ANALYSIS OF ELECTROCHEMICALLY DEPOSITION ZNO AS PHOTOANODE FOR SOLAR CELLS

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

I dedicate this thesis to my beloved parents and siblings, who have been my source of encouragement.

ABSTRACT

A solar cell, also known as a photovoltaic cell, is one of the most promising renewable energy available. There are many methods to deposit a photoanode layer of DSSC, such as doctor blade, sputtering and spin coating; however, there are limitations to each of the methods. Electrochemical deposition, which is a three-electrode method, is a cost-effective method for depositing metal, metallic oxide, and composites. The three-electrode method can also control the coating's thickness and chemical composition by varying the deposition potential/current. Zinc Oxide (ZnO) is an n-type semiconductor with a wide bandgap energy value lying in the range of 3.37 eV. ZnO layers were deposited using an electrodeposition method by varying the solution's deposition time and molarity. The potential difference used in this experiment was -0.61V based on the cyclic voltammetry and chronoamperometry using a potentiostat and NOVA software. The qualities of the deposited ZnO have been studied using Scanning Electron Microscopy (SEM) and Ultraviolet-Visible Spectroscopy (UV-Vis) to find out their characterizations. This research emphasized the Analysis of Electrochemical Deposition ZnO as Photoanode for Solar Cells.

ABSTRAK

Sel suria, juga dikenali sebagai sel fotovoltaik, adalah salah satu tenaga boleh diperbaharui yang paling menjanjikan. Sel suria pemeka pewarna (DSSC) ialah sel solar generasi ketiga yang menukar tenaga suria kepada tenaga elektrik menggunakan bahan kos rendah dan prosedur fabrikasi mudah. Terdapat banyak kaedah untuk mendepositkan lapisan fotoanod DSSC, seperti "Dr.Blade", "sputtering" dan "spin coating"; walau bagaimanapun, terdapat had untuk setiap kaedah. Pemendapan elektrokimia ialah kaedah kos efektif untuk mendepositkan logam, oksida logam dan komposit. Kaedah ini juga boleh mengawal ketebalan salutan dan komposisi kimia dengan mengubah potensi/arus pemendapan. Zink Oksida (ZnO) ialah semikonduktor jenis-n dengan nilai tenaga jurang jalur lebar terletak dalam julat 3.37 eV. Lapisan ZnO dimendapkan menggunakan kaedah elektrodeposisi dengan mengubah masa pemendapan dan kemolaran larutan. Beza keupayaan yang digunakan dalam eksperimen ini ialah -0.61V menggunakan perisian potensiostat dan NOVA. Kualiti ZnO termendap telah dikaji menggunakan Scanning Electron Microscopy (SEM), dan Ultraviolet-Visible Spectroscopy (UV-Vis).

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LIST OF SYMBOLS AND ABBREVIATIONS

For examples:

PV	:	Photovoltaic
DSSC	:	Dye-Sensitized Solar Cell
TCO	:	Transparent Conducting Oxide
Pt	:	Platinum
CuO	:	Copper Oxide
SEM	:	Scanning Electron Microscopes
UV-Vis	:	Ultraviolet-Visible Spectroscopy
PSC	:	Perovskite Solar Cell
ITO	:	Indium Tin Oxide
Ag/AgCl	:	Silver/Silver Chloride
IEA	:	International Energy Agency
DC	:	Direct Current
AC	:	Alternating Current
GaAs	:	Gallium Arsenide
CdTe	:	Cadmium Telluride
CIS	:	Copper Indium Diselenide
CIGS	:	Copper Indium Gallium Selenide

c-Si	:	Crystalline Silicon
a-Si	:	Amorphous Silicon
OPV	:	Organic/Semi-organic PV panels
QD	:	Quantum Dot
TiO2	:	Titanium Dioxide
FTO	:	Fluorine-Doped Tin Oxide
HOMO	:	Highest Occupied Molecular Orbital
LUMO	:	Lowest Unoccupied Molecular Orbital
ZnO	:	Zinc Oxide
NiO	:	Nickel Oxide
MoS2	:	Molybdenum Disulfide
PET	:	Flexible Polyethene Terephthalate
CV	:	Cyclic Voltammetry
XRD	:	X-Ray Diffraction
PCE	:	Power Conversion Efficiecny
FF	:	Fill Factor
VoC	:	Open-Circuit Voltage
Isc	:	Short-Current Photocurrent
NoOH	:	Sodium hydroxide
I-V	:	Current-Voltage
HTL	:	Hole Transport Layer
ETL	:	Electron Transport Layer

CHAPTER 1

INTRODUCTION

This chapter discusses the project introduction, problem statement, project aim, project question, objectives, and the scope of work. Discussion of all subtopics in this chapter is an initiative for this project.

1.1 Project Introduction

Our society requires energy to maintain our quality of life and underlie all other aspects of our economy. Renewable energy technologies promise plentiful, clean energy derived from self-renewing resources, including the Sun, Wind, Earth, and Plants. Solar energy is the radiant light and heat from the sun captured by various methods, including solar power generation, solar thermal energy, such as solar water heating, and solar architecture. A solar cell, also known as a photovoltaic cell, is an electrical device that uses the photovoltaic effect, a physical and chemical phenomenon, to convert light energy directly into electricity using a semiconductor. Solar cells are divided into three generations based on the historical period and the types of materials utilized in their fabrication [1], [2], [3]. This research will investigate and discuss the electrochemical deposition of dye-sensitized solar cells (DSSC) under the third generation of solar cells. A DSSC is a low-cost solar cell that belongs to the thin-film solar cell family[4]–[7]. Zinc oxide (ZnO), one of the oldest known semiconductors, is a promising material among the numerous metal oxide materials for photovoltaic applications

Furthermore, toxic substances produce and process most semiconductors, causing environmental problems. Thus, research efforts have been made to develop materials that could guarantee optimal environmental combability, abundance, and photoactivity characteristics, especially in the last decade. As a result, developing novel materials and assembly processes for low-cost solar cells is a viable option. Accordingly to its low production cost and flexible manufacturing processes, dye-sensitized solar cells (DSSC) have received a lot of interest. Several synthesis methods, such as pulsed laser deposition, chemical vapor deposition, thermal oxidation, sol-gel, photochemical deposition, and electrodeposition, are often utilized to make ZnO thin films. The electrodeposition method has various benefits over other approaches: its simplicity, cheap equipment cost, ability to produce vast area of thin films, and control over film thickness [8]. There are two types of electrochemical deposition, which are two-electrode and three-electrode. This research used three-electrode deposition to deposit ZnO as photoanode for solar cells.

1.2 Problem Statement

Due to its low cost and good performance, dye-sensitized solar cells (DSSC) are gaining much attention as a future renewable energy source[9]. In DSSC, the dye takes the lead by ejecting electrons and activating the process when exposed to light. ITO-coated glass substrates, dye, photoanode, electrolytes, and the counter electrode are the main components of DSSCs [10].

Many methods to deposit a photoanode layer of DSSC, such as doctor blade, sputtering, and spin coating [11]; however, there are limitations for each method, such as in Table 1.1 below.

Table 1.1: Weaknesses of spin coating. sputtering, and Dr. blade

Method	Advantages	Limitations
Spin coating	Low cost and easy to deposit layer on a conductive glass	Easy to produce waste material because the spin coater cannot control the amount of the deposited layer
Sputtering	Use the RF-magnetron reactive to deposit layer, and the uniformity layer is good	High system cost and complexity
Doctor blade method	Low cost and simple method to deposit layer	The uniformity layer of the material is not good and cannot control the thickness of the deposited layer on the conductive glass

In this study, the solution proposed to deposit the ZnO layer as a photoanode was electrochemical deposition. Electrochemical deposition is a cost-effective method for depositing metal, metallic oxide, and composites. This method can also control the coating's thickness and chemical composition by varying the deposition potential/current. Due to its salient characteristics such as low cost, easy synthesis, non-toxicity, high stability, and good optoelectronic properties, ZnO has been widely used in organic solar cells (OSCs) and hybrid solar cells (HSCs) as an n-type inorganic semiconductor in organic solar cells (OSCs) and hybrid solar cells (HSCs).

1.3 Project Aim and Project Question

1.3.1 Project Aim

This project used a three-electrode system electrochemical deposition to deposit the metal oxide layer as a photoanode. Then, the metal oxide layer's qualities and structures were characterized using Scanning Electron Microscopes (SEM) and Ultraviolet-Visible Spectroscopy (UV-Vis). Next, the solar cell's performance was measured with solar simulation to measure the power conversion efficiency (PCE).

1.3.2 Project Question

1. How to deposit the ZnO layer as a photoanode on ITO glass using the three-electrode system?
2. What are the qualities of the layer deposited on ITO glass using electrochemical deposition?
3. What are the changes between the deposited layers if the molarity and deposition time were varied?