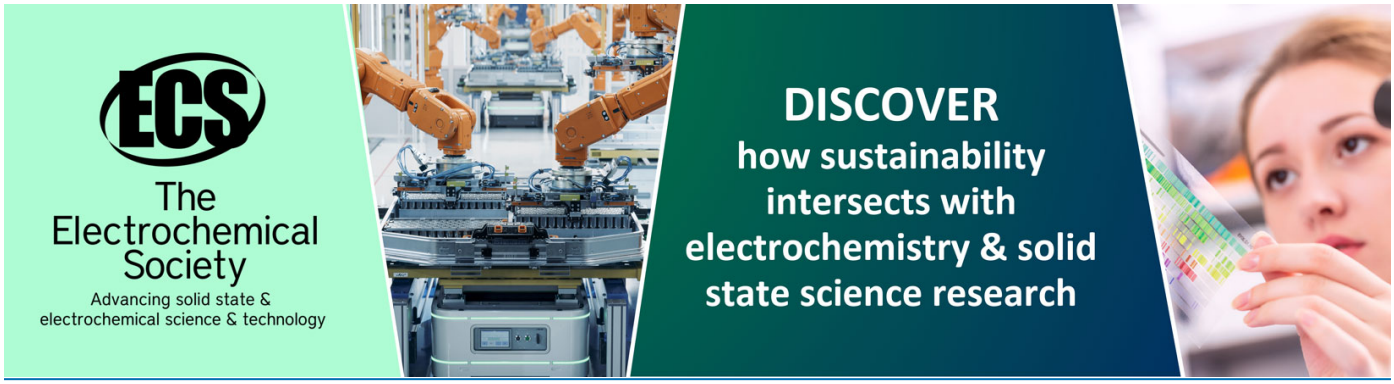
Effect of annealing temperature on optical properties of TiO_2 18 NR-T type thin film



IOP Conf. Series: Journal of Physics: Conf. Series **1011** (2018) 012016 doi:10.1088/1742-6596/1011/1/012016

Effect of annealing temperature on optical properties of TiO_2 18 NR-T type thin film

Nandani[1)], A Supriyanto[1)], A H Ramelan[1)], F Nurosyid[1)]
[1)]Physics Department of Mathematics and Natural Science Universitas Sebelas Maret, Jl. Ir. Sutami No. 36 A Kentingan, Surakarta 57126

E-mail: agusf22@staff.uns.ac.id

Abstract
It has succeeded in growing TiO_2 18NR-T thin film using T-49 screen printing method with an annealing treatment temperature variation of 200°C, 450°C, 500°C and 550°C for 1 hour. The result of TiO2 18NR-T thin film will be characterized using UV-visible Spectrophotometry (UV-*Vis*). Characterization with UV-*Vis* obtained a result that treatment with 4 variations of temperature influence absorbance value and transmittance. The greatest absorbance value was obtained in the sample with temperature treatment 550°C while the largest transmittance value was obtained at temperature 200°C. The absorbance peak is at the wavelength of ultraviolet light. Optical band values in each temperature variation are obtained at 3.53 eV; 3.46 eV; 3.38 eV and 3.2 eV.

1. Introduction

Titanium dioxide (TiO_2) is a semiconductor material having a large optical band gap of 3.2 eV to 3.8 eV [1], making TiO_2 effective for photovoltaic [2] because of its stable properties. TiO_2 can be used in solar cell applications [3-5] because TiO_2 absorbs light at the wavelength of the ultraviolet region [6-8]. The TiO_2 material is a non-toxic, cheap, non-corrosive and easily obtainable material [9-11].

The increasing need encourages scientists to develop transparent materials to produce more advanced technology. There has been much fabrication of thin layers of semiconductor material to obtain new devices from modifying the thin films one of them for transparent solar cell applications [12]. Therefore research on TiO_2 thin films continues to be developed so that the deficiencies they have can be minimized.

Deposition methods have been widely used to produce desired thin films, such as spin coating [13]; sol-gel [14] and screen printing [9]. Each method of deposition has its advantages and disadvantages. In this research using screen printing method, in addition to the effective method is also easy to do.

In this study TiO_2 used in the form of pasta is TiO_2 18NR-T, one of the materials for making a solar window. The deposition was performed using a 49-type screen with a mesh size of 49 per cm. Annealing temperature treatment was provided to determine the effect of temperature rise on the optical band gap of the TiO_2 18NR-T layer. The TiO_2 18NR-T thin film was then characterized by absorption value and its transmittance value to determine the optical band value due to the variation of annealing temperature.

2. Methods

The research begins with preparing the ingredients, TiO_2 which is used is brand dyesol with the type of 18NR-T in the form of a yellow paste, the substrate (glass preparation), ethanol, quads, acetone, and alcohol. While the tool used is ultrasonic cleaner, digital scales, micropipette, stirrer, cellophane tape, screen printing, oven, crucible, furnace and characterized by UV-*Vis* spectroscopy.

Pasta TiO_2 18NR-T, one gram, and ethanol, one mL, were mixed and stirred homogeneously using a magnetic stirrer for 1 hour with a rotation speed of 300 rpm at room temperature. The next stage is deposition of the TiO_2 18NR-T solution in the substrate with screen printing method. The substrate to be used was first washed using ultrasonic cleaner using soap water, quads, acetone and alcohol for 10 min respectively.

The screen printing process is done after the substrate is dry, the screen used is a T-49 type affecting the amount of TiO_2 18NR-T solution to be deposited. In the substrate there is a limitation of the area with the size of 1.5 x 1 cm as the deposition of the TiO_2 18NR-T solution using scouth as:

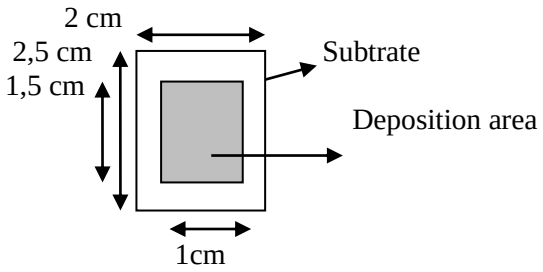


Figure 1: Schematic area of deposition of TiO_2 18NR-T solution

Deposition of TiO_2 18NR-T solution yielding 1 thin layer TiO_2 18NR-T using specification 3 drops of TiO_2 18NR-T solution and 5 times pressure. The result of deposition of theTiO_2 18NR-T solution by screen printing method was then carried out drying using the oven with temperature 130^{o}C for 10 minutes. The best samples were then annealed using a furnace with variations of 200^{o}C, 450^{o}C, 500^{o}C and 550^{o}C aging for 1 hour. The provision of temperature variations aims to compare the results of crystal structure which influence absorbance value, transmittance and optical band gap energy.

The result of thin layer annealing TiO_2 18NR-T is then characterized using UV-*Vis* to measure absorbance value and its transmittance so that it can be processed to produce value of optical band gap energy using the Tauc method.

3. Results And Discussion

Annealing Temperature Dependence of Optical Properties of Thin Film TiO_2 18NR-T

TiO_2 18NR-T thin films have been grown on a glass substrate. The thin growth films prepared using a screen printing method with T-49 mesh size. Annealing treatments with temperature variations of 200^{o}C, 450^{o}C, 500^{o}C, and 550^{o}C were given to determine the effect of absorbance values, transmittance and optical band gap energy in the manufacture of TiO_2 18NR-T thin films. The result of TiO_2 18NR-T thin film above the transparent glass substrate.

The Results of absorbance and reversed transmittance Characterization can be shown with graphs in figure 2 and figure 3. The results of absorbance measurements showed that the treatment of variations in annealing temperature affects the absorbance rate of TiO_2 18NR-T

thin film. The higher the given temperature value, the higher the absorbance value of the TiO_2 18NR-T thin film. This suggests that high temperatures accelerate the evaporation of oxygen during the annealing process.

A high absorbance value results in a low transmittance value, which means the TiO_2 18NR-T thin film with low transmittance is more absorbing than high transmittance. The results of the transmittance measurements can be shown in figure 3. The temperature of annealing affects the transmittance which results in the higher the given temperature decrease. In the wavelength range of 250 nm to 380 nm, there is a significant decrease in transmittance due to TiO_2 18NR-T over absorbing the ultraviolet wavelength region.

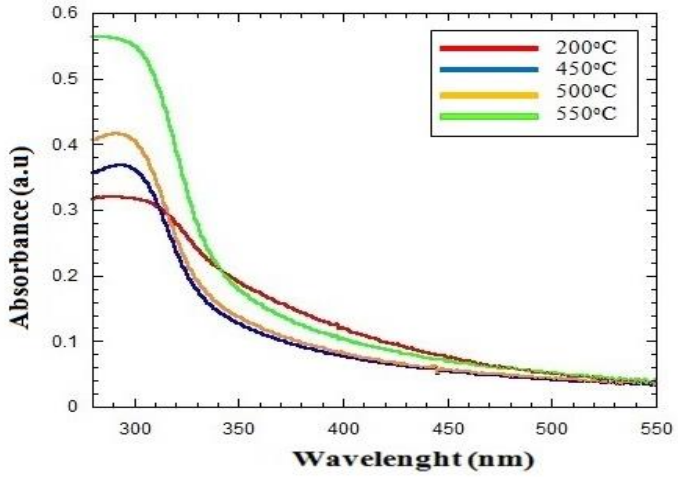


Figure 2. TiO_2 18NR-T thin film absorbance curve with annealing temperature variation of 200°C, 450°C, 500°C and 550°C

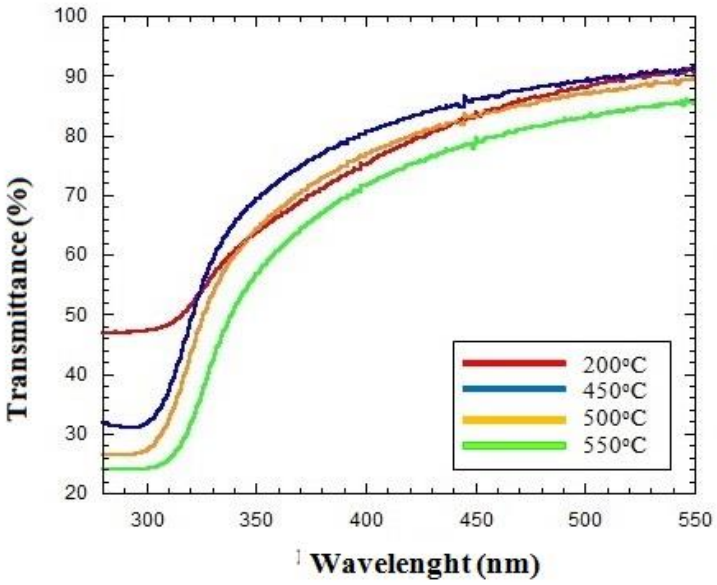


Figure 3. TiO_2 18NR-T thin film transmittance curve with annealing temperature variation of 200°C,

450°C, 500°C and 550°C

Determination of Optical Gap Values of TiO_2 18NR-T Thin Film of Variation of Annealing Temperature

The optical gap value of the TiO_2 18NR-T thin film is obtained using the Tauc Plot method by drawing a straight line on the relationship graph $\alpha h\upsilon^{\frac{1}{2}}$ and $h\upsilon$ to cut the abscissa axis of the energy axis. The calculation uses the equation 1.

$$\alpha h\upsilon = A(h\upsilon - E_g)^2 \quad (1)$$

A is the absorption coefficient, hυ is energy (eV), and E_g is the optical band gap energy.And the calculation of α is calculated by the equation:

$$\alpha = -\frac{1}{d}\ln T \quad (2)$$

The treatment of annealing temperature variations given in the TiO_2 18NR-T thin film produces an optical band gap energy which can be shown in the following figure 4.

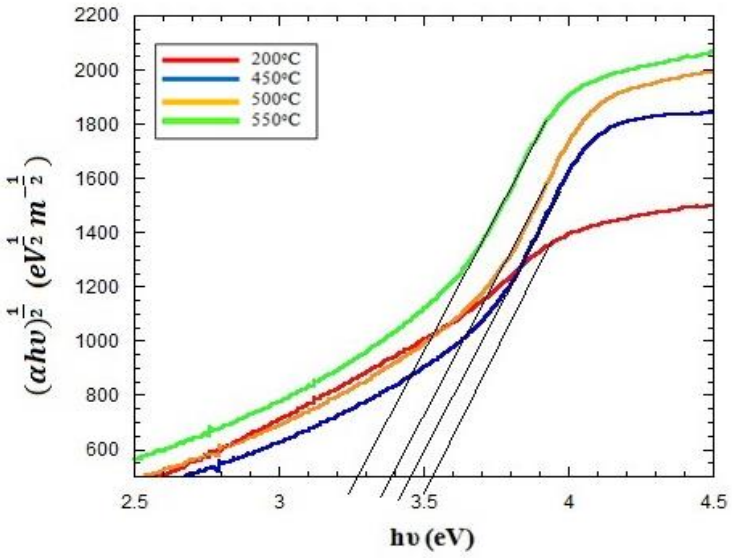


Figure 4. Determination of optical band gap TiO_2 18NR-T using Tauc Plot method.

The effect of annealing temperature on the TiO_2 18NR-T thin film results in different optical band gaps. At annealing temperature treatment of 200°C resulted in the optical band gap of 3.53 eV, while at 550°C maximum given temperature produces optical band gap of 3.27 eV. Increasing annealing temperatures result in a decreased optical band gap.

4. Conclusion

The results are the annealing temperature affects the optical band gap value of the TiO_2 18NR-T thin film; this is accompanied by changes in absorbance and transmittance values. Characterized by UV-*Vis* spectroscopy show that the higher temperature annealing causes the TiO_2 18NR-T thin film more absorbance. The maximum absorbance of the TiO_2 18NR-T thin film appeared at annealing temperature 550°C. This suggests that high temperatures accelerate the evaporation of oxygen during the annealing process. The effect of annealing

temperature is increasing annealing temperatures cause a decreased optical band gap. Minimum band gap energy occurs in the TiO_2 thin film with annealing temperature 550^{o}C is 3.27 eV.

5. Acknowledgments

This research is supported by the grant of Penelitian Unggulan - Universitas Sebelas Maret (PU-UNS), 2017.

6. References

[1] Gratzel, M 2003 *Journal of Photochemistry and Photobiologi Photochemistry*. **4** 145-153
[2] Macak J M, Zlamal M, Krysa J and Schmuki P 2007 *Small*.**3** 300–304
[3] Pugliese D, Lamberti A, Bella F, Sacco A, Bianco S, Tresso E 2014 *Electron.***15** 3715–3722
[4] Roy P, Kim D, Lee K, Spiecker E, Schmuki P 2010 *Nanoscale*.**2**45–59
[5] Gao X, Li J, Baker J, Hou Y, Guan D, Chen J, Yuan C 2014 *Commun*.**50** 6368–6371
[6] Fuyuki T, Matsunami H 1986*J Appl Phys*. **25**128
[7] Gan J Y, Chang Y, Wu T 1998*Appl Phys Lett*.72.
[8] Miao L 2003 *Appl Surf Sci*.**212** 255
[9] Hoffmann M R, Martin S, Choi W, Bahnemann D W, e*nvironmental applications of semiconductor photocatalysis, Chem. Rev*.**95**69–96
[10] Fujishima A, Rao T N, Tryk D A 2000 *Journal Photochem. Photobiol.* **C1**1–21
[11] Tryk D A, Fujishima A, Honda K 2000*Electrochim Acta*.**45**2363–2376
[12] Nurosyid F, FurqoniL, Supriyanto A and Suruyana R 2016. *Journal of Physics.* **776** 1-7
[13] Khan M I, Bhatti K A, RabiaQindeel, Hayat S A and Norah Alonizan 2017 *Result in Physics*.**7** 1437-1439
[14] Zareen A, Ali S and Irfan M 2014 *European Scientific Journal*. **2** 1857-7431