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Single Step Growth of Vertically Oriented Zinc Oxide Nanowire Using Thermal Evaporation

Dzetty Soraya Abdul Aziz[1,a*], Samsudi Sakrani[2,b], Naziha Jamaludin[3,c]

[1]Centre for Pre-University Study, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

[2,3]Faculty of Science, Universiti Teknologi Malaysia, 81310 Johor Bahru, Malaysia

[a*]aadsoraya@unimas.my, [b]samsudi3@yahoo.com, [c]nazihajamaludin91@gmail.com

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Abstract. Commonly, the synthesis of ZnO nanowires involves the use of metal catalyst via a non-direct step growth which contribute to the contamination on the final product. Thus, in this work we synthesized catalyst-free ZnO nanowires using a direct or single step growth of nanowires. Thermal evaporation method is used to synthesize ZnO nanowires on bare glass substrates with different distances between Zn powder and the substrates; on-top (1.2 cm), 16 cm and 18 cm. Field Emission Scanning Electron Microscopy images showed a vertically well-aligned with high density of ZnO nanowires were successfully synthesized via self-seeding process and the longest nanowires were produced at the shortest distance. Energy Dispersive X-ray and X-Ray Diffraction analyses confirmed that high purity of ZnO nanowires were obtained and ZnO (002) strongest and sharp peak was observed, indicating preferentially grown ZnO nanowires along the c-axis perpendicular to the substrates and leading towards single crystal structure. Four peaks were observed in visible range from Photoluminescence spectra (PL) which related to fundamental defects with the highest peak at 3.04 eV. The on-top sample with distance 1.2 cm from Zn powder has the lowest transmittance due to the high thickness of ZnO nanowires. The range of energy band gap for ZnO nanowires obtained from the extrapolation graph is in agreement with PL highest peak approximately 3.00 eV. Therefore, this direct or single step deposition method is of great interest since it has successfully produced ZnO nanowires with significant characteristics without employing the non-direct step growth.

Introduction

One-dimensional (1D) nanostructure materials have stimulated interest among researchers due to the 1D morphologies which enhance the unique properties of metal-oxide nanostructures. This is due to their role as both interconnects and the key units in the fabrication of electronic and optoelectronic devices such as gas sensors, electronic devices, supercapacitor, nanoelectronics, and nanogenerator [1]. Zinc oxide (ZnO) appeared to be one of the very promising 1D metal-oxide nanostructures materials with wide bandgap energy of 3.37 eV and large exciton binding of 60 meV at room temperature. ZnO nanostructures can be synthesized in a form of NWs, nanorods, nanotubes, nanobelts and nanoribbons by various methods either physical or chemical [2]. However, to synthesize them with identical in shape and size along with perfect crystalline structures and without morphological defects has become the challenges for 1D metal-oxide nanostructures development [3]. Generally, ZnO NWs can be synthesized using chemical vapor deposition (CVD) technique and physical vapor deposition (PVD) technique which includes evaporation, sputtering and molecular beam epitaxy (MBE). However, synthesis of ZnO NWs using CVD will subject to higher temperature chemical reactions and safety issue where the toxic from the precursor and by-products will get involved during the CVD process. In contrast, PVD technique involves purely physical methods where solid or liquid source material will be evaporated into the gas phase and condenses onto the substrate. There are few alternatives that will assist the growth of nanowire, for example the use of metal catalyst such as gold. But the use of metal-catalyst is unfavorable due to the contamination to the final products that contributes to the low performance of NWs [4,5]. The type of substrate plays important role in assisting the growth ZnO nanowire therefore substrate with similar lattice constant