STUDY OF GRAPHENE-BASED PEROVSKITE SOLAR CELL

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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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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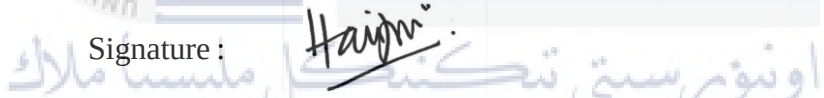

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DEDICATION

I am dedicating my Final Year Project (FYP) of bachelor's degree to my supportive supervisor, Ts. Siti Aisah Binti Mat Junos@Yunus and Ts. Dr. Faiz Bin Arith the most important pillars in carrying out the project and my supportive parents, my family, and all my fellow friends who have supported me in many ways during the completion of this paper and have always accompanied my ups and downs.

ABSTRACT

Perovskite solar cell is a new generation of photovoltaic technologies due to its super power conversion technologies. This project aims to study about the performance of PSC containing graphene base layer. Graphene is indeed very exciting, but producing high quality materials is still a challenge. The main purpose of this study is to simulate, fabricate and analyse the graphene base layer in PSC. The potential of graphene as an hole transporting layer and in electron transport layer the application on perovskite solar cell is analyse using Scaps (a solar cell capacitance simulator) software. Through Scaps software, the parameters of graphene can be observed to know the characteristic of graphene in perovskite solar cell. The efficiency of this solar cell will be optimized by controlling the parameter of this material. The parameter includes the Voc, Jsc, fill factor and power conversion efficiency. All the parameters mention above measured using scanning electron microscope (SEM), UV–visible spectrometer and Keithley 2401 source meter. The simulated data from the software results will be the guidance to fabricate and optimize the performance of solar cell. This study will prove and show the results of the performance and efficiency of graphene base layer in PSC through Scaps software.

ABSTRAK

Sel solar Perovskite ialah generasi baharu teknologi fotovoltaik kerana teknologi penukaran kuasa supernya. Projek ini bertujuan untuk mengkaji tentang prestasi PSC yang mengandungi lapisan asas graphene. Graphene sememangnya sangat mengujakan, tetapi menghasilkan bahan berkualiti tinggi masih menjadi cabaran. Tujuan utama kajian ini adalah untuk mensimulasikan, mengarang dan menganalisis lapisan asas graphene dalam PSC. Potensi graphene sebagai lapisan pengangkut lubang dan dalam lapisan pengangkutan elektron aplikasi pada sel solar perovskite dianalisis menggunakan perisian Scaps (Simulator Kapasitan Sel Suria). Melalui perisian Scaps, parameter graphene boleh diperhatikan untuk mengetahui ciri-ciri graphene dalam sel suria pervoskite. Kecekapan sel suria ini akan dioptimumkan dengan mengawal parameter bahan ini. Parameter termasuk Voc, Jsc, faktor isian dan kecekapan penukaran kuasa. Semua parameter yang disebut di atas diukur menggunakan mikroskop elektron pengimbasan (SEM), spektrometer boleh dilihat UV dan meter sumber Keithley 240. Data simulasi daripada hasil perisian akan menjadi panduan untuk mereka dan mengoptimumkan prestasi sel suria. Kajian

ini akan membuktikan dan menunjukkan hasil prestasi dan kecekapan lapisan asas graphene dalam PSC melalui perisian Scaps.

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LIST OF SYMBOLS AND ABBREVIATIONS

PV	:	Photovoltaic
HTL	:	Hole transport layer
ETL	:	Electron transport layer
PSC	:	Perovskite solar cell
FTO	:	Fluorine doped tin oxide
Voc	:	Open circuit voltage
Jsc	:	Density of short circuit current
TCO	:	Transparent conductive oxide
GO	:	Graphene oxide
MEA	:	Monoethanolamine
EG	:	Ethylene glycol

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CHAPTER 1

INTRODUCTION

This chapter explains about the overview of the project, which includes project background, problem statement, objective, scope of project and literature review.

1.1 Project background

Solar technologies is used to convert sunlight into electrical energy either through photovoltaic (PV) panels that concentrate on solar radiation. The PV cell is composed of semiconductor that can conduct electricity. In semiconductor there is p-n junction and it is mainly use composed to attain high solar cell efficiency. P-junction is called as a hole transport layer (HTL) where it has a high concentration of holes while N- junction or call as an electron transport layer (ETL) has a high concentration of electrons. Solar panel technology has been improving in terms of efficiency and cost, resulting in a surge in demand. There are many type of material used to build up

the solar panel. PV cell are used in solar panels and are produced mostly from silicon crystalline wafers.

Perovskite solar cells have become a rising star in the photovoltaic field. PSC is one of the type solar cell that have shown potential for high performance and remarkable progress in solar cells. The PSC uses $ABX3$ crystal structure known as perovskite structure as an active light-harvesting layer. PSC devices are evaluated based on the roughness of the interface, device cost, PCE values and stability [1]. PSC basic structure consist of an ETL and a hole HTL, where the free electrons and holes transfer. Fluorine-doped tin oxide (FTO) glass and metal are commonly used as the anode and cathode in perovskite solar cells. There are two types of structure in PSC which classified as regular n-i-p and inverted p-i-n structures where it depend on which transport material on the exterior portion of the perovskite encounters light rays first. The electron ETL is deposited first in n-i-p perovskite solar cells, whereas the HTL is deposited first in p-i-n structures. The research regarding PSC is still getting interest because of it high power conversion efficiency and inexpensive compared to existing photovoltaic cell technologies. Perovskite solar cells lose less photon energy during the conversion of light to electricity than conventional solar cells which good in open-circuit voltage to bandgap.

1.2 Problem statement

The third generation of solar cell has been experimented over 2 decades to replace the silicon-based solar cells in the future. However, the efficiency of the solar cell still need an improvement due to several factors. The low mobility and conductivity issues due to the hygroscopic and corrosive behavior of the methoxyphenylamine and Spiro- OMeTAD. The Spiro-OMeTAD layer underwent a severe morphological deformation at high temperature, showing large voids in it,

which reduced the cell performance further [2]. Lithiated salts as additives in Spiro-OMeTAD are the most efficient p- dopants and improve conductivity and hole mobility by rapidly reacting with oxygen and oxidizing Spiro-OMeTAD. PSCs performance may degrade when the films are exposed to high temperatures during the fabrication process [3]. Graphene will serves as a moisture-resistant layer that enhances device lifetime and overcome the efficiency issues in PSCs. This unique structure is used as an alternative as it have high carrier mobility at room temperature, high transparency and high thermal conductivity. Graphene is an exciting material that is getting a lot of attention especially since the 2010 Nobel Prize in physics went to Andre Geim and Konstantin Novoselov, who first isolated Graphene in 2004. Further improvements are necessary for practical device operation such as implementing new high refractive index nanostructured materials to fabricate ultrathin, exible, stable and lightweight solar cells [4]. Thus in this project, the SCAPS-1D software is used to know the performance and suitable parameter of graphene will be used in the PSC.

1.3 Project objective

This project has three objectives which are:

- To simulate the Perovskite Solar Cell utilizing graphene-base using SCAPS-1D software simulator.
- To fabricate the graphene layer as the base layer for Perovskite Solar Cell (PSC) application.
- To analyze the parameters such as power conversion efficiency (PCE), fill factor (FF), short-circuit current (Isc), open-circuit voltage (Voc) in graphenebase layer.

1.4 Project scope

The project aims to simulate and analyze graphene base layer on the emerging solar cell which is PSC. The analysis is conducted by simulation method using SCAPS-1D software. The structure of the solar cell is designed by using different type of graphene material. The efficiency of the solar cells will be optimized by controlling the parameter of this material. The four main parameter includes the Voc, Jsc, fill factor and power conversion efficiency. To achieve maximum efficiency, those parameters that includes in this project of the solar cell were researched thoroughly. Graphene layer that has been simulated will then be fabricate by using spin coat method. Spin coating method will be depositing different concentrations of graphene dispersion for graphene layer formation. This method is to apply a uniform film onto a solid surface by using centrifugal force and requires a liquid-vapor interface [5]. The advantage of this method is its modest deposition procedure and low cost preparation while obtaining a high quality of thin films.