UNIVERSITI TEKNOLOGI MARA

THE INFLUENCE OF TiO_2 SEED LAYER ON THE GROWTH OF ZnO NANORODS FOR UV SENSOR APPLICATION

NUR AMIERAH BINTI MOHD ASIB

PhD

August 2020

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

I hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Nur Amierah Binti Mohd Asib
Student I.D. No.	:	2012245882
Programme	:	Doctor of Philosophy in Science – AS990
Faculty	:	Applied Sciences
Thesis Title	:	The Influence of TiO_2 Seed Layer on the Growth of ZnO Nanorods for UV Sensor Application
Signature of Student	:	..……..
Date	:	August 2020

ABSTRACT

In this work, ZnO nanorod arrays were fabricated at a low temperature by a simple and low cost method of solution-immersion on TiO_2 seed layer coated glass substrate. The TiO_2 seed layers were prepared via sol-gel spin-coating technique. This work consist of two fabrication steps; (a) preparation of TiO_2 seed layer on glass substrate, (b) synthesization of ZnO nanorods on TiO_2 seed layer. The optimization of fabrication parameters, which are mainly related to preparation processes for the seed layer and ZnO nanorods, were studied. Titanium (IV) butoxide was used as starting material for deposition of TiO_2 seed layer on glass substrate. The seed layer was prepared at molar concentrations of 0.05-1.00 M. 0.25 M of TiO_2 showed optimum average surface roughness with highest crystallinity and UV absorption properties. Then, the effect of number coating layers (1-9 layers) which performed by using spin-coating technique was investigated. The highest surface roughness, UV absorption properties and crystallinity with the smallest value of FWHM was observed for seven coating layers. The effects of annealing temperatures (350-550˚C) and times (30-150 min) also were studied. The seed layer annealed at 450˚C for 60 minutes possessed highest surface roughness with enhanced crystallinity and UV absorption properties. FESEM result showed that the TiO_2 seed layer composed of small compact particles with porous nature and the thickness was measured about 222.5 nm. For the second step of fabrication, Zn^{2+} solution were varied from 0.002-0.060 M. Well aligned, uniform, dense ZnO nanorods with prominent (0 0 2) peak and have good UV absorbance was found at 0.040 M. In addition, TEM images prove the successful formation of ZnO nanorods (without hollow). Next, the effects of immersion temperatures (75-95˚C) and times (2-6 h) were observed. It was found that ZnO grown at 90˚C for 4 h have smallest size with dense distribution of nanorods and have good UV absorption properties. Moreover, the effects of annealing temperatures (400-660˚C) and times (30-150 min) were investigated. Smallest size with good distribution of nanorods was also observed when ZnO was annealed at 500˚C for 60 min. FESEM result showed that the average diameter size and length of optimum ZnO nanorods was about 116.7 nm and 3.6 μm. The growth mechanisms of bare TiO_2, bare ZnO and TiO_2:ZnO were also discussed in this work. Lastly, three type of UV sensors were fabricated using different samples of bare TiO_2, bare ZnO and TiO_2:ZnO. These samples were tested using UV measurement system and their performances were compared and discussed. The responsivities of the bare TiO_2, bare ZnO and TiO_2:ZnO based UV sensors were recorded at 7.76×10^{-5} A/W, 2.22×10^{-7} A/W and 1.70×10^{-1} A/W, respectively. Meanwhile the sensitivities of the bare TiO_2, bare ZnO and TiO_2:ZnO based UV sensors were calculated and reported at 1.5, 1.0 and 9.2, respectively. It was proved that the best performance of UV sensor was observed for TiO_2:ZnO nanorods thin film with the increasing of responsivity and sensitivity about 99% and 89.13%, respectively compared to bare ZnO. Hence, a new attempt of utilizing TiO_2 as seed layer to grow nanorods and to be used as based material in fabrication of UV sensor was successful, as nanorods grown on the TiO_2 seed layer exhibit superior properties of packed nanorods with good crystallinity quality and improved UV absorption properties which can produce highly response, sensitive, reproducible and stable UV sensor.

ACKNOWLEDGEMENT

First and foremost, I would like to thank Allah SWT the Almighty for giving me the strength, health and blessing to finish this study. It has been a long and tough journey for me and everyone around me. Without Your blessing, none of this is possible. Alhamdulillah.

I wish to express my sincere thanks to my inspiring supervisor, Assoc. Prof. Dr Zuraida Khusaimi for her advice, encouragement and guidance throughout the research. Her constant encouragement has helped me a lot in this journey. Your mentoring technique is special and one of a kind. It is my honor to be your student and I am really proud of it. I really hope we will continue to collaborate in future. A million thanks also to my co-supervisors Prof. Engr. Dr. Mohamad Rusop Mahmood and Assoc. Prof. Ir. Ts. Dr. Mohamad Hafiz Mamat for their selfless support and advice as well as permission to use their laboratories and equipments.

I would like to thank all of my laboratory mates such as, Nurul Afaah, Noor Aadila, Siti Zulaikha, Najwa Ezira, Rohanieza, Muhamad Amir Ridhwan, Al-Hadi, Robaiah, Hafsa, Nurul Hidah, Nur Munirah, Nur Farhana, and many more. Not to forget Mr. Azlan, Mrs. Nurul Wahida and Mr. Salifairus for their continuous support and help. Thank you to Dr. Mohamad Husairi, Dr. Noor Asnida and Dr. Mohd Firdaus for their guidance throughout my PhD journey.

Special thanks for Mrs. Nida and Mr. Hayub from Faculty of Applied Sciences, Mr. Danial and Mr. Azwan from Faculty of Electrical Engineering for assisting in the FESEM equipment and Mr. Abul Khamis from Faculty of Applied Sciences for his help in the XRD equipment. I also would like to thank Institute of Research Management & Innovation, Universiti Teknologi MARA and Ministry of Higher Education of Malaysia for the scholarship and financial support.

Last but not least, I want to thank my loving and supportive parents, Mohd Asib Yusof and Shamshuanan Majid, and also all my siblings including in-laws, Nur Fatihah, Saiful Islam, Nur Syuhada, Muhd Amierul, Norasmiza, Muhd Aqwa, Nur Ainaa, Muhd Aniq and Muhammad Ajwad for their continuous support, encouragement and understanding. Thank you to my niece and nephew, Nur Ayra Aulia and Muhammad Ayden Aisy for their love and joy which make me stronger every day. They are my great support and strength. All the hard work and sacrifices has finally paid off. Next, a new journey shall begin.

TABLE OF CONTENTS