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STRUCTURAL AND OPTICAL PROPERTIES OF ZnO NANOSTRUCTURES ON NANOSTRUCTURED POROUS SILICON BY THERMAL CHEMICAL VAPOUR DEPOSITION METHOD

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Abstract

Zinc oxide (ZnO) is a direct wide band gap semiconductor material of 3.3 eV and has a large excitation binding energy of 60 meV. The non-toxicity, thermally stable and the wide availability of its component raw materials give additional advantages for ZnO to be used in many applications. In this thesis, the structural and optical properties of ZnO nanostructures have been studied. Thermal chemical vapor deposition method and basic characterization using Scanning Electron Microscopy (SEM), X-ray diffraction (XRD) technique and photoluminescence (PL) measurement become a key idea of this thesis. Two stages preparation was involved are preparation of nanostructured porous silicon (NPSi) substrate and preparation of ZnO nanostructures. A number of ZnO nanostructures samples have been prepared by dividing into four set of experiment that is ZnO deposited on NPSi substrate, on Au-coated NPSi substrate, on Si substrate and on Au-coated Si substrate at various deposition temperatures. It can be observed that NPSi20 subtrate is the best sample to act as a substrate for ZnO preparation as it surface structure is uniform and thickness is better compared to other samples. Besides, NPSi20 have a good characteristic on photoluminescence which is the intensity is higher than other samples and the photon energy gave a maximum value compares to other samples. ZnO has been prepared at various deposition temperatures and it can be observed that at deposition temperature of 400 to 450 °C the ZnO formed like a flower structure with an accumulation of many rods with sharp nanotips at the end of the rod. Increasing the deposition temperature from 500 to 600 °C caused the ZnO structure decomposed and formed as a nanospherical structure. It can be conclude that 400 °C and 450 °C is the optimize deposition temperature to obtain ZnO flower like structure and observed that ZnO which deposited on NPSi and Au-coated NPSi substrate have a higher nucleation density of ZnO particles compared to ZnO deposited on Si and Au-coated Si. From XRD results, as deposition temperature increases the crystallite size decreases and observed that ZnO deposited on NPSi substrate shows a good crystallinity compared to ZnO deposited on Si substrate as the peak is narrower and sharp. From PL observation, it can be seen that, ZnO which deposited on NPSi and Au-coated NPSi substrate shows a low defect emission which indicating that those ZnO has good optical quality compared to ZnO deposited on Si/ Au-coated Si. Besides, ZnO which deposited on NPSi an Au-coated NPSi substrate give higher PL intensity compared to ZnO deposited on Si and Au-coated Si substrate hence give a good luminescence properties that can be applied to LED applications. In conclusion, ZnO which deposited on NPSi either with or without catalyst have higher nucleation site, denser, good crystallinity, low defects and good luminescence properties compared to ZnO deposited on Si substrate.

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CHAPTER 1

INTRODUCTION

1.0 Nanotechnology

Nanotechnology refers to the design and synthesis of materials and devices at the nanometer level (1nm = 10^{-9}m). Nanotechnology has been identified to have a great potential in electronic, optoelectronics, medicine, energy, farming and food production as well as environment. The three disciplines of fundamental science - physics, chemistry and biology as well as material science - are combined into one since nanotechnology has been developed.

The idea of nanotechnology was introduced in 1959 when physicist; Richard Feynman gave a lecture exploring the idea of building things at the atomic and molecular scale imagined the entire Encyclopedia Britannica written on the head of a pin [1]. In his talk the first use of the concepts in 'nano-technology' was in "There's Plenty of Room at the Bottom". The focus of his speech was about the field of miniaturization and how he believed man would create smaller and powerful devices.

The preparation on the nanomaterials and nanoparticles are inevitable in discussing nanotechnology. There are many techniques for the synthesis of nanoparticles including top-down and bottom-up approaches that have been developed by scientist and engineers. For instance top-down approaches are milling or attrition, repeated quenching and lithography. The synthesis of nanoparticles from bottom-up approaches is more accepted since there are many methods have been developed. For example nanoparticles are synthesized via liquid or vapour phase technique. Scientist are more likely to come up with completely different ways which are to build from the bottom-up approaches rather than using tradional top-down approaches as engineering at the nanoscale is no simple feat.