



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DEVELOPMENT OF ZINC OXIDE (ZNO)
NANOFLOWER FOR ELECTRON TRANSPORT
MATERIAL OF DYE-SENSITIZED SOLAR CELL**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Electrical And Electronic Engineering Technology (Electrical and Electronic) with Honours.

by

**FARIDZUAN BIN BAKAR
B071610283
940816065393**

**FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING
TECHNOLOGY**

2019

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: DEVELOPMENT OF ZINC OXIDE (ZNO) NANOFLOWER FOR
ELECTRON TRANSPORT MATERIAL OF DYE-SENSITIZED SOLAR CELL

Sesi Pengajian: 2019

Saya **FARIDZUAN BIN BAKAR** mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (X)

- SULIT* Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972.
- TERHAD* Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.
- TIDAK TERHAD

Yang benar,

Disahkan oleh penyelia:

.....

.....

FARIDZUAN BIN BAKAR

Ahmad Nizamudin b. Muhammad

Mustafa

Alamat Tetap:

Cop Rasmi Penyelia

X

X

X

Tarikh:

Tarikh:

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini

DECLARATION

I hereby, declared this report entitled DEVELOPMENT OF ZINC OXIDE (ZNO) NANOFLOWER FOR ELECTRON TRANSPORT MATERIAL OF DYE-SENSITIZED SOLAR CELL is the results of my own research except as cited in references.

Signature:

Author : FARIDZUAN BIN BAKAR

Date:

APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Electrical and Electronic) with Honours. The member of the supervisory is as follow:

Signature:

Supervisor : Ahmad Nizamudin b. Muhammad Mustafa

ABSTRAK

Cahaya matahari boleh menghasilkan arus dan voltan untuk menjana tenaga elektrik. Oleh kerana pengeluaran karbon dioksida yang menyebabkan pemanasan global, sel solar adalah calon peranti tenaga bersih yang baik. Sel suria pewarna pewarna dikenali sebagai pengeluaran kos rendah kerana bahan mudah diperolehi. Proses ini mengubah cahaya yang kelihatan ke dalam tenaga elektrik. Kajian ini akan memberi tumpuan kepada nanopartikel zink oksida untuk digunakan. Projek ini adalah mengenai pembangunan nanopartikel seng oksida untuk elektron yang mengangkut bahan. Kerja ini adalah untuk melihat nanopartikel zink oksida yang digunakan sebagai lapisan pengangkutan elektron. Dalam tahun-tahun akan datang, dijangka sumber tenaga alternatif yang menjanjikan (DSSCs) akan meningkatkan sumbangan penting kepada pengeluaran tenaga keseluruhan. Hal ini disebabkan oleh menawarkan fabrikasi murah dan ciri menarik seperti ketelusan. Oleh itu, tenaga mempunyai banyak kelebihan berbanding teknik tenaga lain seperti mengelakkan kerugian penghantaran, beroperasi tanpa bunyi dan memerlukan penyelenggaraan yang sangat sedikit. Selain itu, tidak ada pelepasan gas dan gas rumah hijau dalam sistem sel solar.

ABSTRACT

Sunlight possesses generated current and voltage to generate the power energy of electricity. Due production of carbon dioxide causing global warming, the solar cell is the good candidate clean energy devices. A dye-sensitized solar cell is known to be the low-cost production because the material is easy to get. This process transforms any visible light into electrical energy. This research will focus on zinc oxide nanoparticles to be used. This project is about the development of zinc oxide nanoparticles for electrons transporting material. This work is to observe the nanoparticles of zinc oxide used as the transport layer of electrons. In the coming years, it is expected that the promising alternative energy source (DSSCs) will increase the significant contribution to overall energy production. This is mainly due to offering a low-cost fabrication and attractive features such as transparency. Thus, the energy has many advantages over other energy techniques such as avoiding transmission losses, operating without noise and requiring very little maintenance. Moreover, there are no toxic and greenhouse gas emissions in solar cell systems.

DEDICATION

This book dedicated to Mom and Dad.
Thank you for your love and sacrifice

ACKNOWLEDGEMENTS

Bismillahirrahmanirahim.

Firstly, I would like to thanks Allah Almighty for His blessing for his power for me to complete this thesis and my final year project called “DEVELOPMENT OF ZINC OXIDE (ZNO) NANOFLOWER FOR ELECTRON TRANSPORT MATERIAL OF DYE-SENSITIZED SOLAR CELL”.

Furthermore, I would like to take this opportunity to express my deepest gratitude to Mr. Ahmad Nizamudin b. Muhammad Mustafa as my supervisor. His invaluable guidance and full support for give knowledge that make this project complete according to planning. I appreciate him with unlimited positive advice and helping me in order to understand the chemical term for the whole project.

I would like to express my gratefulness towards my parents Mdm. Basharah bt. Awang that always give me the full support and advice until completing my Final Year Project. Lastly but not least, my sincerely appreciation also extends to all my friends who give encouragement and helping me in completion of this project at Universiti Teknikal Malaysia Melaka.

Thank You.

TABLE OF CONTENTS

	PAGE
TABLE OF CONTENTS	x
LIST OF TABLES	xiv
LIST OF FIGURES	xv
LIST OF APPENDICES	xvi
LIST OF ABBREVIATIONS	xvii
LIST OF SYMBOLS	xviii
CHAPTER 1 INTRODUCTION	1
1.1 Background	1
1.2 Project Objective	4
1.3 Problem Statement	5
1.4 Scope	6
1.5 Project Significance	6
CHAPTER 2 LITERATURE REVIEW	7
2.1 Introduction	7
2.2 History of solar panel	7
2.2.1 First generation solar cells	9
2.2.2 Second generation solar cells	9

2.2.3	Third Generation Solar Cells	10
2.3	Structure of Dye-sensitized solar cells.	12
2.3.1	TCO and FTO layer	13
2.3.2	TiO ₂ as the photo-electrode	15
2.3.3	ZnO as the electrode transport layer	16
2.3.4	Procedure for the preparation of Dssc	17
2.3.5	Dyes for Dssc photosensitizer	18
2.3.6	Turmeric as dyes for DSSCs	19
2.3.7	Electrolytes for the DSSCs	20
2.3.8	CuSCN Copper(I) thiocyanate as hole-transport layer	21
2.4	Electrical characteristic of DSSCs	71
2.4.1	Open circuit voltage (V _{oc})	71
2.4.2	Short circuit current (I _{sc})	72
2.4.3	Maximum voltage, V _m	74
2.4.4	Maximum Current, I _m	74
2.4.5	Fill factor, FF	74
2.4.6	Efficiency, η	75
2.5	Latest research of Dye-synthesized.	22
2.5.1	2.4.1 Nanowire ETL	22
2.5.2	2.4.2 Nano Crystal ETL	23
2.5.3	2.4.3 Nano tube Array ETL	26

2.5.4	2.4.4 Nano spheroidal ETL	27
2.6	Comparison table.	29
2.7	Summary	31
CHAPTER 3 METHODOLOGY		34
3.1	Introduction	34
3.2	Planning Flow Chart ZnO	36
3.3	SCAPS, Solar cell simulation	38
3.4	Fabrication	38
3.4.1	Material and chemical preparation	39
3.4.2	Preparation ZnO Nano flower	39
3.4.2.1	Cleaning	40
3.4.2.2	Apply Zinc Nano Flower Structure	40
3.4.3	Preparation TiO ₂ Nano particle	43
3.4.3.1	Cleaning	43
3.4.3.2	Apply TiO ₂ Nano particle	43
3.4.4	Nanoparticle synthesis	44
3.4.5	Preparation Turmeric as dyes	45
3.4.6	Approximation of surface area	45
3.4.7	Back contact	47

3.4.8	Electrolyte	47
3.4.9	Solid-State Dye sensitizer solar cell	48
3.4.9.1	Apply Cuscn as hole transport layer	48
3.4.9.2	Apply CuI as hole transport layer	49
3.4.9.3	Ruthenizer N7091 as dye	50
3.5	Characterization	51
3.5.1	X-ray powder diffraction (XRD)	51
3.5.2	Scanning electron microscope (SEM)	52
3.5.2	Raman spectroscopy	52
CHAPTER 4 RESULT AND DISCUSSION		69
4.1	Introduction	69
4.2	SCAPS, Solar cell simulation,	69
4.4	X-ray Powder Diffraction (XRD)	77
4.4.1	ZnO ₂ Nano flower	78
4.4.2	Copper(I) Iodide (CuI)	79
4.4.3	Copper(I) thiocyanate (Cuscn)	81
4.5	Scanning electron microscope (SEM)	84
4.5.1	ZnO Nano flower	85
4.5.2	Copper(I) thiocyanate (Cuscn)	85
4.5.3	Copper(I) Iodide (CuI)	86
4.6	Raman spectroscopy	86
4.5.1	ZnO Nano flower	87
4.5.2	Copper(I) thiocyanate (Cuscn)	87

4.5.3	Copper(I) Iodide (CuI)	88
4.7	Discussion	88
4.7.1	Effect of ZnO Nano flower parameter on Efficiency	88
4.7.2	Effect of temperature of annealing on efficiency.	89
4.7.3	Effect of thickness on efficiency	89
CHAPTER 5 CONCLUSION AND RECOMMENDATION		90
5.1	Conclusion	90
5.2	Recommendation	91
REFERENCES		92
APPENDIX		95

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1:	Comparison of article	31
Table 3.1:	ZnO Nano flower growth fabrication	42
Table 3.2:	TiO ₂ fabrication	44
Table 3.3:	CuSCN fabrication	49
Table 3.4:	CuI fabrication	49
Table 4.1:	Voc and Isc ZnO DSSCs Nano flower	76

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1:	Structure of DSSCs ('NANCY W. STAUFFER', 2017).	13
Figure 2.2:	Structure of DSSCs (Law et al., 2005)	20
Figure 2.3:	Diagram of nanowire-based(Freitag, 2018)	21
Figure 2.4:	Molecular structure of Coumarin derivative(Hara et al., 2001)	22
Figure 2.5:	Structure (Rani et al., 2008)	23
Figure 2.6:	Intergration of transparent nanotube. (Mor et al., 2006)	24
Figure 3.1:	Structure of Dye-sensitized.	33
Figure 3.2:	Project Flow Chart	34
Figure 3.3:	Arrangement of ITO in beakers.	41
Figure 3.4:	PID controller graph	42
Figure 3.5:	Screen printing coating	43
Figure 3.6:	Spin coater	48
Figure 4.1:	Problem that set at Scaps simulation Solid state Dssc Cuscn htm	69
Figure 4.2:	Output parameter Scaps simulation	70
Figure 4.3:	Problem that set at Scaps simulation Solid state Dssc CuI htm	70
Figure 4.5:	Output parameter Scaps simulation	70
Figure 4.6:	IV curve of a solar cell showing the open-circuit voltage.	71
Figure 4.7:	IV curve of a solar cell showing the short-circuit current.	72

Figure 4.8:	I-V curve	75
Figure 4.9:	Xrd ZnO Nanoflower	78
Figure 4.10:	ZnO ₂ from 20°theta to 90°theta	79
Figure 4.11:	CuI Xrd spectrum	80
Figure 4.12:	CuI Xrd spectrum	81
Figure 4.13:	CuSCN Xrd spectrum	82
Figure 4.14:	CuSCN Xrd spectrum	83
Figure 4.15:	SEM images of: ZnO nanoflower.	85
Figure 4.16:	SEM images of: CuSCN nanoflower	85
Figure 4.17:	SEM images of: ZnO nanoflower	86
Figure 4.18:	Raman spectroscopy of: ZnO nanoflower	87
Figure 4.19:	Raman spectroscopy of: CuSCN	87
Figure 4.20:	Raman spectroscopy of: CuI	88

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
1	Materials and Chemicals	87
2	Materials and Chemicals	88
3	Manual spin coater	89
4	Gantt Chart PSM1	90
5	Gantt Chart PSM2	91

LIST OF ABBREVIATIONS

CdTe	-	Cadmium Telluride
CIGS	-	Copper Indium Gallium Selenide
DSSCs	-	Dye-Sensitized Solar Cells
TiO₂	-	Moment of inertia
V_{oc}	-	Open-Circuit Voltage
I_{sc}	-	Short-Circuit Current
J_{sc}	-	Short-Circuit Density
ITO	-	Indium tin oxide
TCO	-	Transparent conducting oxide
NC(s)	-	Nanocrystal(s)
FWHM	-	Full width at half maximum
Ru	-	Ruthenium
ZnO₂	-	Zinc oxide
J-Vcurve	-	Current density vs. voltage plot
I	-	Iodide
I₃	-	Triiodide
ETL	-	Electron Transport Layer

LIST OF SYMBOLS

Ω	-	Ohm
\$	-	US Dollar

CHAPTER 1

INTRODUCTION

1.1 Background

Due to the growth of the globe that the population makes an increasing demand for electrical city. At the same time, the earth is experiencing a threatening global warming and therefore the best solution will be used renewable energy sources such as solar cell power. However, a solar panel in the market is so expensive. Today's energy technology is steadily increasing and solar cells have created markets for many applications, from small electronic to large power stations. Solar power is a growing energy technology. The conversion efficiency of silicon-based solar cells has reached an efficiency of 25.6% for mono-Si and 20.4% for PolySi (Gooijer, Dijk and Gymnasium, 2016). The solar cells of the second generation are based on thin-film technologies. Amorphous Si (10.1 %), CdTe (19.6 %) are some of the well-established solar cell devices of the second generation. The solar cell devices of the third generation such as Organic (10.7 %) and dye-sensitized solar cells (14.1 %) (Gooijer, Dijk and Gymnasium, 2016). Dye-sensitized solar cells (DSC) are considered to be one of the most promising alternatives to conventional silicon based photovoltaic devices due to their ease of manufacture, flexibility and low production cost of around 1/5 of the Silicon-based PV solar cells ' production costs. Though DSC is substantially cheaper and easier to manufacture and promising laboratory research reveals interesting and fast progress in the efficiency of the DSC. Therefore, dye-sensitized solar cells DSCs emerged as a new class of low-cost energy conversion devices with simple manufacturing procedures. In addition, in diffuse light or cloudy conditions,

DSSC shows higher conversion efficiency than polycrystalline Si. Monocrystalline photovoltaic devices are believed to become a viable contender for future solar converters on a large scale. Nevertheless, the efforts are continually being undertaken to improve the performance of DSSCs and hence the competitiveness of this technology in the world Market. It is now possible to completely depart from the First and the second generation's solar cells devices by replacing the phase contacting the semiconductor by an electrolyte thereby forming dye-sensitized solar cells.

Renewable energy from Malaysia consists of biomass, biogas, modest hydro and solar cells as well. Biogas is usually identified as new petrol generated within the lack of oxygen by your breakdown of the normal subject. Biomass creates subject operating out of carbon dioxide, hydrogen along with oxygen in term of modest hydro could be the improvement regarding hydroelectric strength as it is usually renewable energy in which changes sunlight energy into electrical energy. There are four common solar cells and there are monocrystalline, polycrystalline, thin film and hybrid solar cell.

Monocrystalline cells develop the best efficiency among any kind of cells however as the increased generation expense in comparison with polycrystalline cells possess generally cheaper every watt as the strength develop but the polycrystalline cells slightly much less efficient when compared with monocrystalline cells yet need more space of roof area to get the same result volume. In thin film solar cells or also known as amorphous, silicon cells comprise silicon atoms within a skinny layer rather than a very composition. Thin film solar cell can absorb the light readily compared to the other traditional solar cells. Therefore, the cells can be much slimmer and thinner.

Photovoltaic is currently the fastest developing technology in which accustomed to make electrical energy throughout electricity production. Over 90% of the material

found in solar based on silicon for the reason that source material. This material is among the most valuable pieces of solar panels based on silicon. Thin films with silicon-based solar panels tend to be an inexpensive choice. There are about three most common thin films solar panels these days, for instance, Copper Indium Gallium Selenide (CIGS), Cadmium Telluride (CdTe) along with Amorphous Silicon (a-Si). TCO or transparent conductive oxide applicable to solar cells to increase the efficiency of the converted solar cells and matched with the absorption spectrum of the solar cells. This is because solar cells suffer efficiency loss due to spectral mismatch. Although CIGS has the highest efficiency yet CdTe has slightly different efficiency and also low cost in manufacturing. These low cost can reduce the money used in production and bill payment for user.

A dye-sensitized solar cell is one of the thin film solar 4 of the solar cell. A dye-sensitized solar cell made of low-cost materials and cheaper manufacturer. The flexibility of the dye-sensitized solar cell gives the advantage as it makes life goes easier. This is because due to the flexible dye-sensitized solar cell, it can be carrying out even can be folded and save more space. It can absorb diffused sunlight and fluorescent light. Moreover, the solar cells also work in cloudy weather and low light condition.

The electrolyte solution used in developing the solar cell contains volatile organic solvents and must carefully seal. Generally, dye-sensitized solar technology uses a liquid electrolyte that has temperature stability problems. For example, at the low temperature, the electrolyte may freeze and stopping power production as well as lead to physical damage. While at a higher temperature it will cause the electrolyte to expand and the panel sealing process a major problem.

A dye-sensitized solar cell is still in the early stages of the development cycle. With widespread studies and experiment, the efficiency may gain as high as the traditional

solar cell. The dye-sensitized solar cell has more advantages compared to the other solar cell as the manufacturing need low-cost production. Besides that, it can be made only in the laboratory or even in the garage. Overall, the dye-sensitized solar cell technology actually an attractive technology whereby using the natural 5 dyes it may create different colour or even pattern for the solar cell. Although the efficiency not as high as the other, currently even small increases in the dye-sensitized solar cell conversion efficiency may cause them suitable for some roles.

1.2 Project Objectives

Thus this project includes several objectives and aims:

- i. To study Zinc oxide (ZnO) material for electron transport layer (ETL).
- ii. To fabric dye synthesized solar cell which a Zinc oxide (ZnO) Nano flower as electron transport layer.
- iii. To characterize dye synthesized solar cell and analysis the efficiency.