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The real εr and imaginary εi parts of the d - electric constant for TiO2/Fe2O3 films were determined formula εr=n2-k2 and εi=2nk . The variation of the real (εr) and imaginary (εi) parts of the dielectric constant for diffe - ent film thicknesses are illustrated in figures (8.9). The figures reveled that the values of the real part are higher than that of the ima - inary part. It is observed from the figs. that the real and imaginary dielectric constants decrease with the increase of the wavelength of the incident radiation and this behavior is due to the change of reflectance and abso - bance.

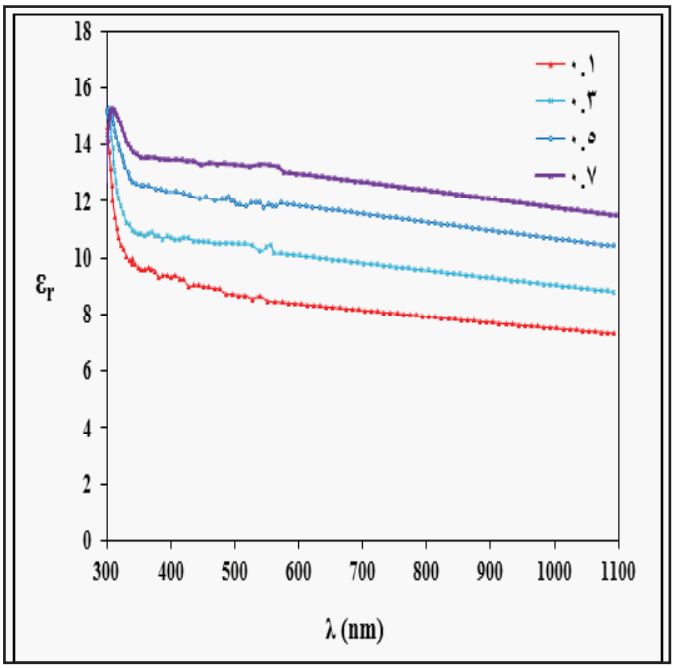

Fig.8. Real part of dielectric constant for TiO2/Fe2O3 films

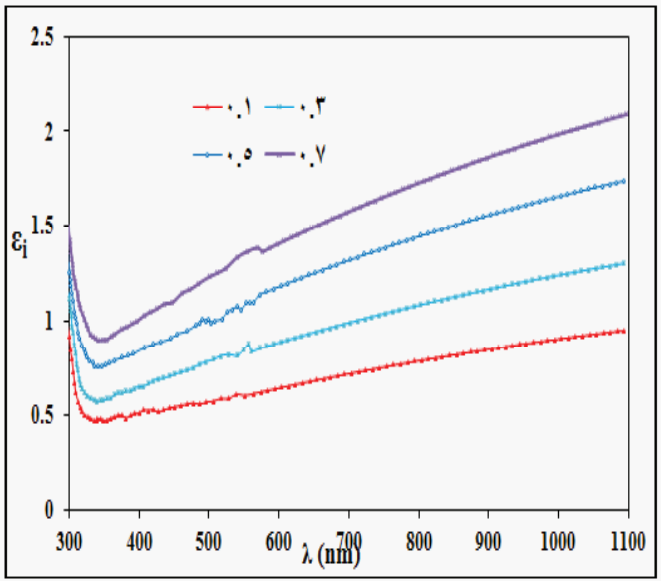

Fig.9. Imaginary part of dielectric constant for TiO2/Fe2O3 films

4-CONCLUSIONS

In this work، TiO2/Fe2O3 films of different TiO2 content have been prepared by pulse laser deposition technique onto glass su - strate. The films show direct band gap in the range 3.3 –4 eV. The films exhibit high a - sorbance in the UV region from ~ 300 nm to 1100 nm. And low absorbance in the visible / near infrared region from ~ 300 nm to 1100 nm. Variations in the optical constants with wavelength are found to be TiO2 content d - pendent of the films. The optical properties refractive index، optical band gap and low dielectric constant of the as-deposited films

Fig.6. shows the variation of refractive index as a function of the wavelength for TiO2/ Fe2O3 films. It is found from this fig.4. That the refractive index decreases with the i - creasing of wavelength of the incident photon. The value of refractive index for TiO2/Fe2O3 films it is found from this fig.(6) that increa - es with the increase TiO2 content. From the figure it is evident that the refractive index increases from 3.65 to 3.95 with the t TiO2 of the film which is in good agreement with those reported by other researchers.

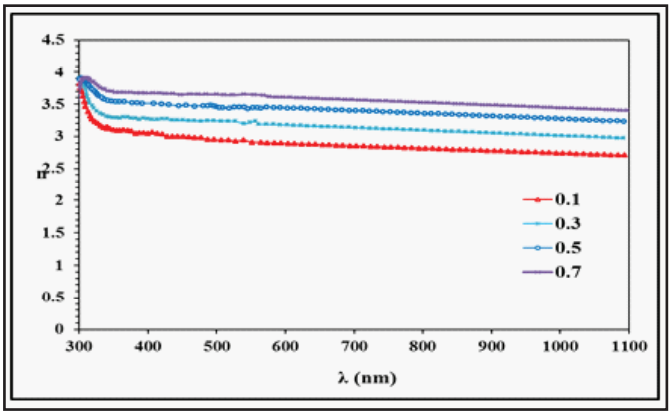

Fig. (6) The Refractive index versus wav - length of incident radiation for TiO2/ Fe2O3 films

The behavior of extinction coefficient is nearly similar to the corresponding absor - tion coefficient; the variation of extinction coefficient for TiO2/Fe2O3 films with wav - length is shown in figure 7. It is observed that the extinction coefficient decreases with the increase of the TiO2 contents. The rise and fall in the extinction coefficient is directly related to the absorption of light. as shown in fig.(7) for TiO2/Fe2O3 films at different extinction coefficient from fig.(5). we can observed that the extinction coefficient for TiO2/Fe2O3 films increases with increasing the extinction coefficient (12) .

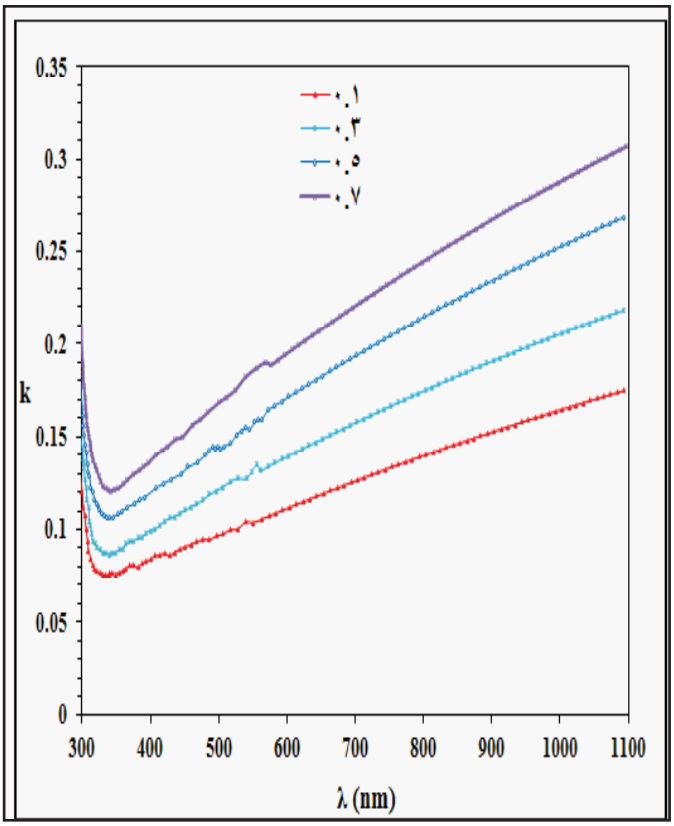

Fig.(7). The Extinction coefficient versus wavelength of incident radiation for TiO2/ Fe2O3 films

The energy band gap can be estimated by a - suming a direct transition between valence and conduction band of TiO2/Fe2O3 film. In order to determine the direct optical band gap was used the relation as follows

$\alpha h\upsilon = A(h\upsilon - Eg)1/2$ ...(3)

Where A is a parameter independent of hν and Eg is the optical band gap.

Plotting the dependence of (αhυ)2 versus hυ، the value of optical band gap can be d - termined by extrapolating the linear po - tion of this plot to (αhυ)2 =0.Such plots for representative TiO2/Fe2O3 films are shown in Fig. 5.The obtained values of optical band gap، (3.3-4) eV for films deposited at 600 is in good agreement with those reported by other researchers 10،11 . The reduction in the optical band gab is probably due to the increase Absorption coefficient and modi - cation of the ferrite structure.

the increase Absorption coefficient Hematite Iron(III) oxide.

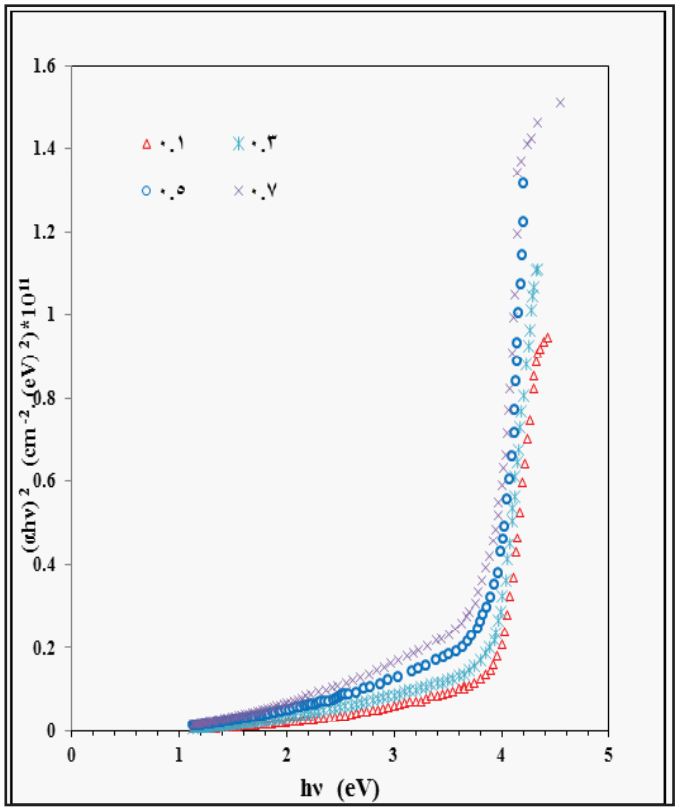

Fig. (5) The plot of (αhυ)2 vs. hυ for TiO2/ Fe2O3 films

Optical properties for thin films

The spectral dependence of The optical tran - missions of TiO2/Fe2O3 films with thickness 150nm are characterized by strong m at short wavelength region within the range (300-1100)nm. We can observe that from this figure(3) All specimens showed transmi - sion less than (60%) in the wavelength (300-500nm) and increment to reach to (66.94%) at (x=0.1) in the wavelength (1100nm). In general, it may be observed from Fig (1) that transmittance decreases with increasing of TiO2 content.

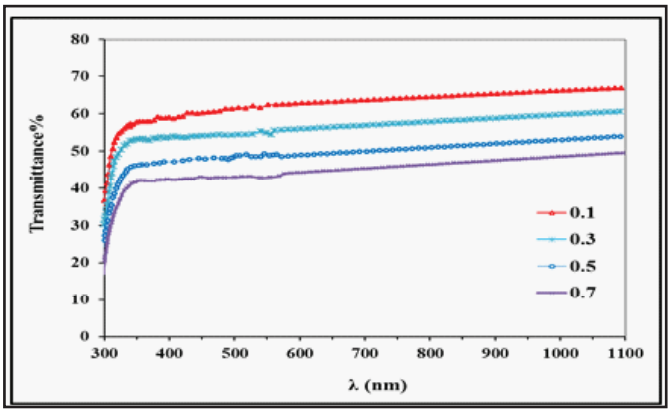

Fig. (3) The Transmittance spectra for TiO2/Fe2O3 films

The absorption coefficient (α) of TiO2/Fe2O3 films prepared by using pulse laser deposition technique are determine from the region of high absorption at the fundamental absorption edge of film. The absorption coe - ficient (α) was calculating using using la - bert law equation (1)

$$\text{Ln} = 2.303\ A = \alpha t \qquad \ldots\ldots\ldots\ldots (2)$$

Where:

Io and I: are the incident and transmitted light respectively.

A: is the optical absorbance and (t) is the film thickness.

Fig.4 shows the absorption coefficient as a function of wavelength. From this figure, TiO2/Fe2O3 film exhibits a strong absor - tion of photons at the short wavelength r - gion (λ=320nm) in the region.

It could be observed that the absorption coefficient increases with increasing wav - length due to decrease in transmittance. The maximum value of absorption coefficient at (x=0.7) which is value reach to (76602.8 cm-1). In general, it may be observed that the absorption coefficient increases with i - creasing of TiO2 content.

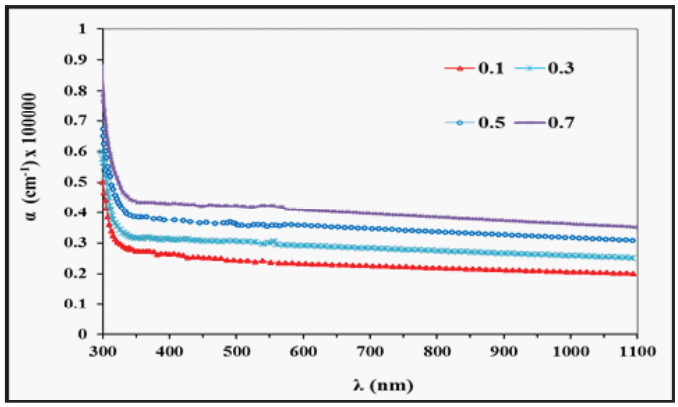

Fig. (4) The absorbance spectra for TiO2/Fe2O3 films

correspond miller indices (110) referred to the TiO2 while the other one (110) referred to the ferric oxide (7) .

The XRD spectra data of TiO2/Fe2O3 film presence of Miller indices corresponding to (110) and (211) major lattice planes identified by the consultation of powder diffraction file card no. 230-0296 . Additionally, minor lattice planes of (311), and (220) were present (8, 9) . A point of interest is that the pre - erential orientation is the (110) direction at (2θ=27.4°) of the films and this may be due to the layer stability of the (220) planes which r - flects the more relaxed bonds with minimum energy. Table (1) presents the experimental and the standard values (from International Centre for Diffraction Data) for TiO2/Fe2O3 thin films with different (TiO2) content.

Table (1): X-ray diffraction spectra data for TiO2/Fe2O3 thin films with different TiO2 content.

TiO_2 ratio	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	d_{hkl} Std.(Å)	hkl	phase	card No.
0.1	24.1739	0.2484	3.6787	32.7	3.6832	(110)	Fe_2O_3	96-101-1268
	27.4037	0.5466	3.2520	15.0	3.2448	(110)	TiO_2	96-410-2356
	33.2671	0.2981	2.6910	27.8	2.7010	(211)	Fe_2O_3	96-101-1268
	35.6025	0.2484	2.5197	33.6	2.5174	(10$\bar{1}$)	Fe_2O_3	96-101-1268
	39.4286	0.2981	2.2835	28.3	2.2938	(222)	TiO_2	96-410-2356
	40.9689	0.4969	2.2011	17.1	2.2070	(210)	Fe_2O_3	96-101-1268
	45.0435	0.2981	2.0110	28.8	2.0522	(120)	TiO_2	96-410-2356
	49.5652	0.3975	1.8377	22.0	1.8416	(202)	Fe_2O_3	96-101-1268
	54.0870	0.5963	1.6942	15.0	1.6955	(312)	Fe_2O_3	96-101-1268
	57.7640	0.7950	1.5948	11.4	1.6003	(332)	Fe_2O_3	96-101-1268
0.3	24.2733	0.1988	3.6638	40.9	3.6832	(110)	Fe_2O_3	96-101-1268
	27.6522	0.3478	3.2233	23.5	3.2448	(110)	TiO_2	96-410-2356
	33.3665	0.2484	2.6832	33.4	2.7010	(211)	Fe_2O_3	96-101-1268
	35.8509	0.2981	2.5028	28.0	2.5174	(10$\bar{1}$)	Fe_2O_3	96-101-1268
	39.6273	0.3478	2.2725	24.3	2.2938	(222)	TiO_2	96-410-2356
	41.1180	0.4472	2.1935	19.0	2.2070	(210)	Fe_2O_3	96-101-1268
	45.1925	0.2981	2.0048	28.9	2.0522	(120)	TiO_2	96-410-2356
	49.6149	0.2981	1.8359	29.4	1.8416	(202)	Fe_2O_3	96-101-1268
	54.1863	0.2981	1.6913	29.9	1.6955	(312)	Fe_2O_3	96-101-1268
	57.8634	0.3478	1.5923	26.1	1.6003	(332)	Fe_2O_3	96-101-1268
0.5	24.4224	0.2484	3.6418	32.7	3.6832	(110)	Fe_2O_3	96-101-1268
	27.7019	0.2484	3.2177	32.9	3.2448	(110)	TiO_2	96-410-2356
	33.4161	0.2484	2.6793	33.4	2.7010	(211)	Fe_2O_3	96-101-1268
	35.9503	0.1988	2.4961	42.0	2.5174	(10$\bar{1}$)	Fe_2O_3	96-101-1268
	36.1230	0.1843	2.4845	45.3	2.4860	(101)	TiO_2	96-410-2356
	39.6770	0.3975	2.2698	21.2	2.2938	(222)	TiO_2	96-410-2356
	41.4658	0.4472	2.1759	19.0	2.1858	(111)	TiO_2	96-410-2356
	45.2919	0.1988	2.0006	43.3	2.0522	(120)	TiO_2	96-410-2356
	49.6646	0.2981	1.8342	29.4	1.8416	(202)	Fe_2O_3	96-101-1268
	54.5839	0.3975	1.6800	22.5	1.6860	(211)	TiO_2	96-410-2356
	56.8696	0.3478	1.6177	26.0	1.6224	(220)	TiO_2	96-410-2356
	57.9130	0.2981	1.5910	30.5	1.6003	(332)	Fe_2O_3	96-101-1268
0.7	24.2236	0.2981	3.6712	27.3	3.6832	(110)	Fe_2O_3	96-101-1268
	27.5031	0.2484	3.2405	32.9	3.2448	(110)	TiO_2	96-410-2356
	33.2671	0.2484	2.6910	33.4	2.7010	(211)	Fe_2O_3	96-101-1268
	35.7516	0.2484	2.5095	33.6	2.5174	(10$\bar{1}$)	Fe_2O_3	96-101-1268
	36.1988	0.1988	2.4795	42.1	2.4860	(101)	TiO_2	96-410-2356
	41.2671	0.2484	2.1859	34.2	2.1858	(111)	TiO_2	96-410-2356
	45.1429	0.1988	2.0069	43.3	2.0522	(120)	TiO_2	96-410-2356
	49.5155	0.3478	1.8394	25.2	1.8416	(202)	Fe_2O_3	96-101-1268
	54.4348	0.2484	1.6842	36.0	1.6860	(211)	TiO_2	96-410-2356
	56.7205	0.2484	1.6216	36.3	1.6224	(220)	TiO_2	96-410-2356

Sample preparation

Ferrites with general formula TiO2/ Fe2O3 (where x=0.1،0.3،0.5، and 0.7)، were prepared by PLD technique. Nano Powders of Fe2O3 and TiO2 were weighed and mixed a - cording to the general composition formula by moles ratio. The powders were mixed and blended homogenously through dry mixing using a ball mill. After powder mixture، they were pressed using a die with diameter (1cm) to produce specimens in a pellet shape. The pressing load used was (3 ton) and the spec - men held for 1min under pressure using a hydraulic press (of a maximum load 15 ton). The specimens were then sintered at 900C° for two hours and then left to cool down to room temperature. Ferrite thin films were prepared by pulse laser deposition. An inc - dent beam of Nd؛YAG SHG Q-switched l - ser was focused on the target surface to make an angle of (45°) with it. The films were d - posited on glass substrates at room temper - ture. The characteristics of laser source are (λ=1064nm)، energy 900mJ، frequency 6Hz، distance between substrate and target 1cm with chamber pressure of (6x10-2mbar)، and number of pulses 900. The films were a - nealed in an oven at a temperature of 600°C for 2hr. The spinel structure was characte - ized by x-ray diffraction carried out using Shimadzu XRD-6000 diffractometer with Cu kα radiation (λ=1.5405A°) at scanning speed 5 deg/min. The Atomic Force Microscopy (AFM)studies were performed on Angstrom Advanced Inc، 2008 ،USA. Scanning Electron Microscopy (SEM) studies were performed using (JOEI JSM-6400) with magnification 589 and 477. The optical Absorbance of the films was measured in the spectral range 300-1100nm.usingUV spectrophotometer.

Thickness Measurement؛

Film thickness measurements were done using optical interferometer method، by TF-C-UVIS-SR spectrometer test thickness range 20×104Å -50 . This method is based on interference of a light beam reflected from a thin film surface and substrate bottom، with error rate at 3%. He-Ne laser (0.632μm) as the light source was used and the thickness is determined using the formula؛

$$t = \Delta x / x \times \lambda / 2 \quad \ldots.1$$

Where (x) is the fringe width، (Δx) is the di - tance between two fringes and (λ) wavelength of laser light (6) .

3. Results and discussion

X-ray Diffraction

Figure 1 shows XRD patterns of TiO2/ Fe2O3 where(x=0.1،0.3،0.5and0.7) prepared by PLD technique. The patterns were compared with standard data (96-230-0296) and the form - tion of single phase cubic spinel structure in all specimens was confirmed with the a - pearance of secondary phases. The comp - nent TiO2/ Fe2O3 were multi phases. The

1- Introduction

Among the various forms of iron o - ides، maghemite (γ-Fe2O3) and hematite (α-Fe2O3) are of great importance in tec - nological and industrial applications (1، 2) . Among the transition metal oxide semiconductors، Fe2O3 has been one of the most extensively explored materials as a ca - didate electrode. Compared to other sem - conductor materials، hematite (α-Fe2O3) has many potential advantages. Maghemite has numerous applications like recording، memory devices، magnetic resonance ima - ing، drug delivery or cell targeting. Hematite exhibits high resistance to corrosion، ther - fore، it has been extensively used in many fields which include photo-anode for photo assisted electrolysis of water. It is an active component of gas sensors، catalyst، lithium ion battery، pigments and oxidizer in the - mite composition. It is also used in magnetic fluids، also called ferrofluids، for damping in inertial motors، shock absorbers، heat tran - fer fluids (3) .

Titanium oxide thin film has been one of the most extremely studied oxides because of its role in various applications namely photo-induced water splitting، dye synthesized solar cells، environmental purifications gas sensors display devices، batteries etc (4،5) .

This study reports the synthesis of novel TiO2/Fe2O3 thin film via pulse laser deposition technique. The effect of post deposition annealing on the optical and electrical properties were also reported. For performance improvement was carried out with the nano-sized Fe2O3 thin layer Manufacturing Nanostructures.

2-Experimental

Raw material

Nano powder filler of Titanium oxide and Fe2O3 were supplied by Cristal Globa Phama Company with particle size 50 nm and 57nm is shown in Fig (1and 2) respectively.

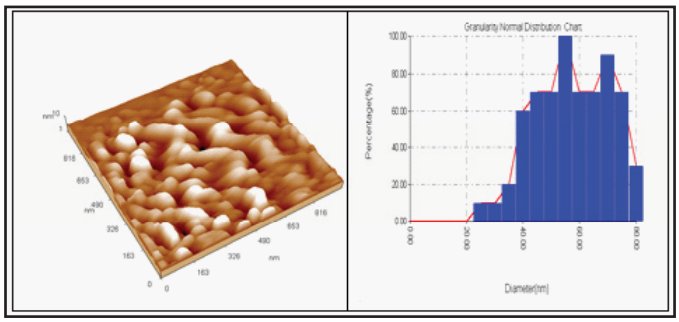

Fig (1)؛ Granularity normal distribution chart for nano Fe2O3 particles

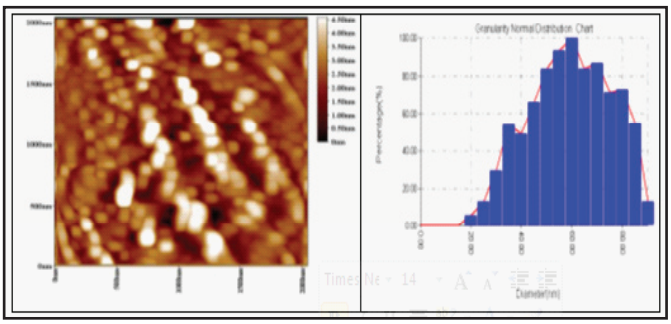

Fig (2)؛ Granuality normal distribution chart for nano TiO2particls

Structural and optical properties of TiO2/ Fe2O3 nano crystalline thin film by pulsed laser deposition

محضر بالترسيب ليزر النبضTiO2 / Fe2O3

دراسة الخصائص الهيكلية والبصرية لغشاء نانو

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زيدون طارق محمد نوري
كلية دجلة الجامعة- قسم تقنيات البصريات

الخلاصة :
رسبت أغشية رقيقة من TiO2 / Fe2O3 لتراكيز مختلفة 0.1، 0.3، 0.5 and0.7 من TiO2 بتقنية الترسيب بالليزر النبضي على ارضية من الزجاج. درست الثوابت البصرية مثل (معامل الانكسار (n) ،ثابت العزل الحقيقي والخيالي(εi،r) ومعامل الخمود (k) للاغشية المرسبة من تحليل طيف النفاذية . حسبت فجوة الطاقة البصرية لاغشية TiO2 / Fe2O3 من منحني (αhυ) 2 مع طاقة الفوتون. ،وقيم فجوة الطاقة تتناقص بزيادة نسبة TiO2 وكانت فجوة الطاقة لهذه الاغشية تتغير من) 3.3الى 4) الكترون فولت .

Abastract
Nano TiO2 / Fe2O3 thin film with different concentrations 0.1، 0.3، 0.5 and 0.7، of TiO2 ،were deposited by pulsed laser deposition technique on glass substrate. The optical constants such as (refractive index n ، dielectric constant εi،r and Extinction coefficient κ) of the deposition films were obtained from the analysis of the exper - mental recorded the optical transmission of TiO2 / Fe2O3 thin films with thickness 150nm spectral data. The optical band gap of TiO2 / Fe2O3 films is calculated from (αhυ) 2 vs. photon energy curve. The optical band gap of the TiO2 / Fe2O3 films was found to be in the range 3.3 to 4 eV and the band gap decreases with increase TiO2 content of the film.