SYNTHESIS AND CHARACTERIZATION OF POLYANILINE AS PLUGGING PINHOLES IN CdS/CdTe.

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MASTER OF SCIENCE (PHYSIC)

UNIVERSITI PERTAHANAN NASIONAL MALAYSIA

2020

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Thesis submitted to the Centre for Graduate Studies, Universiti Pertahanan Nasional Malaysia, in fulfilment of the requirements for the Degree of Master in Science (Physic).

2020

ABSTRACT

The formation of pinholes on CdS/CdTe thin film solar cell happen due to many reasons. As a result, the pinholes lead to short circuit and eventually will degrade the performance of solar cell. This study was aimed to achieved three objectives which are to synthesis and deposit PANI thin film by varying the pH and aniline concentration, to characterize the optical, structural and morphology properties of PANI layer as plugging pinholes and to investigate the performance of PANI layer as plugging pinhole on CdS/CdTe solar cell. All the samples had been labeled as A (PANI with 0.10 M concentration of aniline and pH of acid 2.50), B (PANI with 0.25 M concentration of aniline and pH of acid 2.50), C (PANI with 0.50 M concentration of aniline and pH of acid 3.40) and D (PANI with 0.50 M concentration of aniline and pH of acid 2.50). PANI thin films had been successfully synthesized and deposited by using electrodeposition technique. From optical characterization, the band gap of PANI layer had been determined to be 3.90 eV for sample A, 4.70 eV for sample B, 3.80 eV for sample C and 3.86 eV for sample D which were higher than the whole thin film device. XRD result revealed that all the deposited PANI layers pattern are amorphous. Result obtained from FTIR confirmed the footprint of PANI and Raman spectrometer confirmed the half oxidized emeraldine base of PANI. SEM results show that the most homogenous layer is A, with 0.10 M concentration of aniline, pH 2.50. This layer show cementing effect in covering all the substrate with a very thin layer of PANI and suggested that this layer is the most suitable to be chosen as plugging pinholes on solar cell device. Finally, the test on efficiency of

solar cell device with layer of PANI show the best increment of efficiency goes to layer of 0.10 M of PANI with the efficiency of 3.1% as compared to uncoated solar cell which is only 1.7%.

Keywords: Polyaniline, aniline monomer, acidic pH, conducting polymer, emeraldine base, oxidation state

ABSTRAK

Pembentukan pin lohong pada filem nipis CdS/CdTe boleh berlaku atas pelbagai faktor. Kesannya, pin lohong ini akan membawa kepada keadaan litar pintas dan seterusnya mengurangkan kecekapan solar sel. Kajian ini dijalankan bertujuan untuk mencapai tiga objektif utama iaitu mensinstesis dan mendeposit filem nipis polyanilin (PANI) dengan cara memvariasikan pH dan juga kepekatan anilin. Keduanya adalah untuk mencirikan ciri optikal, struktural dan juga morfologi lapisan PANI sebagai peyumbat lohong pin dan ketiga adalah untuk menyiasat kecekapan lapisan PANI sebagai penyumbat lohong pin pada CdS/CdTe solar sel. Semua sampel telah dilabelkan sebagai A (PANI dengan kepekatan anilin 0.10 M dan pH 2.50), B (PANI dengan kepekatan anilin 0.25 M dan pH 2.50), C (PANI dengan kepekatan anilin 0.50 M dan pH 3.40) dan D (PANI dengan kepekatan anilin 0.50 M dan pH 2.50). Filem nipis PANI telah berjaya disintesis dan juga didepositkan menggunakan teknik elektrodeposisi. Melalui pencirian optikal, jurang tenaga lapisan PANI telah ditentukan kepada 3.90 eV untuk sampel A, 4.70 eV untuk sampel B, 3.80 eV untuk sampel C dan 3.86 eV untuk sampel D. Jurang tenaga kesemua sampel ini didapati melebihi jurang tenaga peranti solar cel filem nipis CdS/CdTe. Hasil pencirian XRD telah mendedahkan yang semua corak lapisan PANI adalah amorfos. FTIR pula telah mengesahkan profil PANI dan Raman spectrometer telah mengesahkan bahawa lapisan PANI yang disintesis adalah terdiri daripada “emeraldine base”. Hasil daripada SEM menunjukkan bahawa lapisan yang paling homogen adalah lapisan A dengan kepekatan anilin 0.10 M dan pH 2.50. Lapisan ini telah menunjukkan “cementing effect” dan berjaya meliputi keseluruhan substrat dengan baik. Akhirnya, ujian kecekapan peranti

sel suria dengan lapisan PANI dijalankan. Peranti yang tidak diselaputi dengan lapisan PANI menunjukkan kecekapan peranti sebanyak 1.7% manakala, sampel A menunjukkan peningkatan dengan kecekapan 3.1%

Kata kunci: Polianilin, anilin monomer, pH berasid, polimer konduksi, asas emeraldin, keadaan pengoksidaan.

ACKNOWLEDGEMENT

All praise to ALLAH The Almighty because without His command, I cannot even have completed my master. I would like to express my deepest appreciation to my main supervisor, Dr Nor Azlian bt Abdul Manaf as she plays a very vital role in ensuring my thesis submission. Her patience, motivation, enthusiasm and guidance really help me in all time of the research as well as during writing time. I could not imagine how my research route without help and advice from her. Besides that, I would like to give a special thanks to my co-supervisor, Dr Siti Zulaikha binti Ngah Demon as she really helps me in order to develop my research analysis skills and how to present data.

Beside that, I would like to thank my dear husband, Mr Ahmad Zaim for continuous mental and financial support and my very best friend Mrs Fasihah Nur that always there to help me. I also would like to thank my dear sister Nur Amirah that always help me cope with during my up and down doing master. My deepest thanks also goes to Nasuha, as without her help I would not be able to survive in UPNM, all my friends in UPNM that always lending their ears and support me through my hard time, discussion about the data and always teach me with passion and sincerely. I could not imagine how ALLAH can send me so much nice people that always there whenever I need them. Only ALLAH can repay what they did to me and may they always get blessing from Him.

Lastly, I would like to thank my family and family in law, my father and mother that always pray for my success and raise me up to be who I am now.

APPROVAL

The Examination Committee has met on 9th June 2020 to conduct the final examination of Nur Atikah binti Shaari on her degree thesis entitled 'Synthesis and Characterization of Polyaniline as Plugging Pinholes in CdS/CdTe'.

The committee recommends that the student be awarded the Master of Science (Physics).

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Student's full name : Nur Atikah binti Shaari

Date of birth : 1st March 1990

Title : Synthesis and Characterization of Polyaniline as Plugging Pinholes in CdS/CdTe.

Academic session : 2017/2018

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LIST OF ABBREVIATIONS

Si	Silicon
Ge	Germanium
P	Phosphorus
B	Boron
CdTe	Cadmium telluride
CIGS	Copper indium gallium diselenide
a-Si	Amorphous silicon
DCCS	Dye sensitized solar cells
CdS	Cadmium sulphide
TCO	Transparent conducting oxide
FTO	Fluorine tin oxide
ITO	Indium tin oxide
PANI	Polyaniline
HOMO	Highest occupied molecular orbital
LUMO	Lowest unoccupied molecular orbital
CP	Conducting polymer
LB	Leucoemeraldine base
EB	Emeraldine base
P	Pernigraniline
RF	Radio frequency
CBD	Chemical bath deposition
CVD	Chemical vapour deposition
UV-VIS	Ultraviolet-visible
FTIR	Fourier transform infrared
XRD	X-ray diffraction
SEM	Scanning electron microscope
DI water	Deionized water
A/D	Analog to digital
CCD	Charged-couple device

MIS	Metal/insulator/semiconductor

CHAPTER 1

INTRODUCTION

Chapter 1 comprises of research background study, problem statement, objectives, significant of the study and the thesis outline. In background study, brief history about solar cell and related issues as well as the brief introduction of polymer Polyaniline (PANI) also being discussed.

1.1 Background Study

1.1.1 Brief history of solar cell

Solar cell is an electronic device that convert the sunlight (solar radiation) into direct current electricity through photovoltaic effect. The phenomenon of photovoltaic effect was first discovered in 1839 by A. E. Becquerel when he did experiment that involved the solid electrodes in an electrolyte solution. While doing the experiment, he realized that the voltage of the cell increased when the electrodes were exposed to the sunlight. Following the finding, W. G Adam and R.E. Day observed the photovoltaic effect on the solidified selenium in 1877 and in 1883, first solar cell was developed by

using selenium on a thin layer of gold by Charles Fritts (L.M Frass,2014). In 1954, Bell Lab was the first to announce that they had successfully developed a modern silicon solar cell that has an efficiency about 6% and in 1955, the solar cell was commercialized and sold at $25/cell or $1,785/Watt. U.S Signal Corps Laboratories had created solar cell that are more resistant to the radiation damage that are better suited for space in 1958 (Chapin et al, 2008).

1.1.2 Solar cell generations

The development of solar cell can be divided onto four generations. The first generation of solar cell mainly made from the silicon (Si) or germanium (Ge) and being doped with phosphorus (P) and Boron (B), which until recently is the most efficient and long-lasting solar cell. However, there are some disadvantages of first-generation solar cells. The disadvantages are the price of silicon-based solar cell is quite expensive compare to the power output and it cannot withstand high temperature on sunny day as it will make the solar cell to lose some of their efficiency. In the first generation of solar cell, there are four types of Si-based solar cells that are used for residential place. They are the monocrystalline silicon cells, polycrystalline silicon cells and amorphous silicon cells.

The second generations of solar cells are called the thin-film solar cells since when they are being compared with the crystalline silicon based, the materials made from layers of semiconductors only a few micrometres thick. This category of solar cell will be further discussed in section 1.1.3. Basically, three types of second-generation solar cell that are considered to be in this category are the cadmium telluride (CdTe), copper indium gallium diselenide (CIGS) and the amorphous silicon (a-Si). The efficiency of second generation

of solar cells might be less than the first generation, however the manufacturer costs also much lower compared to the first-generation solar cell. This allow the manufacturer of solar panel within this type of technology to produce and sell solar panel at a much lower cost. In this research work, the focus is given on the second generation of solar cell whereby we develop polymeric layer in order to compare the efficiency of the solar cells.

The third generation of solar cell is also the latest and ongoing research of solar cell. The objectives of this third generation of solar cell are to improve the solar cells that have been already commercialize, less expensive and to develop with more different uses. This generation of solar cell are being made from variety of materials such as nanotubes, silicon wires, organic dyes and quantum dots. Some examples of the third generation of solar cells include the dye sensitized solar cells (DSSC), nanocrystal based solar cells, organic solar cell, polymer solar cells and perovskite solar cells. However, this type of solar cell needs the most current and high level of technologies in order to produce them. Even though the third generation of solar cell can be another achievement in the solar cells field, currently it still has low efficiency and short lifetime issue.

1.1.3 Thin film solar cell and related current issue

As being described in Section 1.1.2, thin film solar cell also known as the second generation of solar cell. Among the three types of thin film solar cell, CdTe is known to be the leading material for the cost-effective solar cells. It has many advantages such as easy manufacturing, can be produced at lower cost, energy band gap of ~1.5 eV which is close to the ideal value for photovoltaic conversion efficiency, have high optical absorption and also high chemical stability. There are the factors that make CdTe a

preferable material to fabricate solar cells. In theoretical, the efficiency of CdTe thin film solar cells is expected to be between 25% to more than 27 % as mentioned by (Tetsuya et al, 1997) and (Bosio et al, 2006). However, study performed in University of South Florida recorded that the conversion efficiency can be obtained at 15.8% while research made by Tetsuya can obtain photovoltaic conversion of efficiency of 16.0 %. (Bosio et al,2006) find that the highest energy conversion that can be obtained by the photovoltaic cell is 16.5% on the laboratory scale.

One of the best structures for CdTe cells are heterojunction structure with the n-type cadmium sulphide (CdS) as a window layer with the efficiency of approximately 23%. The electrical behaviour have been found by (Wu Xi,2004) when the formed heterojunction can lead to a high fill factor of 0.77 in produced solar cells. Normally, CdS/CdTe are fabricated in a superstrate configuration as shown in Figure 1.1. Since CdS/CdTe solar cells have a superstrate structure, and the light incident passes through CdS, they need a transparent substrate such as glass. The glass is deposited with transparent conducting oxide (TCO) that will be act as a front contact. TCO that usually used as a deposit on the glass are fluorine tin oxide (FTO) or indium tin oxide (ITO) and both can be obtained easily.

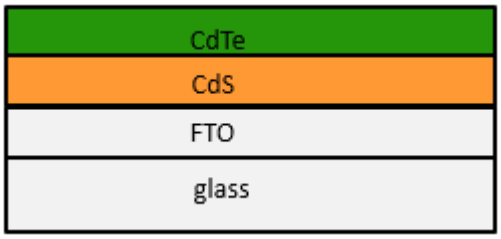

Figure 1.1: Superstrate structure of CdS/CdTe thin film solar cell.

1.1.4 Method to passivate the pinholes on solar cell device

While fabricating CdS/CdTe thin film solar cells, pinholes may arise for so many reasons such as surface contamination, temperature annealing during fabrication or random incomplete associate of CdTe grains during deposition. Pinholes can lead to the shunting of the photovoltaic after the deposition of the metal back contact and seriously degrade the overall performance of solar cell circuit (Tessema, 2012). Started from 1982, Basol already suggest to fill in the pinhole with a photochemically cured insulating polymer, but the method does not further explain (Basol, 1982). However, the study focuses on how to destroy the shunt path or the electrical short that was resulted when the final electrode of the solar cell device was deposited.

Several methods had been used in order to solve this problem. (Kawakami et al,1994) had try to converted the electrically conducting material of the shunt to an insulator and (Deng and Vijh, 2007) had suggest to perform shunt passivation by simultaneous photochemical activation. In 2011, Basol suggested to find the area of the shunt and remove the electrode material so that it will remove the defect part of the photovoltaic device (Basol, 2011). Another method to passivate the shunt is by performing the electrochemical treatment by selectively depositing insulating polymer on the layer of