Azhar K. Sadkhan
Office of the Vice President for Scientific Affairs and Post Graduate Studies, University of Technology
Baghdad, Iraq.
azharazhar118@yahoo.com

Suaad A. Mohammed
Ministry of Education,
Baghdad, Iraq.

Mohammed K. Khalaf
Ministry of Science and Technology, Department of Materials Research, Baghdad, Iraq.

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The Growth Characteristics of RF-Magnetron Sputtered Nanocrystalline TiO_2 Thin Films

Abstract- *In this paper, RF Magnetron sputtered TiO_2 thin films deposited on glass slices at various powers (75,100,125 and 150) Watt for (1.5) hour and different thickness (62.5-88-118 and 132.6) nm, the TiO_2 thin films annealed with 400°C for 2 hour and the morphology and structure of these films are described by X-ray diffraction XRD and atomic force microscopy AFM to show the phase structure. X-ray diffraction investigation uncovered that the crystalline size of the TiO_2 thin films displays an expanding pattern with increasing the sputtering power. The preferred orientation of (101) was watched for the films deposited with sputtering power of (75,100,125 and 150) Watt.*

Keywords- *Titanium dioxide, Thin films, RF sputtering.*

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1. Introduction

The production of TiO_2 thin films is one of major researches in photovoltaic area to limit the optimum conditions for sputtering TiO_2 thin film on different substrates. Many of methods have been used to prepare TiO_2 thin films as DC or RF sputtering, chemical vapor deposition and sol-gel process, etc [1].

TiO_2 can be found in three main crystalline phases Anatase (tetragonal), Rutile (tetragonal) and Brookite (orthorhombic). The first two phases have excellent photocatalytic and antibacterial properties [2]. Rotile TiO_2 has some good properties over Anatase phase like as higher dielectric constant, , higher electric resistance, higher chemical stability, higher refractive constant[3].

High chemical and thermal stabilities, higher refractive index (Anatase=2.488, Rutile=2.609, Brookite=2.538), low absorbance and low dispersion in visible and near-infrared spectral area [4].TiO_2 (Anatase) is an n-type semiconductor, thin films of TiO_2 utilized as optical coating, solar cell, integrate circuits, heat reflecting layer and waveguides have also been shown to be resistance to corrosive and mechanical attack and show stability over lengthy time span duration.[5]. The application of these thin films include great important areas as renewable energy production represented by solar cell, smart window, gas sensors, photoconductive, hydrogen production, etc. [6].

The aim of this work is preparing the TiO_2 nanostructures thin films by using the RF magnetron sputtering and studying the effect of sputtering power in some physical properties which play a role in solar cells fabrication

2. Experimental

RF sputtering method utilized to product TiO_2 thin films on glass substrates with different working conditions as shown in table (1) where, P_1 is the base vacuum pressure and P_2 is the working argon pressure of vacuum sputtering chamber, T is the substrates temperature which was in the rang (55-65) due to the sputtering processes. The target type is TiO_2 of 99.99% which was powder and formed by pressing and sintering in 600°C in dimension (D=5cm,thickness of 3mm), and the distance between target and substrates holder is 5 cm. In this work TiO_2 thin films thickness is measured by using an optical method by using Phillips BLK-CXR-SR-25 Spectrometer.

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

Table 1: The working conditions of TiO_2 thin films preparing via RF sputtering method

POWER(Watt)	Thickness Th (nm)	$P1(Torr)\ \times 10-3$	P2(Torr) ×10-3	T°(C)
75	62.5	4.23	7.45	55
100	88	4.13	7.9	60
125	118	5.5	7.12	58
150	132.6	4.15	7.15	65

The crystalline size, roughness and free mean square of thin film surface measured by atomic force microscopy (AFM ntegra NT-MDT). The crystalline structure can be determined for any thin film the X-Ray diffraction (XRD) which is Japanese type (Shimad Zu 7000), the crystalline size (D) was measured using Debye-Scherrer's formula(1):**[7]**

$$D = \frac{K\lambda}{\beta \cos\theta}$$

(1)

Where the symbol k is mean the shape factor which taken as 0.94, λ is the X-ray wavelength (1.5406A°) for Cu-k_{α}, β is the full width at half-maximum (FWHM) and θ is the (Bragg's angle). [7].

3. Results and Discussion

Roughness is the most important parameter because an optimum roughness facilities the photons absorption, Figure 1 shows the two and three dimensions AFM images of the TiO_2 thin films at different sputtering power.

We can notice that the grain size of the deposited films was detected to be in the range (16-71)nm with increasing in sputtering power. Higher roughness was resulted due to the formation of deep channels and large bulging grains on the surface, which contributes to the smooth film s Figure 2 shown XRD pattern of TiO2 thin films deposited on glass substrate by different power and annealing at 400°C for 2 hour. urface.

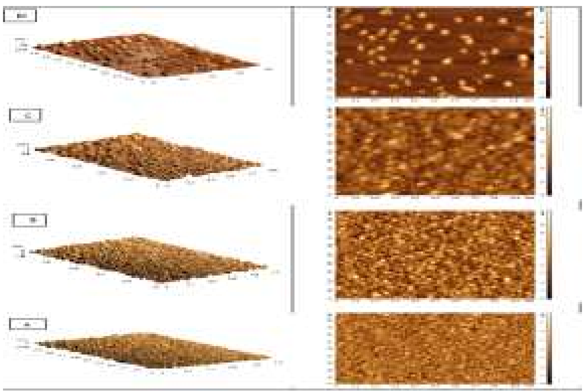

Figure 1: AFM images of TiO_2 thin film at (75, 100, 125 and 150) Watt with sputtering time=1.5hour

It can be observed that the average roughness increases with increasing power. Table (2) shows the values of average grain size, root mean square and roughness with different power, the grain size and surface roughness raise and morphology of the grains become crystalline.

Table 2: The values of grain size and roughness at different power

Power (Watt)	Average Roughness(nm)	Root mean square(nm)	Average grain size(nm)
75	0.643	0.816	16.4
100	1.044	1.434	19.5
١٢٥	1.081	1.469	28.5
١٥٠	4.105	6.297	71.5

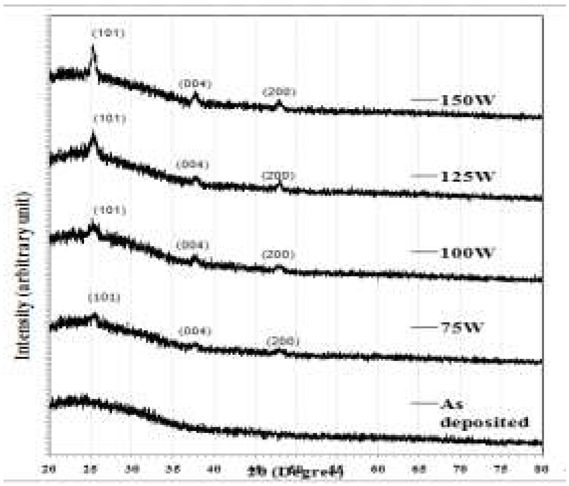

Figure 2: XRD pattern of TiO2 thin film at (75 , 100 , 125 and 150)Watt with sputtering time=1.5hour

It is clear from Table 3 which displays results of comparison between annealed and non-annealed films that the TiO_2 film in as deposited case (non annealing) be amorphous structure. In addition, the as deposited specimens included the powers of 75,100,125 and 150 Watt have same pattern before annealing (as deposited).on the other hand, annealing TiO_2 films with 400°C for 2 hour having various values of crystalline size about (6.2 to16.4) nm, i.e the grain size increases with increasing the power and the thickness of these films. The 2θ at peaks 25.30,37.76 and 48.03 confirms the TiO_2 Anatase structure, that agree with [8].

Table 3: Characteristics of TiO_2 thin film at different power estimated from XRD data

Power (Watt)	Thickness (nm)	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	hkl	Phase	d_{hkl} Std.(Å)
As deposited				Amorphous				
75	62.5	25.3012	1.3200	3.5173	6.2	(101)	Anatase	3.5172
100	88	25.3024	1.2390	3.5171	6.6	(101)	Anatase	3.5172
		37.7662	0.7438	2.3801	11.3	(004)	Anatase	2.3799
		48.0333	0.7344	1.8926	11.8	(200)	Anatase	1.8925
125	118	25.3036	1.0090	3.5169	8.1	(101)	Anatase	3.5172
		37.7674	0.6322	2.3801	13.3	(004)	Anatase	2.3799
		48.0345	0.6242	1.8926	13.9	(200)	Anatase	1.8925
150	132.6	25.3048	0.7910	3.5168	10.3	(101)	Anatase	3.5172
		37.7686	0.5374	2.3800	15.6	(004)	Anatase	2.3799
		48.0357	0.5306	1.8925	16.4	(200)	Anatase	1.8925

4. Conclusion

The influence of sputtering power on the microstructural morphologies of TiO_2 thin films deposited by using RF-Magnetron sputtering technique were scanned in the present work. XRD studies showed that TiO_2 thin films deposited at (75,100,125 and 150) Watt sputtering power are amorphous. Subsequent annealing during 2h at 400°C. The TiO_2 films deposited on glass slices had a preferred crystal plane orientation in the (101) direction with various sputtering power, strong diffraction peaks indicating TiO_2 in Anatase phase that good agreement with [8]. AFM measurements of the films are effected with growing in the sputtering power due to the growing in the surfacediffusion.

5. References

[1] P. Kajitvi Chyanukul, J. Ananpattarachai, and S. Pongpom, "Sol-gel preparation and properties study of TiO_2 thin films for photocatalytic reduction of chromium (VI) in photocatalysis process," Science and Technology of Advanced Materials, vol.6, no. 4, 352-358, 2005.

[2] L. Bedlikyan, S. Zakhariev, and M. Zakharieva, "Titanium dioxide thin film: preparation and optical properties," Journal of Chemical Technology and Metallurgy, vol. 48, no. 6, 555-558, 2013.

[3] J. Adawiya Haider, N. Zainab Jameel, and Y. Samar Taha, "Synthesis and characterization of TiO_2 nanoparticales via sol-gel method by pulse laser ablation," Engineering and Technology Journal, vol. 33, no. 5, 2015.

[4] R. Zallen, M.B. Moret, "The optical absorption edge of Brookite TiO_2," Solid State Communications, vol. 173, no. 3, 2006.

[5] A. Enesca, Andronic, A. Duta, and S. Manolache, "Optical properties and chemical stability of WO_3 and TiO_2 thin film photocatalysts," Romanian Journal of Information Science and Technology, vol. 10, no. 3, 269-277, 2007.

[6] Z. Thaira Altayyar, Shubhra Gangopadhyay, "perovskite thin film preparation and energy band-gap determination for solar cell applications," Engineering and Technology Journal, vol.34, no. 14, 2016.

[7] A. Muhsin Kudhir, S. Raad Sabry, K. Yousif Al-Haidarie, "Effect of flow rate on characterizations of TiO_2 nano fibers using electro spinning method," Engineering and Technology Journal, vol. 33, no. 9, 2015.

[8] M. Ba-abbad muneer, H. Abdul Amir kadhum, A. Bakar mohamad, S. takriff mohd, k. sopian, "Synthesis and catalytic activity of TiO_2 nanoparticles for photochemical oxidation of concentrated chlorophenols under direct solar radiation," International Journal Electrochemical Science, Vol. 7, No. 3, 4871-4888, 2012.

Author(s) biography

Azhar kadhim sadkhan, master degree of applied physics, Applied Science Department, University of Technology, Baghdad, Iraq. She have

many researches in applied physics and solar cells.