FABRICATION AND CHARACTERIZATION OD DYE-SENSITIZED SOLAR CELL BY USING DRAGON FRUIT AND HENNA

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ABSTRACT

Solar cell is one of the renewable energy sources that available to replace the non-renewable energy such as fossil fuel energy. In general, solar cell also called as photovoltaic cell converts the sunlight into electrical energy. Solar cells can be divided into three generation where Dye-sensitized solar cell (DSSC) is the third generation of solar cell which the advantage of the wide band gap semiconductor that sensitized to the light. Nowadays, researchers in all over the world are looking for a low cost technique or process to bring down the solar cell cost as the demanding for solar cell is increase from day to day. DSSC have the potential to generate green energy as it required low cost fabrication and inexpensive equipment. This project present the fabrication of DSSC using natural dyes that extracted from dragon fruit and henna. X-ray Diffraction (XRD) was carried out to study the microstructure of the material. Tests were conducted under the sunlight and the performance DSSC in terms of fill factor, efficiency, current density is investigated by using digital multimeter. We have successfully showed that the DSSC using dragon fruit and henna are potential candidate as a dye sensitizer and factors limiting of the DSSC are discussed.

ABSTRAK

Sel suria merupakan salah satu sumber tenaga yangboleh diperbaharui yang sedia ada untuk menggantikan sumber tenaga yang tidak boleh diperbaharui seperti tenaga fosil. Secaram amnya, solar sel juga dikenali sebagai sel fotovoltik me nukarkan pancaran matahari kepada tenaga elektrik. Sel suria boleh dibahagikan kepada tiga generasi, dimana sel suria terpeka pewarna merupakan generasi solar sel yang ke tiga yang mempunyai kelebihan semikonduktor dengan jurang jalur lebar yang sensitive terhadap cahaya. Pada masa kini pengkaji di seluruh dunia sedang mencari teknik atau proses yang murah untuk menurunkan harga sel solar disebabkan permintaan terhadap sel solar yang meningkat dari hari ke hari. Sel suria terpeka pewarna mempunyai potensi untuk menghasilkan tenaga hijau kerana ia memerlukan kos fabrikasi yang murah dan bahan peraltan yang tidak mahal. Projek ini membincangkan fabrikasi sel suria terpeka pewarna menggunakan pewarna neutral yang diekstrak daripada buah naga dan daun inai. Pembelauan sinar-x (XRD) dilakukan untuk mengkaji mikrostruktur bahan. Ujian dijalankan di bawah sinaran matahari dan tahap sel suri terpeka pewarna dikaji dari segi, factor mengisi, kecekapan, dan ketumpatan arus, dengan menggunakan multimeter digital. Kami Berjaya menunjukkan yang sel suria terpeka pewarna menggunakan buah naga dan inai merupakan bahan yang berpotensi untk menjadi pemeka warna dan fakator factor yang membatasi sel suria terpeka pewarna juga dibincangkan.

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LIST OF ABBREVIATION

AM	-	Air Mass
CdTe	-	Cadmium Telluride
CIGS	-	Copper Indium Gallium (di) Selenide
DSSC	-	Dye-sensitized Solar Cell
ITO	-	Indium Tin Oxide
SEA	-	Solar Elevation Angle
XRD	-	X-Ray Diffraction

CHAPTER 1

INTRODUCTION

This chapter will discuss about the introduction, problem statement, objectives, scope of the project.

1.1 Introduction

Fossil fuels energy such as coal, petroleum, and natural gases are one of the non- renewable energy. As the human population in all over the world is increase from day to day, so demanding for fossil fuels is also increase. However fossil fuel is a non-renewable energy that will run out and deplete from day. Besides that, consuming fossil fuels give bad impacts especially to the environment as it gives out carbon dioxide when burn and this will cause a greenhouse effect. Researchers have developed a new solution to overcome this problem which is solar cell. Solar cell also called as photovoltaic cell converts the sunlight into electricity. Solar power is safer and more environmental friendly as it uses a clean source and the most important is it will never be run out. The application of solar cell can be seen on calculators, some mobile phones and watches. An enough power for a household can be provided by connecting several solar cells array.

The performance of a solar cell is measured by its efficiency at turning sunlight into electricity. This is depends on the material that make up the cell. A typical commercial solar cell has an efficiency of 15% after converting sunlight to generate electricity [1]. In order to get high efficiencies, larger arrays are needed and a higher cost will be. The first solar cells were built in the 1950s with efficiencies of less than 4%. Photovoltaic market production is currently dominated by silicon based solar cell but because the cost of equipment for fabrication process is high, the electricity generation cost of silicon based solar cell is difficult to compete with fossil energy [2].

Figure 1.1 : PV array on the roof of private home

1.2 Problem Statement

Production of crystalline silicon is too expensive due to cost of raw material. Even this type of solar cell is dominating the commercial market but a very pure silicon is needed in order to get a high efficiency.

Cadmium in Cadmium telluride (CdTe) solar cell is listed as one the toxic material. Cadmium telluride is toxic if ingested, if its dust is inhaled, or if it is handled improperly without appropriate gloves and other safety precautions. The disposal and long term safety of cadmium telluride is a known issue in the large-scale commercialization of CdTe solar panels.

1.3 Project Objectives

There are few objectives that need to be achieved for this project. The objectives of this project are listed as below:

1. To develop DSSC solar cell using low cost processing technique.
2. To develop DSSC solar cell using natural dye as sensitizer.
3. To analyze electrical characterization of DSSC solar cell.

1.4 Project Scope

In this project, dyes were extracted from dragon fruit and henna. These dye were used as photosensitizer in DSSC. Fabrication processes of DSSC were carried out by using screen printing technique. At the end of this project, all the parameter of DSSC; short circuit current (Isc), voltage open circuit (Voc), fill factor (ff), and efficiency (η) were measured.

1.5 Thesis Outline

This thesis contains five chapters to describe the project of Fabrication and Characterization of Dye-sensitized Solar Cell by Using Dragon Fruit and Henna where the first chapter is Introduction followed by Literature Review, Methodology, Result and Discussion and Conclusion.

Chapter I – Introduction of the project discussed the background of the study, problem statement, scopes and the objectives of developing this project.

Chapter II – Literature Review consist the background study and research before developing this project. The content of the background studies such as the information about the dye-sensitized solar cell.

Chapter III – Methodology described about the methods or approaches used in solving the projects. In this chapter, all the steps taken in fabrication process were discussed.

Chapter IV – Concentrates on the result and discussion of this project. This chapter consist the electrical characteristic of dye-sensitized solar cell and the efficiencies achieved.

Chapter V – Conclusion consist of the summary of the project. After the project is done, recommendations are made for the betterment of the project or upgrades that might be done in the future.

CHAPTER 2

LITERATURE REVIEW

This chapter contains the literature review on theoretical concepts applied in this project. It contains the information gathering of the project in order to complete the whole project

2.1 Introductio

Researchers in all over the world are concentrating to bring down the PV cost and making solar cells to be more efficient. The cost can be cut down by developing thin film technologies where less costly materials such as CIGS/CIS are used. The total cost of the system will also come down by using a cheaper deposition method such as printing technology into the manufacturing. A thin film is a layer of material with a nanometer (monolayer) to several micrometers in thickness.

2.1.1 Different generations of solar cells

Solar cells are divided into three generations. The first generation contains solar cells that are expensive to produce and have a low efficiency. The second generation contains solar cells that are cheaper to produce but have a lower efficiency as the cost per watt is lower than in first generation cells. The third generation contains solar cells that said to be very efficient. The technology of this generation is not yet commercial, but there is a lot of research going on in this area. The goal is to make third generation solar cells cheaper to produce but with higher efficiency.

2.1.1.1 First Generation Solar Cells

The first generation includes cells consisting of Crystalline silicon (c-Si) or Germanium that are doped with Phosphorus and Boron in a pn-junction. This generation is dominating the commercial market. A very pure silicon is needed for Silicon cells in order to get a high efficiency. The price is high compared to the power output. This is due to the energy-requiring process.

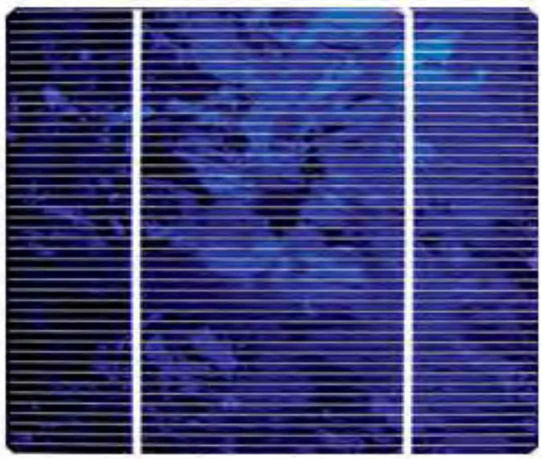

Figure 2.1: Multicrystalline silicon solar cell.

2.1.1.2 Second Generation Solar Cells

The second generation includes cells consisting of Amorphous Silicon Cells (a-Si), Polycrystalline silicon cells (poly-si), Cadmium Telluride Cells (CdTe), and Copper Indium diSelenide (CIS) Cells (CIGS/CIS). In Amorphous Silicon Cells, hydrogen is applied to the silicon to make it possible to dope the silicon with boron and phosphorus. The cells are built up with the sequence metal base contact, n-layer, intrinsic layer, p-layer, transparent contact, glass substrate. When they are exposed to sunlight, the efficiency of the cell is drop. This effect is created in the intrinsic layer. By using several thinner layers, the effect can be reduced by. Polycrystalline silicon is a low cost substrate. Cadmium Telluride Cells are made from a heterojunction with cadmium sulfide, just like the copper indium diselenide. Cadmium telluride cells also have an ideal bandgap(1.44eV). Copper Indium Diselenide consist of $CuInSe_2$. This material is one of the best light absorber known, and about 99% of the light is absorbed before reaching 1 μm into the material. There have been made homojunctions of CIS, but a heterojunction with cadmium sulfide(CdS) has been found to be more stable and efficient. Cadmium Telluride Cells also have an ideal bandgap(1.44eV).

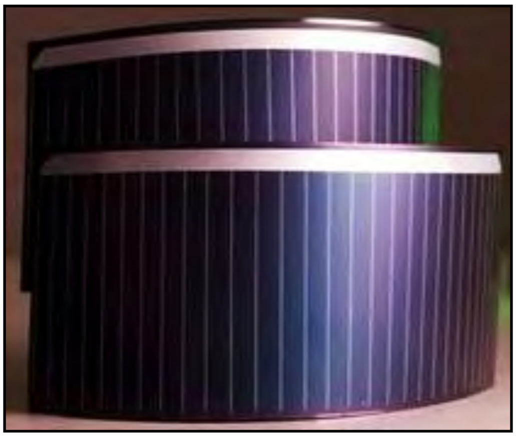

Figure 2.2: Flexible Copper Indium Gallium

2.1.1.3 Third Generation Solar Cells

The third generation includes cells consisting of Nanocrystal solar cells, Polymer solar cells, and Dye sensitized solar cell (DSSC). DSSC, a new type of solar cells, have attracted considerable attention due to their environmental friendly and low cost of production. However the third generation solar cells is still at the research stage as their efficiency is quite low compare with the first and second generation. Figure 7 shows the world solar cell efficiency record (National Center for Photovoltaics, 2013)

Figure 2.3: A monolithic series-interconnected transparent dye-sensitized solar-cell (DSC) module.

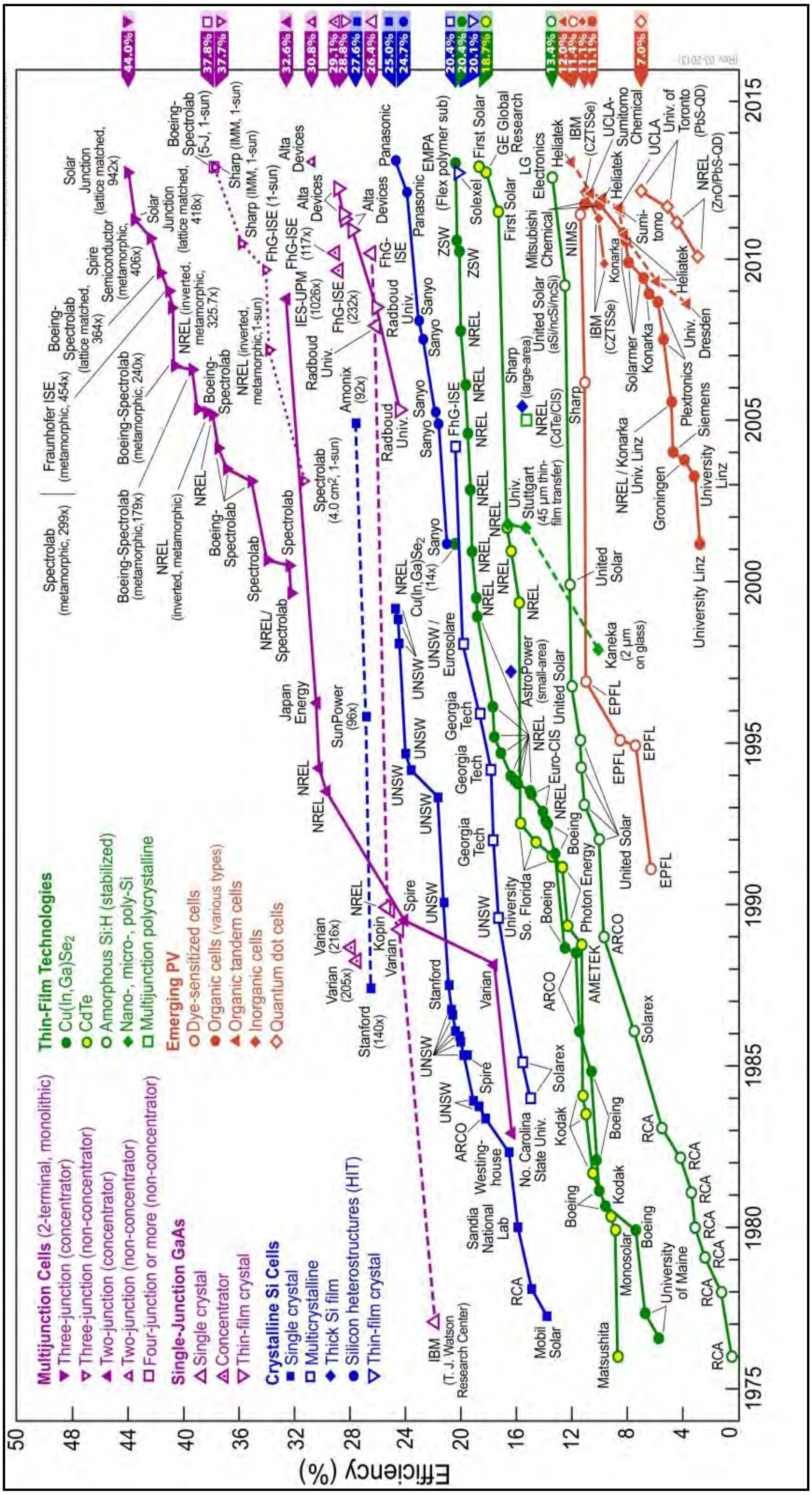

Figure 2.4: World solar cell efficiency record.

2.2 Dye-sensitized solar cell (DSSC)

Dye-sensitized solar cell (DSSC) is a new type of solar cell that attracted the attention from the researchers in all the world due to their low cost of production and environmental friendliness. DSSC was first developed by O'regan and Gratzel [3]. Like other solar cells, the DSSCs are used for converting light energy into useable electricity. The first efficiency of DSSC reported is 7.1% [4]. then efficiency of the DSSC has been improved to 11.5% [5].

Table 2.1 The different between DSSC and other type of solar cells

	si	**Cdte**	**DSSC**
Best research-cell efficiency	27.6%	19.0%	11.5%
Advantages	• High efficiency • Long life span	• Low cost manufacturing	• Ease of fabrication • Low cost of material production
Disadvantages	• High cost fabrication • Expensive raw material	• Medium efficiency • Rigid glass substrates • Cadmium is highly toxic	• Low efficiency