ภาคผนวก ก

การหาความหนาฟิล์มจากสเปกตรัมเปอร์เซ็นต์การส่งผ่านที่ใช้หลักการแทรกสอดของแสง

ในการหาความหนาฟิล์มจากสเปกตรัมเปอร์เซ็นต์การส่งผ่านที่ใช้หลักการแทรกสอดของแสงโดยมีความสัมพันธ์ดังสมการ

$$Optical\ path\ difference = 2dn = m\lambda \quad ; m = 0,1,2,3\ldots \max ima \tag{1}$$

$$Optical\ path\ difference = 2dn = \left(m - \frac{1}{2}\right)\lambda \quad ; m = 1,2,3\ldots \min ima \tag{2}$$

$$2n_{film}d_{film} = m_1\lambda_{\max 1} \tag{3}$$

$$2n_{film}d_{film} = m_2\lambda_{\max 2} \tag{4}$$

(3)-(4)

$$\frac{2n_{film}d_{film}}{\lambda_{\max 1}} - \frac{2n_{film}d_{film}}{\lambda_{\max 2}} = m_1 - m_2 \tag{5}$$

ให้ $M=m_1-m_2$

$$d_{film} = \left|\frac{M\lambda_{\max 1}\lambda_{\max 2}}{2n_{film}(\lambda_{\max 2} - \lambda_{\max 1})}\right| \tag{6}$$

เมื่อ M=1

$$d_{film} = \left|\frac{\lambda_{\max 1}\lambda_{\max 2}}{2n_{film}(\lambda_{\max 2} - \lambda_{\max 1})}\right| \tag{7}$$

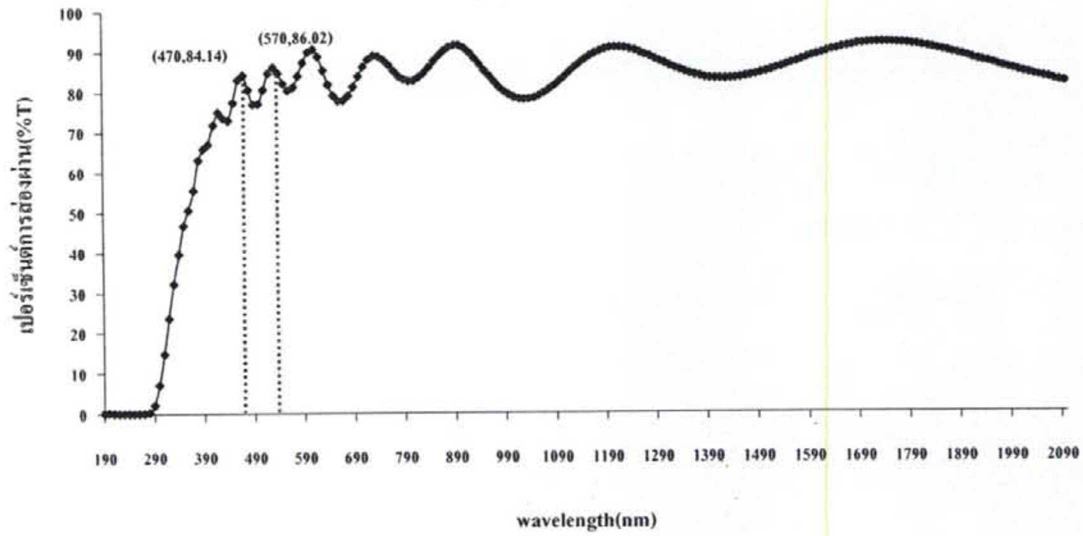
เมื่อ d_{film} คือความหนาของฟิล์ม (nm)

λ_{max1} คือความยาวคลื่นที่พีค 1 ณ ตำแหน่งสูงสุด (nm)

λ_{max2} คือความยาวคลื่นที่พีค 2 ณ ตำแหน่งสูงสุด (nm) ถัดจากพีคที่ 1

n_{film} คือ ดัชนีหักเหของฟิล์ม

ตัวอย่าง การคำนวณค่าความหนาฟิล์มจากสเปกตรัมเปอร์เซ็นต์การส่งผ่านที่ใช้หลักการแทรกสอดของแสง



จากรูปเป็นสเปกตรัมเปอร์เซ็นต์การส่งผ่านของฟิล์มซิลิกอนไนไตรด์ เงื่อนไขการเคลือบกำลังไฟฟ้า 160 วัตต์ ความกว้างพัลส์ไฟฟ้า 3696 นาโนวินาที เวลาของการเคลือบ (s) เป็น 4000 วินาที และการป้อนก๊าซอาร์กอนต่อไนโตรเจนเท่ากับ 50:15 sccm

จากรูป λ_{max1}= 470 นาโนเมตร λ_{max2}= 570 นาโนเมตร $n_{Silicon\ nitridefilm}$= 2.03 แทนค่าในสมการ (7)

$$d_{film} = \left| \frac{(470\times10^{-9})(570\times10^{-9})}{2(2.03)(570-470)\times10^{-9}} \right|$$

$$d_{film} = 659.85\times10^{-9}\ \text{m}$$

$$d_{film} = 659.85\ \text{nm}$$

ภาคผนวก ข

ผลงานวิจัยในวารสารทางวิชาการ

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Effect of DC Power on Structural and Hydrophilic Activity of TiO_2 Films

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Keywords: TiO_2, Hydrophilic, DC Magnetron Sputtering, DC Power

Abstract. In this work, we present the effect of DC power from 100 W to 500 W on the structural and hydrophilic activity of TiO_2 films. The TiO_2 films were prepared by DC magnetron sputtering on the glass substrate without any external heating. The structure of TiO_2 films were analyzed by atomic force microscope and X-ray diffraction. XRD patterns indicated the films were amorphous. The surface roughness and grain size were enlarged by the increasing of the DC power while the substrate temperature was climbed up with the increasing of the DC power. From the point of energetic ion bombardment, it was related with DC power between sputtering processes. The hydrophilic activity of TiO_2 films were analyzed by the contact angle meter. The water contact angle decrease with increasing of the DC power.

Introduction

Recently, TiO_2 thin films have been intensively investigated as a photocatalytic material. Understanding the fundamental process and enhancing the photocatalysis are the major research focus in our term, bearing in mind industrial application, such as transparent and colorless coating that possess anti-fogging, self-cleaning or antibacterial activities for general purpose glass windows [1].

TiO_2 thin films can be prepared by several different methods including DC magnetron sputtering, chemical vapor deposition (CVD), sol-gel technique, etc. Among these, the DC magnetron sputtering method is commercially preferred because of high deposition rate at lower temperatures. This approach shows a good adhesion with substrate and easier control of atomic composition in thin films [2]. In this study, the effects of DC power on the structural and hydrophilic activity of TiO_2 films were investigated.

Experimental

TiO_2 thin films were coated on the glass substrate by DC magnetron sputtering with the varies range of DC power from 100 W to 500 W with 100 nm thickness. TiO_2 films were prepared from Ti target (99.995% purity, 3″ in diameter, and 0.25″ thick) by DC magnetron sputtering. For sputtering processes, reactive gas flow rate of Ar and O_2 were 50 and 45 sccm, respectively. A turbo molecular pump was used to achieve a base pressure of 6×10^{-4} Pa (before introducing the gas mixture). The surface wettability was evaluated by using a contact angle meter; UV illumination was carried out using a fluorescent blacklight while the surface roughness of TiO_2 films was investigated with atomic fore microscope (AFM, SII SPA 400, Japan).

Results and Discussion

In this study, the XRD spectrum without any remarkable peak indicated that the structures of TiO_2 thin films were amorphous. The influences of DC power on surface morphology of TiO_2 films were investigated by AFM. Fig. 1 shows the 3D AFM images for TiO_2 films. Fig. 2 shows grain size and surface roughness of TiO_2 films as a function of DC power. This result shows grain size and surface roughness toward the vertical direction on the film deposited at higher DC power.

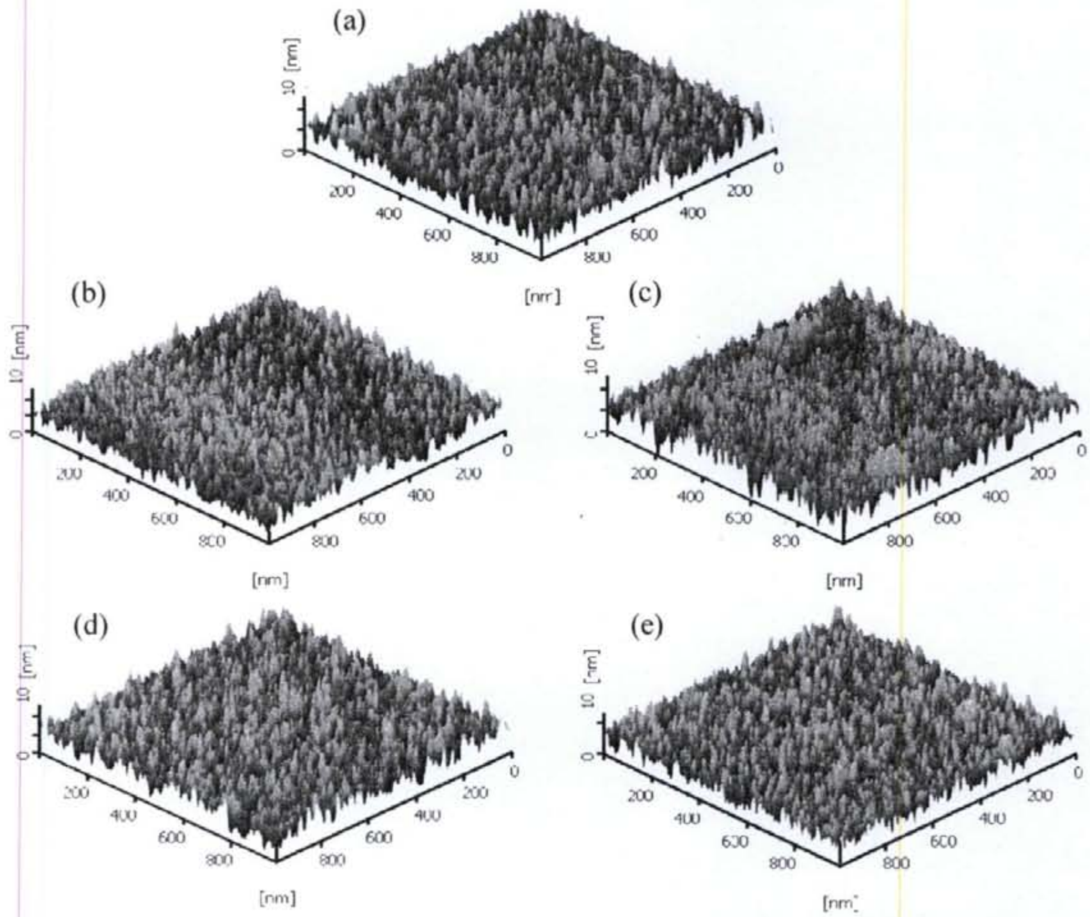


Figure 1. 3D AFM images of TiO_2 for deposited with DC power of (a) 100 W, (b) 200 W, (c) 300 W, (d) 400 W and (e) 500 W.

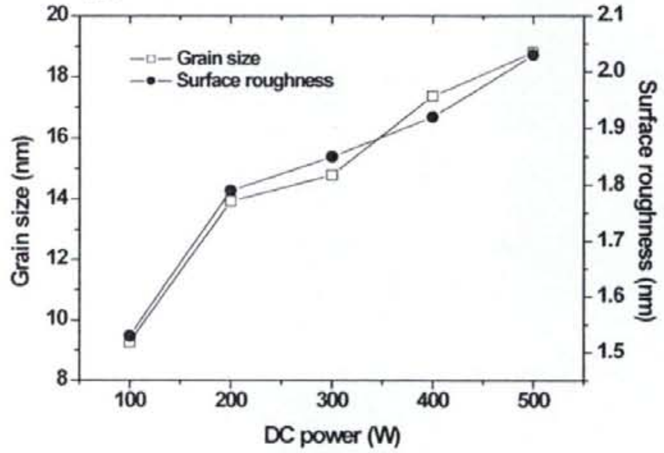


Figure 2. Grain size and surface roughness of TiO_2 films as a function of DC power.

Fig. 3 shows the change of substrate temperature measured at the back of substrate as a function of films thickness for varies of DC power. This result shows the difference accumulate substrate temperature depends on DC power. Due to the energetic ions bombardment depending on DC power and it affected on growth films process, therefore the TiO_2 films coated with higher energetic of sputter atoms were suitable arrangement of atom with lager grain size.

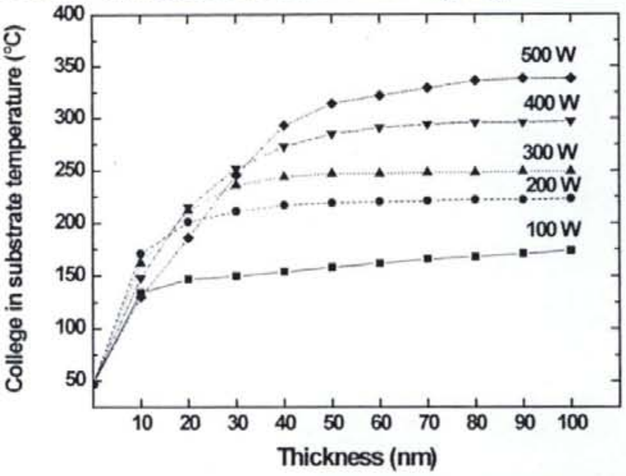
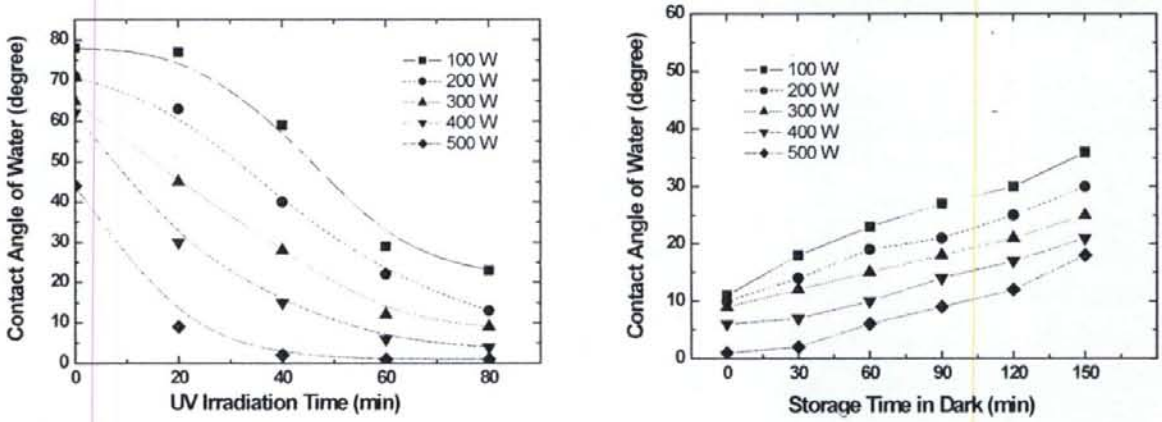


Figure 3. Change of substrate temperature measured at the back of substrate as a function of films thickness for DC power of 100 W, 200 W, 300 W, 400 W and 500 W.



(a) (b)

Figure 4. Time dependence of the water contact angle in ambient atmosphere upon UV illumination with intensity of UV 1.2 mW/cm^2 (a) and in the dark (b).

Contact angle measurements were conducted to examine the surface wettability of the TiO_2 thin films. Fig. 4 shows the time dependence of water contact angle of the film upon UV illumination (Fig. 4a) and in the dark (Fig. 4b). The power density of UV in this experiment is equivalent to 1.2 mW/cm^2. As shown in the Fig. 4(a), water contact angle decreases with increasing illumination time. One hour is sufficient to give a high hydrophilic activity. This result of the conversion form hydrophobic to hydrophilic is explained by assuming that the surface Ti^{4+} sites are photo reduced to the Ti^{3+} state accompanying oxygen vacancy, and dissociative water adsorption on the vacancy site [3].

Fig. 4(b) shows the time dependence of water contact angle of the sample in the dark after UV illumination for 2 hours. This result shows the water contact angle increases with increasing storage time in dark for all films. The initial contact angle of 500 W TiO_2 film was almost zero after the completion of hydrophilization with sufficient UV illumination. The initial contact angles are different of each DC power. The storage time in dark was proportion to DC power. In this work, TiO_2 films have a different grain size and surface roughness. Therefore, TiO_2 prepared via high DC power has large surface area and low water contact angle.

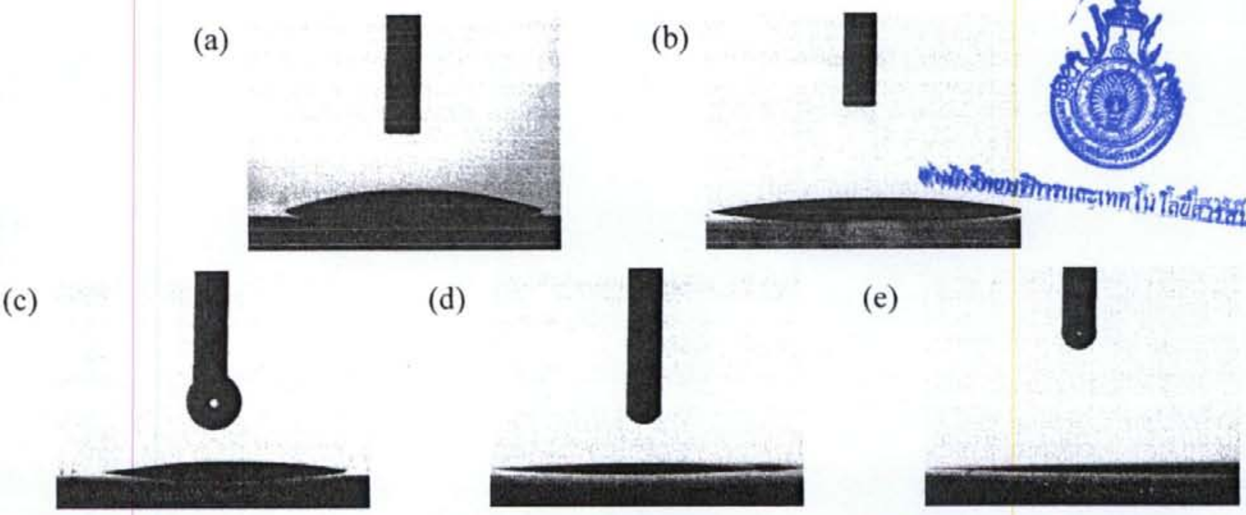


Figure 5. Picture collected during contact angle measurements in ambient atmosphere upon UV illumination of 80 min with UV intensity of 1.2 mW/cm^2 for TiO_2 deposited with DC power of (a) 100 W, (b) 200 W, (c) 300 W, (d) 400 W and (e) 500 W.

Fig. 5 shows the surface treatment process dependence of the water contact angle of TiO_2 films coated with varies DC power from 100 W to 500 W. After UV illumination of 80 min, the water contact decrease to 23, 13, 9, 4 and 1 degree correspond to DC power of 100 W, 200W, 300W, 400 W and 500 W. So TiO_2 film coated with DC power of 500 W is better than 400 W, 300 W, 200 W and 100 W.

Summary

TiO_2 thin films deposited by DC magnetron sputtering method with 100 nm of the film thickness were investigated. XRD measurements of the films show the amorphous structure. Aforementioned results shown, we can conclude that TiO_2 film has large grain size, high surface roughness and high substrate temperature when DC power increases. Furthermore, the hydrophilic property of TiO_2 film is good when film was coated with high DC power.

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