***IJACSSEJournal**- International Journal of Advanced Computer Systems and Software Engineering*

E-ISSN: 2716-5256 online

The Effects of Annealing Temperature on TiO_2/ZnO Bilayer Thin Film Using Sol-gel Spin Coating Technique

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ARTICLE HISTORY
Received: 10 February 2021
Accepted: 6 April 2021
Published Online: 29 April 2021

KEYWORDS
Thin Film
Annealing
Sol-Gel Spin Coating Technique

ABSTRACT

TiO_2 and ZnO have excellent properties and have similar band gap energy. The drawbacks experienced by TiO_2 is plausible to overcame by layering these two nano-semiconductor to amplify the photocatalytic efficiency and may increase the conductivity of the composite and homogenous, well spread particles and have high surface area morphology. The structural, morphological and optical properties of TiO_2/ZnO bilayer thin film at 400, 500 and 600℃ annealing temperature have been observed. TiO_2/ZnO bilayer thin film has been deposited on fluorine-doped tin oxide (FTO) substrate by using sol-gel spin coating technique with spin speed of 3000rpm. TiO_2/ZnO bilayer thin film has been successfully fabricated on fluorine-doped tin oxide (FTO) substrate using sol-gel spin coating technique. In this research, annealing of FTO/ TiO_2 layer thin film is set at 600℃. It is found in this study that 500℃ is the most suitable temperature to anneal TiO_2/ZnO bilayer thin film to produce the best structural, morphological and optical properties.

1.0 INTRODUCTION

A solar cell is a simple semiconductor device that converts light energy into electrical energy. The transformation is cultivated by engrossing light and ionizing crystals atoms making free, adversely charged electrons and emphatically charged particles.The photovoltaic panels are made up of solar cells (Boer, K. W. (2002). 1). At this present time, thin film fabrication is introduced because it is affordable utilizing and non-toxic materials prepared by energy-efficient processes (Nagai, M., Mizushima, Y., Mohamad, F.,Sasano,J., Izaki, M. & Mohamad Arifin, N. L. (2011).).

Many researchers have studied the capability of the dye-sensitized solar cell by using other semiconducting metal oxide such as zinc oxide (ZnO), titanium dioxide (TiO_2), copper (I) iodide (CuI), and tin dioxide (SnO_2). Similar photocatalytic mechanism and approximately equal band gap energy like TiO_2 made ZnO a suitable candidate to be layered with.

TiO_2 has a bandgap of 3.2 eV and is widely known as a good material due to its high photovoltaic activity, stable in aqueous solution and relatively low cost (Tian, J., Chen, L., Dai, J., Wang, X., Yin, Y. S. & Wu, P. W. (2009).). However, TiO_2 has two major drawbacks during photocatalytic process which are high electron hole recombination rate and limited absorption of visible light. ZnO has wide bandgap energy which is 3.37eV and 60meV of electron mobility at room temperature. This makes it as the most utilized material in dye sensitized solar cells. Moreover, recombination rate will be reduced with the high electron mobility of ZnO thin film (Zeng, Y. (2009).).

The outstanding properties and substantial applications of both the semiconductors have enticed the researchers. However, ZnO is a direct band gap energy meanwhile TiO_2 is an indirect semiconductor which make their intrinsic semiconductor characteristics different (Tian, J., Chen, L., Dai, J., Wang, X., Yin, Y. S. & Wu, P. W. (2009).). The drawbacks experienced by TiO_2 is plausible to overcame by layering these two nano-semiconductor to amplify the photocatalytic efficiency and may increase the conductivity of the composite and homogenous, well spread particles and have high surface area morphology since both TiO_2 and ZnO have excellent properties and have similar band gap energy.

2.0 METHOLOLOGY

In this study, TiO_2 solution preparation began by mixing titanium (IV) butoxide, n-butanol, acetic acid and deionized water. The solution is then stirred at room temperature for 24 hours. TiO_2 thin films were deposited on fluorine doped tin oxide (FTO) substrate using sol-gel spin coating technique for 30 seconds with 3000rpm spin speed.

The TiO2 thin film is then annealed at 600°C for 60 minutes. After that, zinc acetate dehydrates, iso-propanol, diethanolamine, deionized water is mixed together producing ZnO solution. Next, the solution undergoes spin coating method depositing ZnO on TiO_2 for 30 seconds with 3000rpm spin speed. The TiO_2/ZnO bilayer thin film then undergoes annealing process for 60 minutes according to the varied parameter of annealing temperature as shown in Figure 1. The flowchart of the experimentas process is as shown in Figure 2.

The structural, morphological and optical properties of the TiO_2/ZnO bilayer thin films were are characterized by X-ray powder diffraction (XRD) and Field emission scanning electron microscopy (FESEM) respectively.

Annealing temperature of FTO/TiO_2 layer (°C)	Annealing temperature of TiO_2/ZnO layer(°C)
600	400
600	500
600	600

Figure 1: Annealing temperature parameter.

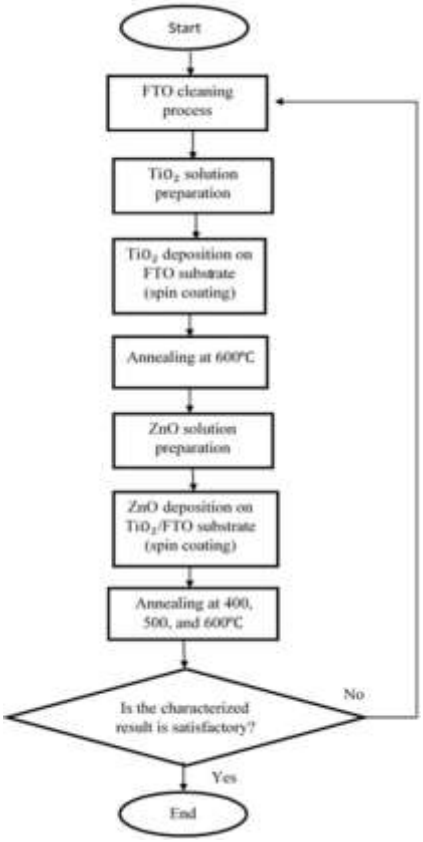

Figure 2: The experiental process flowchart.

3.0 RESULTS AND DISCUSSION

In this study, XRD is to determine the presence of FTO, anatase (TiO2) and zincite (ZnO) on the samples that were varied on the annealing temperature which are 400, 500 and 600℃. The characterization was conducted at 20 to 80° scanning area angle (2θ). Figure 3 shows XRD pattern of FTO/TiO2 annealed at 600℃ and TiO2/ZnO bilayer thin film annealed at 400, 500 and 600℃.

What can be concluded from structural properties analysis is, 500℃ is the most suitable temperature to anneal

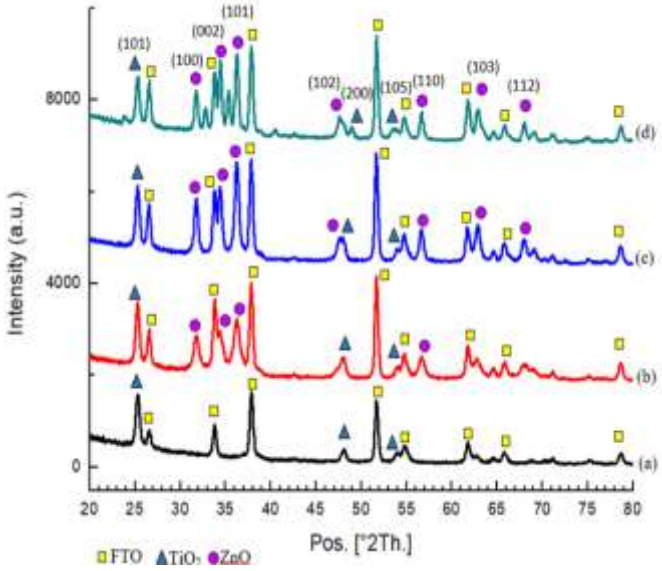

Figure 3: XRD pattern of FTO/TiO_2 annealed at 600℃ and TiO_2/ZnO bilayer thin film annealed at 400, 500 and 600℃

TiO2/ZnO bilayer thin film to get better structural properties. This is because the peak intensity is the highest with no foreign elements or compound were present.

In this study, FESEM is to analyse the microstructure of the samples that were varied on the annealing temperature which are 400, 500 and 600℃. The characterization was conducted at 50, 000 and 100, 000x magnification for each samples. Figure 4, 5 and 6 shows the morphological images of TiO_2/ZnO bilayer thin film annealed at 400, 500 and 600℃. Different annealing temperature gives different grain size as seen from figures 4, 5 and 6. Comparing to the varied temperature, sample with 600℃, has the biggest grain size. This proves the literature which stated that higher annealing temperature produces bigger grain size (Ibrahim, N. B., Ahmad, S. & Al-Shomar, S. M. (2013).).

Hence, what can be concluded from morphological properties analysis is, 600℃ is the most suitable temperature to anneal TiO_2/ZnO bilayer thin film to get better morphological properties. This is because the

grain size is largest among the varied parameters among the scope of this research with no foreign elements or compound was present.

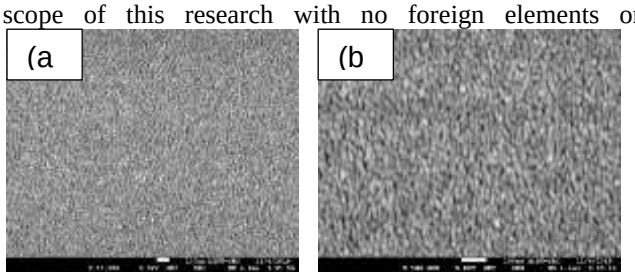

Figure 4: TiO_2/ZnO bilayer thin films annealed at 400ºC for magnification (a) 50,000 and (b) 100,000x

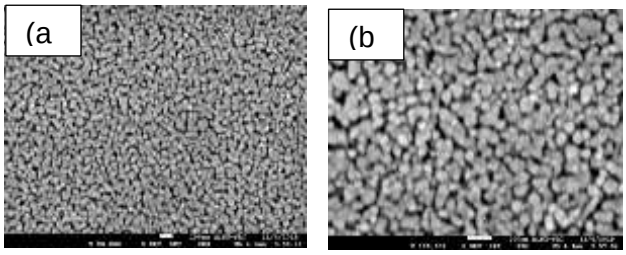

Figure 5: TiO_2/ZnO bilayer thin films annealed at 500ºC for magnification (a) 50,000 and (b) 100,000x

[2]

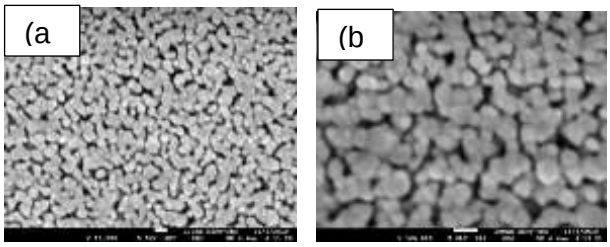

Figure 6: TiO_2/ZnO bilayer thin films annealed at 600ºC for magnification (a) 50,000 and (b) 100,000x

[4]

5.0 CONCLUSION

Based on the results obtained from the three methods, it can be concluded that the All the objectives of the study have been successfully accomplished. TiO_2/ZnO bilayer thin film has been successfully fabricated on fluorine-doped tin oxide (FTO) substrate using sol-gel spin coating technique. The parameter used in this study is different annealing temperature of TiO_2/ZnO bilayer thin film. The film has successfully deposited and annealed with the parameter which is 400, 500 and 600℃. It is found in this study that 500℃ is the most suitable temperature to anneal TiO_2/ZnO bilayer thin film to produce the best structural and morphological properties.

Acknowledgement

The authors would like to thank the Research, Innovation, Commercialization and Consultation Management (ORICC), Universiti Tun Hussein Onn Malaysia (H713 Tier 1 Fund) for sponsoring the research and development of this project. The authors also wish to thank the Management, Dean, Head of the Departments, and Faculty of Electrical and Electronic Engineering (FKEE) of Universiti Tun Hussein Onn Malaysia (UTHM), for their support to bring this work in reality.

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