UNIVERSITI TEKNOLOGI MARA

CONTROLLABLE GROWTH OF ZNO-BASED NANOWIRES SYNTHESIZED VIA ULTRASONIC-ASSISTED SOL-GEL AND IMMERSION TECHNIQUE

NOOR FATIN SOFEA BINTI ZULKIFLI

Thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science
(Material Sciences and Technology)

Faculty of Applied Science

August 2022

ABSTRACT

ZnO nanowires (NWs) were particularly fascinating due to their quasi one-dimensional (1-D) structures exhibiting quantum confinement effects and broad surface to volume ratios. ZnO NWs have attracted considerable attention over the last decade due to their various outstanding physical properties and potential applications in many emerging sectors such as optoelectronics for low and short wavelength, photonics, actuator and solar cells. However, there are some issues regarding ZnO NWs such as morphological size and thickness control, mass production, high temperature, complex experimental setup, and high cost, which are undesirable for an industrialized process. Besides, the non-homogeneous reaction of precursor and solvent during the mixing process will lead to the formation of large particles size and reduce the surface area of the nanostructures. This process leads to weak transport of electron and high recombination through defects state such as grain boundaries. Additionally, the uses of pure ZnO has a number of limitations such as high resistivity and low carrier concentrations, which restrict their potential applications. Besides, inability of pure ZnO to be directly used in optoelectronic devices is restricted due to its poor optical characteristics. Thus, to solve this issue, doping process is essential to improve optical properties of ZnO. Therefore, this current study was performed to synthesize ZnO-based NWs arrays via ultrasonic-assisted sol-gel immersion technique. In this study, several parameters were studied regarding the growth of vertically-aligned ZnO NWs arrays, including different molarity of precursor concentration (1-100 mM), different growth times (1-5 h) and different types of doping (Cr, Co, Ni, Er and Cu). The structural, morphological and optical properties of the synthesized films were characterized via Field-Emission Scanning Electron Microscope (FESEM), X-ray diffraction (XRD) and ultraviolet-visible spectrophotometry (UV-Vis), respectively. Results show that the optimization of ZnO NWs thin films at different molarity of precursor concentrations exhibited that the film at 25 mM possess the most uniform morphology, highly crystalline and has the lowest band gap than the other samples. Meanwhile, the optimum growth times was 3 hours due the growth of vertically-aligned ZnO NWAs with length of approximately 1.15 μm were grown preferentially along the c-axis. Further study on the effect of different types of dopants on ZnO NWs were investigated. It was found that introducing Cr as a dopant for ZnO showed enhancement for ZnO NWs which prevented the fast electron-hole recombination revealed as best dopant due to lower band gap. These remarkable enhance the performance of ZnO NWs. Thus, vertically-aligned ZnO NWs arrays thin films are promising candidate which seems very useful for many emerging sectors such as optoelectronics.

ACKNOWLEDGEMENT

First and foremost, I would like to express my highest appreciation to my supervisor, Ts. Dr. Mohd Firdaus Bin Malek for his continuous advice, encouragement, guidance, and excellent supervision throughout this research journey. His constant encouragement has helped me acquire and develop some of the skills and intricacies of good independent research. My extended appreciation also to my co-supervisors, Assoc. Prof. Ir. Ts. Dr. Mohamad Hafiz bin Mamat and Ts. Dr. Ruziana Mohamed for their undivided support and valuable contributions. Also, many thanks to Prof. Engr. Dr. Mohamad Rusop bin Mahmood for his indirectly contributed to this research.

My special gratitude to my research group members and friends for their help, motivation, kindness, and support during my studies. My appreciation also goes to the technical staffs at NANO-SciTech Lab (NST), and Faculty of Applied Sciences of UiTM, especially Mr. Azlan Jaafar, Ts. Salifairus Mohammad Jafar, Ts. Irmazatussyehdany and Mr. Faizal Halim for sacrificing their precious time and helping me to accomplish my research. They are incredible colleagues to associate and work with.

Special dedication goes to my beloved father, Zulkifli Bin Omar and my lovely mother, Che Azuwal Binti Halim, and my only brother, Mohd Zulazrie Haqeemee for their encouragement, understanding, patience and endless love during my studies. It was their dream that made me successful in this journey. Finally, I would like to express my deepest appreciation to my beloved husband, Muhammad Zahirruddin Bin Zaini for being with me in difficult times. I am very grateful to have them around me whenever I need help and encouragement. They are my source of strength to face the twists and turns of challenges throughout this study. Thank you for your endless love. This piece of victory is dedicated to all of you. Alhamdulillah.

Noor Fatin Sofea binti Zulkifli
August 2022

TABLE OF CONTENTS