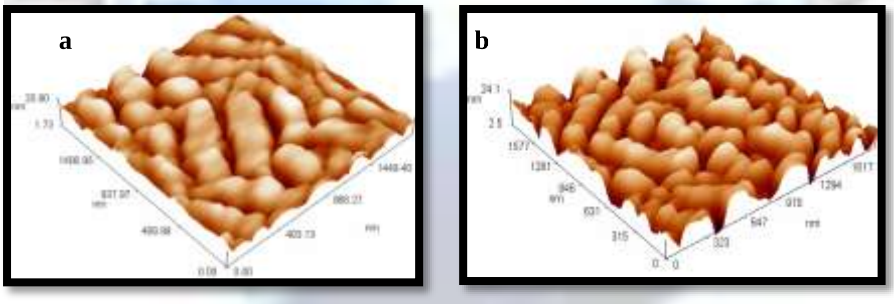


Fig. (7). AFM images for ZnO100%: (a) incident angle (0), substrate temperature (450°C), (b) incident angle (45°), substrate temperature 450°C.

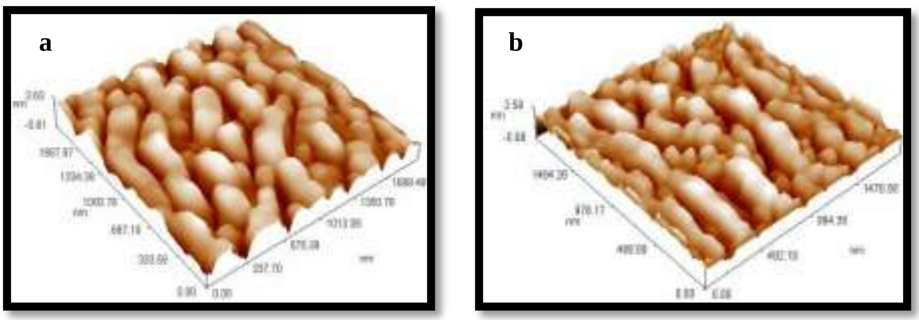


Fig. (8). AFM images for SnO2 100%: (a) incident angle (0), substrate temperature (450°C), (b) incident angle (45°) , substrate temperature 450°C.

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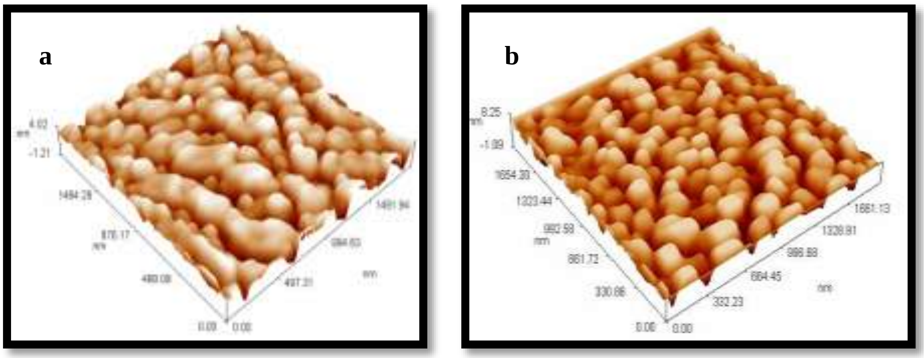

Fig. (9).AFM images for ZnO 50%,$SnO_2$50%: (a) incident angle (0),substrate temperature (450^{o}C), (b) incident angle (45^o),substrate temperature 450^{o}C.

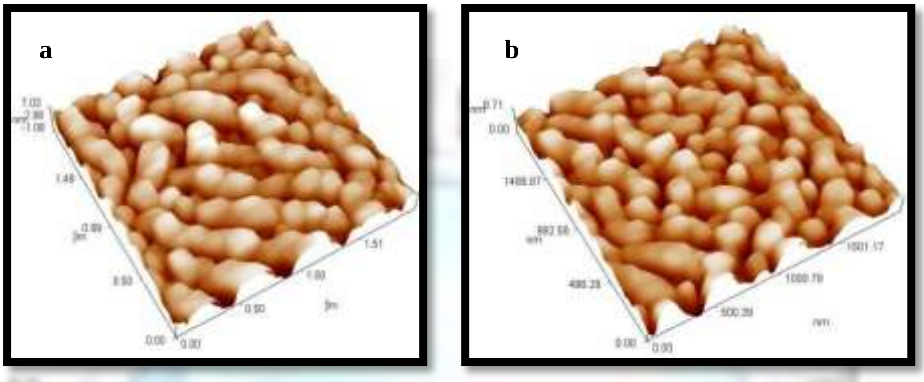

Fig.(10).AFM images for ZnO70%,$SnO_2$30%: (a)incident angle (0),substrate temperature (450^{o}C), (b)incident angle (45^o) ,substrate temperature 450^{o}C.

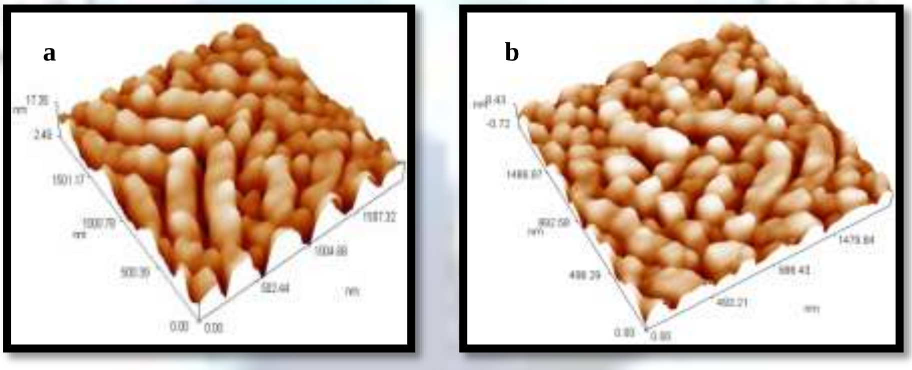

Fig.(11).AFM images for ZnO90%,SnO_2 10%: (a) incident angle (0), substrate temperature (450^{o}C), (b) incident angle (45^o), substrate temperature 450^{o}C.

Table (8) Roughness and grain size at incident angle (0,45) for all prepared samples

Volume ratio	Incident angle	RMS Roughness	average Grin Size(nm)
ZnO(100%),SnO_2(0%)	0	2.39	90.2
ZnO(100%),SnO_2(0%)	45	3.9	107.69
ZnO (0%), SnO_2 (100%)	0	0.532	80.86
ZnO (0%), SnO_2 (100%)	45	0.619	120.64
ZnO(50%), SnO_2 (50%)	0	0.726	82.29
ZnO(50%), SnO_2 (50%)	45	1.13	100.11
ZnO(70%), SnO_2 (30%)	0	1.13	96.46
ZnO(70%), SnO_2 (30%)	45	1.22	102.93
ZnO(90%), SnO_2 (10%)	0	1.4	91.62
ZnO(90%), SnO_2 (10%)	45	2.1	106.63

Increase of the incident angle of the spray to (45) degree for different ratios causes the increase in the average grain size, which in turn leads to increased roughness, as shown the Figure (12).

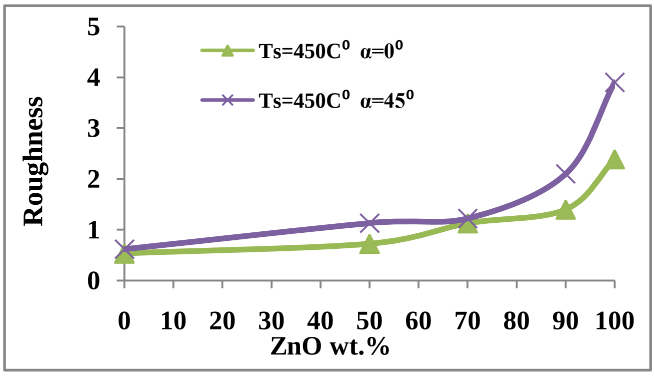

Fig. (12) The effect of ZnO wt.% ratio on the grain size measured by the AFM.

The effect of ZnO wt. %n ratio on the surface roughness of the films shown in the Figure (13).

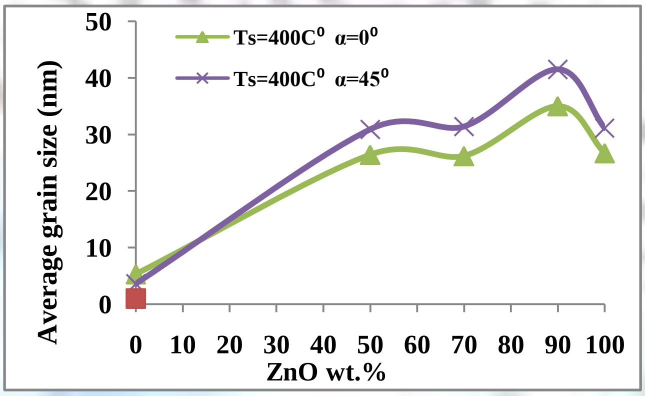

Fig. (13) The effect ZnO wt.% ratio on the roughness measured by the AFM.

D. Scanning Electron Microscopy (SEM)

The morphological properties of all films were investigated using (kyky em3200 model, made in china) scanning electron microscope (SEM, at operating voltage is 20.00 kV). Figures (14 to 18) show the SEM micrographs surface and cross-section for the thin film composite at substrate temperature (450 OC) with incident angle spray (0 & 45) degree, all the micrographs for surface and the cross-section show the homogenous, uniform distribution, high growth. Figure (16 -1) show the needle like. Figure (16-2) show that the fiber like. Figure (17) show the hexagonal nano rods. Figure (18-2) show the rich particles (high growth). In the state of incident angle spray pyrolysis deposited thin films, it is noticed forms like high density rod or needles [7, 8].

It is postulated that in the initial stages of film formation a random distribution of small crystallites is created on the substrate and each crystallite acts as a nucleus for further growth, thus the region behind the crystallite is prevented from receiving metal spray because this region is in the shadow of crystallite. Therefore, as the crystallite grows into a rod, the area behind it is left vacant as far as its shadow extends [9].

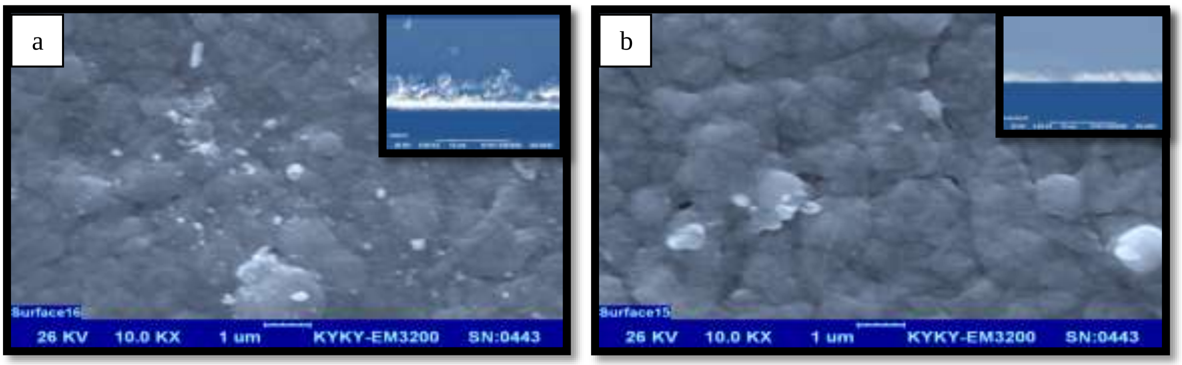

Figure (14).The micrograph SEM surface and the inset image shows the cross section SEM for ZnO 100%: (a) with temperature deposition (450°C) and incident angle (0) degree, (b) with temperature deposition (450°C) and incident angle (45) degree.

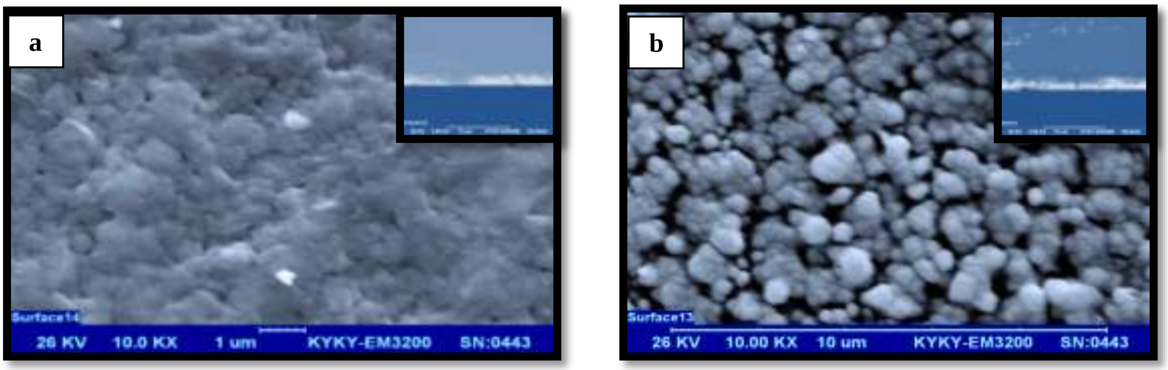

Fig. (15) The micrograph SEM surface and the inset image shows the cross section for SnO2 100%: (a) with temperature deposition (450°C) and incident angle (0) degree, (b) with temperature deposition (450°C) and incident angle (45) degree.

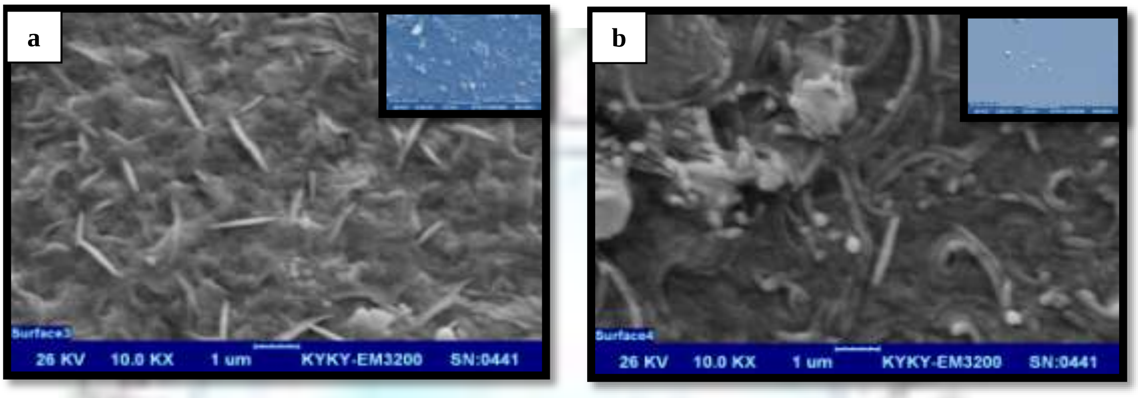

Fig.(16) The micrograph SEM surface and the inset image shows the cross section for ZnO 50% :SnO_2 50%: (a) with temperature deposition (450°C) and incident angle (0) degree, (b) with temperature deposition (450°C) and incident angle (45) degree.

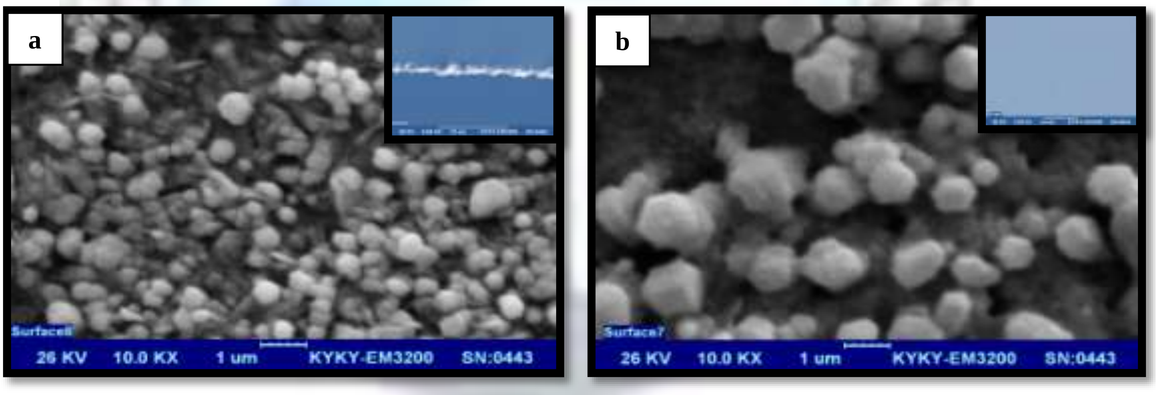

Fig.(17) The micrograph SEM surface and the insetimage shows the cross section for ZnO 70% :SnO2 30%: (a) with temperature deposition (450°C) and incident angle (0) degree, (b) with temperature deposition (450°C) and incident angle (45) degree.

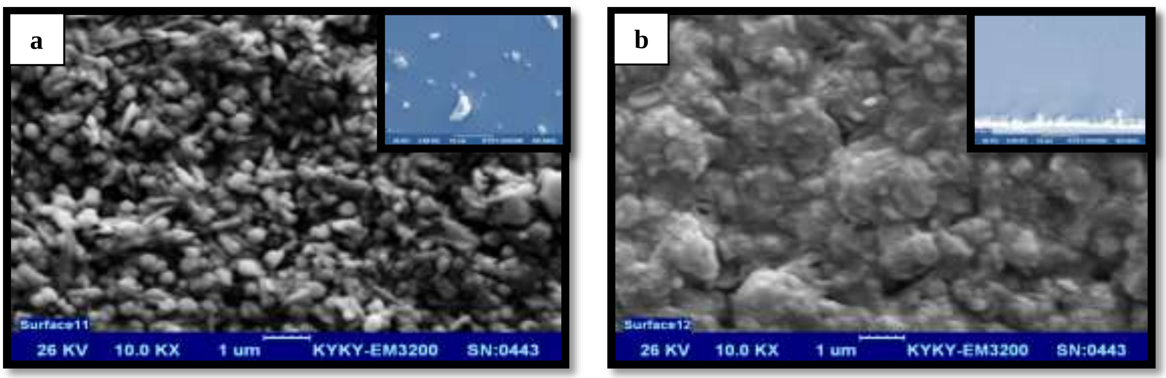

Fig.(18).The micrograph SEM surface and the insetimage shows the cross section for ZnO 70% : SnO2 30%: (a) with temperature deposition (450°C) and incident angle (0) degree, (b) with temperature deposition (450°C) and incident angle (45) degree.

Conclusion

From the obtained results of the present work we can conclude that:

1. The structure of all thin films was (nanostructure) at optimum condition by chemical spray pyrolysis.
2. From the X-ray diffraction investigation, the crystalline structure of ZnO thin films was a polycrystalline with a hexagonal wurzite structure, the crystalline structure of SnO2 thin films was a polycrystalline with a tetragonal structure the increasing of volume ratio, incident angle of the spray, increased the substrate temperature caused to increase the average grain size.
3. The surface morphology of the thin films deposited at different condition (volume ratio, substrate temperature, incident angle spray) on glass was high surface roughness and uniform growth.
4. All the thin films prepared show high growth (crystallization) at different conditions especial (ZnO90%:SnO2 10%), substrate temperature (450 ^{o}C), incident angle (45) degree.

References

[1] T. Bora, H.H. Kyaw, M. Poyai, J. Dutta, "The 3rd Thailand Nanotechnology Conf. Asian Institute of Technology, 2009.

[2] Alkaya, R., Kaplan, H., Canbolat, S.S., Hegedus, A, "Comparison of fill factor and recombination losses in amorphous silicon solar cells on ZnO and SnO2", Renew. Energ,, 34, 1595-1599, 2009.

[3] X. Song, Z. Wang, Y. Liu, C. Wang and **L. Li**, "A high sensitive gas sensor for ethanol based on Mesoporous ZnO-SnO_2nanofibres", *Nanotechnology*, 2009.

[4] C. Liangyuan, B. Shouli, Z. Guojun, L. Dianqing, C. Aifan, C.C. Liu, "Synthesis of ZnO–SnO2 nano-composites by micro-emulsion and sensing properties for NO_2",Sens. Actuators, B 134, 360–366, 2008.

[5] Korotcenkov, G.,"Metal Oxides for Solid-State Gas Sensors: What Determines Our Choice", Mater. Sci. Eng. B 7, 139, 1-23, 2007.

[6] D. A..Neaman, "Semiconductor physics and devices, basic principles", 3d Ed, Mc Grow Hill, New York, 2003.

[7] J. K. Cho, T.Yamazaki, E.Kita and A.Tasaki, "Magnetic Anisotropy of Co Thin Films Prepared by Oblique Incidence II – Effect of Oxidation– ", Japanese Journal of Applied Physics, 27, 2, 420, 1988.

[8] W. E. Weston, T.C.Baker, C. J. Smith, A.L.Chavez, V. K. Grotzky and J. F. Capes, "Physical vapor deposition of chromium and iron", Journal of Vacuum Science and Technology, 15, 1, 54, 1978.

[9] R. T. Kivaisi, "Optical properties of obliquely evaporated aluminium films", Thin Solid Films, 97, 153, 1982.