UNIVERSITI TEKNOLOGI MARA

BIOSYNTHESIS OF HIGH VERTICALLY ALIGNED MAGNESIUM-ZINC OXIDE NANORODS CORE/SHELL MEDIATED BY *PANDANUS AMARYLLIFOLIUS* LEAVES EXTRACT

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ABSTRACT

The previous biosynthesis method, utilizing a one-step approach, resulted in a random distribution or disordered rod structures rather than vertically aligned ZnO nanorods. This drawback limits the optical and electrical efficiency in optoelectronic applications. Hence, a double step approach referring to seed layer development as first step followed by ZnO nanorods deposition as a second step in overall synthesis was highlighted in this study. The study was divided by 4 major sections: (1) preparation of PA leaves extract, (2) preparation of Mg-doped ZnO seed layer on glass substrate and (3) deposition of ZnO nanorods on Mg-ZnO seed layer and (4) synthesization of Mg-doped ZnO nanorods core/shell. The study initially investigated the impact of various preparation techniques of PA extract as a stabiliser on the synthesis of ZnO seed layers. The results indicate that the treated PA (TP) extract greatly enhances UV-Vis absorbance by 194% compared to untreated PA (UP). Mg-doping to ZT (MZT) prepared at pH 7, with 5 w/v% PA, 0.2 M zinc nitrate hexahydrate, and annealed at 350°C further stabilizing the structures, leading to a homogeneous and uniform particle size. The average's diameter size was found to be 8.13 nm ± 0.91. In the third section, ZnO nanorods grown on prepared MZT using the solution-immersion method are referred to ZZMZT. ZZMZT, primarily hexagonal ZnO with a wurtzite structure, grow perpendicularly to the substrate and show a 290% increase in UV absorption due to enhanced light trapping and nanorod alignment. Additionally, ZZMZT demonstrates a 55% increase in crystallinity and a 47% reduction in diameter size. Mg-doped ZnO nanorods in a core-shell configuration (MZCS), as confirmed by HRTEM and EDX mapping, exhibit a 38% reduction in dislocation density, leading to enhanced I-V characteristics while preserving structural and morphological integrity. MZCS also exhibits 17% higher UV intensity compared to ZZMZT and superior I-V performance with a current of 13.23 μA at 1-5 volts. This study underscores the critical role of PA extract preparation in optimizing ZnO seed layer synthesis for vertically-aligned Mg-doped ZnO nanorods and highlights water-based and low-temperature synthesis with minimal environmental impact. MZCS is proposed to portray a comparable durability when perform under different environmental conditions (e.g., temperature and humidity) due to the protective Mg shell. From a practical standpoint, meticulous optimization of synthesis parameters is crucial to achieving a balance between doping levels and defect density, thereby ensuring improved long-term stability.

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~Rabiatuladawiyah Bt Md Akhir~

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Background of study is divided into several key subchapters includes zinc oxide (ZnO) nanostructures, synthesis of zinc oxide nanostructures, doped ZnO nanostructures and biosynthesis method. Background of study provides an overview of different structures ZnO possible have and its brief properties, followed by doping method requirement, along with a concise introduction of core-shell structures and the role of doping elements. Lastly, Mg-ZnO core-shell nanostructures via low-temperature solution immersion technique was presented.

1.1.1 Zinc Oxide Nanostructures

ZnO is a direct band gap semiconductor with the hexagonal wurtzite crystal structure, having a wide band gap of 3.37 eV at room temperature and large exciton binding energy about 60 meV. This wide bandgap allows it to absorb ultraviolet (UV) light, and then it emits visible light when electrons recombine with holes in the crystal structure (Sanakousar et al., 2022). Due to its unique crystal structure and wide bandgap characteristics, ZnO exhibits luminescent properties. Luminescence is a phenomenon that occurs when atoms or molecules absorb energy and subsequently emit it as visible light. One of the examples is photoluminescence (PL) that refers to the phenomenon where zinc oxide emits visible light when it is subjected to ultraviolet (UV) light. Owing to its excellent luminescent properties, ZnO is a promising material for the development of optoelectronic and photovoltaic devices. ZnO is also non-toxic, has high photosensitivity, chemically stable, low cost in production, commercially available with large area single crystal substrates (Qi et al., 2017). Over the last few years, ZnO nanostructures with electronic and optical properties have received a tremendous interest among researchers. It has been understood that there are many types of ZnO nanostructures such as nanoparticles (0-D), nanotubes, nanorods (1-D), nanosheet (2-D) and nanoflowers (3-D). The variation of ZnO