UNIVERSITI TEKNOLOGI MARA

# PREPARATION AND CHARACTERIZATION OF ZnO NANORODS ON POROUS SILICON NANOSTRUCTURES USING SOL-GEL IMMERSION METHOD

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Thesis submitted in fulfillment of the requirements
for the degree of
**Master of Science**

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## Candidate's Declaration

I declare that work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and it is 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.

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## ABSTRACT

This thesis presents the preparation and characterization of ZnO nanorods on porous silicon nanostructures (PSiNs) using sol-gel immersion method. A simple method to synthesize the ZnO nanorods from aqueous solution that contain zinc nitrate hexahydrate ($Zn(NO_3)_2{\cdot}6H_2O$) and hexamethylenetetramine ($C_6H_{12}N_4$) is presented. ZnO nanorods were prepared under different parameters such as molar concentration of precursors, immersion times, immersion temperatures and annealing temperatures to obtain the optimum growth parameter of ZnO nanorods on PSiNs substrate. All samples are then characterized by Scanning Electron Microscope (SEM) to study the surface morphology, X-Ray Diffraction (XRD) for purity and crystallinity of ZnO nanorods and Photoluminescence (PL) spectrometer to study the luminescence properties and defect states of ZnO nanorods. From the characterization measurements of the samples, observed that ZnO structures showed the width of ZnO microrods can be reduced to nanorods size by decreasing the molar concentration of precursor and increasing the immersion temperatures from 65 to 95°C at 15 h immersion time. X-ray Diffraction pattern for all samples corresponded to the hexagonal ZnO phase and it showed the orientation of nuclei is random on the PSiNs substrate. While photoluminescence study at room-temperature showed strong UV emission and several weak emissions at blue wavelength region which may suggest good materials for fabricating optoelectronic devices such as light emitting diodes (LEDs), solar cell, sensor and laser diodes (LDs).

## LIST OF TABLES

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Zinc Oxide

### 2.1.1 Introduction

Zinc Oxide (ZnO) is an II-VI group compound semiconductor with direct wide band-gap energy about 3.37 eV and a large excitation binding energy (60 meV) at room termperature [1,2]. The excitation binding energy of ZnO is much higher than the thermal energy at room temperature (26 eV) and it also much higher than other potential materials such as ZnSe (22 meV), GaN (25 meV) and ZnS (40 meV), which has made ZnO a good material for field emission display, solar cell, chemical sensors, short-wavelength light emitting diodes (LEDs) and laser diodes (LDs) applications [3-7]. Table 2.1 shows the key properties of ZnO and provides a comparison with GaN, ZnSe and ZnS [8].

Table 2.1 Comparison of different semiconductors [8]

| **Property** | **ZnO** | **GaN** | **ZnSe** | **ZnS** |
|---|---|---|---|---|
| RT Energy band gap, $E_g$ (eV) | 3.37 | 3.4 | 2.7 | 3.7 |
| RT exciton binding energy, $E_B$ (meV) | 60 | 25 | 22 | 40 |
| RT stable phase | Wurtzite | Wurtzite | Blende | Blende, Wurtzite |
| Lattice parameter (at 300K): | | | | |
| $a_0$ (Å) | 3.25 | 3.12 | 3.9 | 3.81 |
| $c_0$ (Å) | 5.21 | 5.19 | 6.53 | 6.23 |
| Melting temperature (K) | 2248 | 1973 | 1790 | 2103 |