Optical Sensor Based on Dye Sensitized Solar Cell (DSSC)

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ABSTRACT

An optical sensor is designed to convert a number of light energy in to electrical energy. The sensor hasbeen successfully measured using light illuminance to achieve electric parameters as the sensor output. In this research the optical sensor design was characterized according to the voltage and current output with the stimulus from mercury lamp. The sensor is customized from Dye-Sensitized Solar Cell with photo-electrode and photo-catalysator of Titanium Dioxide and extracted tobacco chlorophyll dye. Spin coating method was conducted to fabricate the thick layer deposition using selected material. Based on the absorbance measurement, it shows that tobacco dye has the characteristics of visible light absorption in the wavelength of 300-000 nm. The result of this research revealed that from 2 variation of optical sensor design square with active area of (2 cm x 2 cm) and (1 cm x 1 cm). Analitycal result shows that the sensor has wide linear characteristic in certain light illuminance both of output current and voltage.

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1. INTRODUCTION

Application of optical sensor have been widely used in the field of energy savings [1], image sensor [2], communication and other applications [3]. A few number of research in the sensor technology, specially in optical sensor that is shows from a little domestic/local sensor production sold commercially. Today, a renewable energy is being encouraged specially the use of solar cell. Solar cell is a device that converts the energy of light directly into electricity by photovoltaic. In order to measure the intensity of the light, the optical sensor is needed. The measurement of intensity is playing an important role regarding to the process of conversion between the light energy to electricity. Development of the optical sensor based on photo-electrochemical was obtained with the introduction of fractal thin film dye-sensitized solar cells previously [4]. Many studies are realized on the dye used for sensitizing DSSC since it is the principal source of the photo-generated current by the cell. However, the price of this dye stays even higher. Nevertheless, the natural dye becomes more real concurrent to an artificial one, as the efficiency of cell sensitized with this dye remains low [5]. The principle and the research optical sensor from the development of DSSC using TiO2 as the active layer with variation dye has been characterized in the previous research [6-7]. The TiO2 not only has attractive oxide semiconductor for DSSC, but also suitable for sensor applications [8].

Indonesia is rich of tobacco that supplies the cigarette factory. However, based on World Health Organization (WHO) data, from year to year the number of death in Indonesia is increase, the most cause of death is smoking. Regarding to that problem become the dilemma of the government because there are options that to be chosen i.e safe tobacco farmers or the health of smokers. To attend that problem, the change of point of view is needed. The use of tobacco for electronic component material is important and become the one of the solution to divert tobacco function as cigarette. If tobacco is applied to electronic material, it also uses a renewable energy and organic material. In this research investigates the optical sensor based on tobacco dye. At the moment, so many researches work in sensor but the size of the sensors are big and use non-renewable materials. The size of sensor is influence to the use of sensor and energy saving. To enhances and builds the competency in sensor research, this research works on design an optical sensor uses tobacco dye for alternative solution, economic and it easy to fabricate. The aims of this research are to analize the performance of optical sensor in form variation and the effectivity of dye absorption as electron transport medium. The performance of optical sensor could be characterized using voltage and current output testing [9].

This research has presented optical sensor based on DSSC using Tobbacco chloropyll that used organic material and designed in 2 models in order to obtain the performance of optical sensor based on voltage and current output. In this research the optical sensor design was characterized according to the voltage and current output with the stimulus from mercury lamp. The sensor is customized from DSSC with photo-electrode and photo-catalysator of Titanium Dioxide and extracted tobacco chlorophyll dye. Spin coating method was conducted to fabricate the thick layer deposition using selected material.

2. RESEARCH METHOD

The research design of Optical sensor based on DSSC is shows in Figure 1. In this research, the designs of Transparent Conductive Oxide (TCO) have the same form is square but vary in size. The same treatment is given to all designs in testing step. The design of TCO is shown in Table 1.

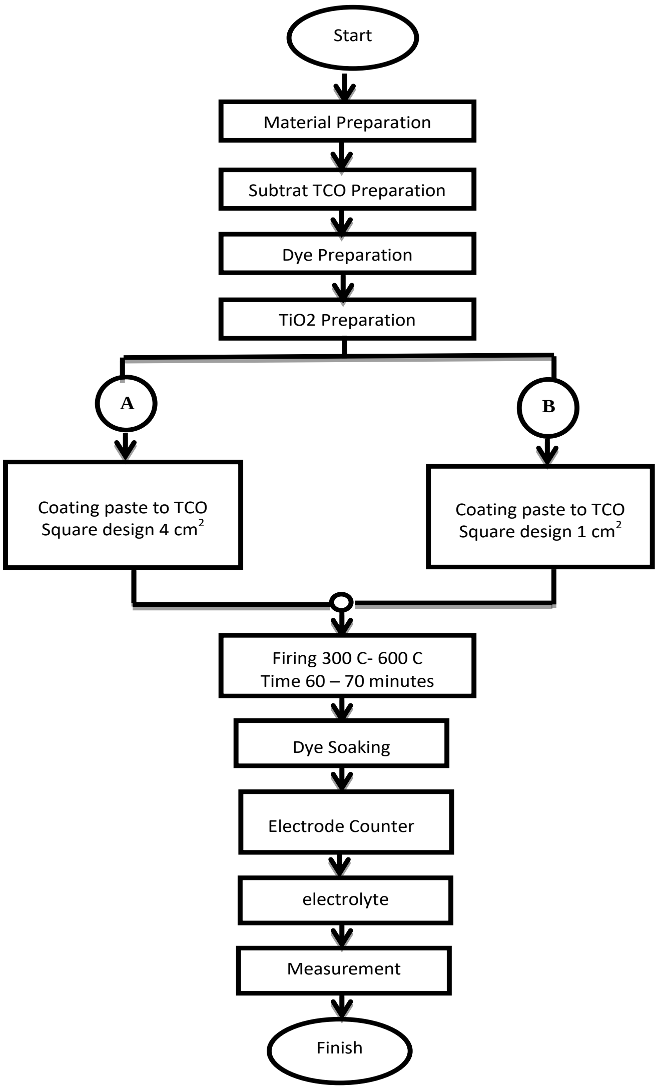
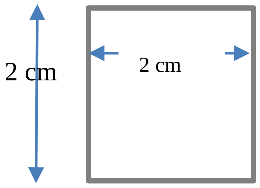
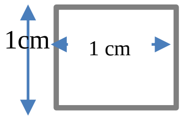


Figure 1. Flow chart of Sensor Design

Table 1. Design of TCO active area

No	Design of TCO	Area
1		Area$_1$= s x s Where : s = side In here the form of sensor design is square with the side 2 cm, so Area $_1$= sxs= 2cmx2cm = 4 cm^2
2.		Area$_2$= s x s Where : s = side In here the form of sensor design is square with the side 1cm, so Area$_2$= sxs= 1cmx1cm = 1cm^2

a) Design and Creating the Paste

In this step aims to create a paste from TiO_2. The materials that are used in this design included TiO_2 powder, Polyvinyl Alcohol (PVA) and aquades. The process of making a TiO_2 paste involved TiO_2 powder, 1.5 grams PVAand 13.5 ml aquades. All the materials are stired use magnetic stirrer in 80˚C during 30 minutes that aims to obtain the solution thick and homogen. This solution is called binder solution. Continually, in order to obtain a paste of TiO_2 the binder solution is mixed with 0.5 gram TiO2 powder. TiO_2 paste uses for deposition into TCO glass.

b) Coating paste into TCO

The spin coating method is chosen in this process where TiO_2 paste is coated into TCO. Spin coating is a method coating desposition in order to distribute the liquid using high speed rotation (1000 rpm) [2].

c) Firing TiO_2 Paste

Firing process using electrical furnace, th e temperature is sets to 200^{o}C for 30 minutes. It aims to obtain the perfect attachment between TiO_2 and TCO glass.

d) Soaking TiO_2 into Tobacco dye

TiO_2 layer is soaking into tobacco dye for 30 minutes. In here, the chlorophyll absorption is happened on the surface of TIO2.

e) Carbonization for Electrode Counter

In this research, the carbonization process is done by heating the conductive side of glass TCO on a candle flame during 1 minute until the conductive side of TCO glass is covered by carbon.

f) Giving an Electrolit Solution

The electrolit is given to the TiO_2 by dripping the electrolit solution using pipette around 5 drops or 0.25 ml. The electrolit is used for medium of electron transport from carbon to the dye.

g) Design of Sensor

In this stage, the TCO photoelectrode glass is attached to the TCO counter electrode in layer form and clamped using clip that aims to be more denses and not shifting [3]. Figure 3 shows the design of sensor.

3. RESULTS AND ANALYSIS

In this section, it is explained the results of research and at the same time is given the comprehensive discussion. There are some testing result including absorption testing, voltage testing, current testing.

3.1. Absorption Testing

In this stage aims to analize the performance of tobacco dye can absorp visible light at 300 nm-800 nm wavelength. The result of testing is shown in Figure 2.

The level of tobacco dye absorption shows that tobacco dye has the characteristics of visible light absorption in the rate of a maximum of 4 (a.u) at a wavelength of 300-510 nm, and a minimum of 1.5 (a.u) at a wavelength of 750-800 nm.

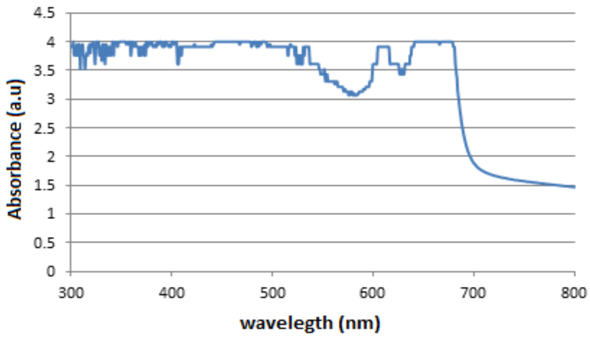


Figure 2. Absorbance Spectrum Measurement

3.2. The Voltage Testing

3.2.1 The Influence of Radiation Temperature to Output Voltage in Design Variation.

Based on the data of median value using five times voltage testing is shown in Figure 3.

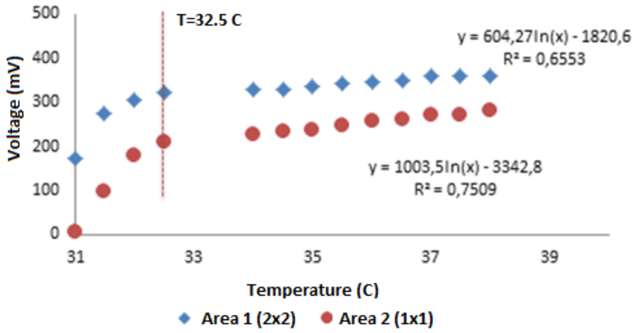


Figure 3. The relationship between area and Temperature

The Graph of temperature radiation to the output voltage in variation design From that graph can be noted that the temperature of radiation is increase because the lenght of time radiation. The temperature has been increased at 32.5 oC, this resulted the output voltage also increased. However, the temperature above 32.5 oC did not give significant increasly to the output voltage. It because the temperature increasly rise that affect to the tobacco dye structure is damage. It also possible that it works beyond exceeds the limit light absorption and high temperature exposure has been done so the quality of subtrate TCO is decrease.

3.2.2 The Influence of Area Sensor Design to Output Voltage

Based on the data of median value using five times voltage testing to every design is shown in Figure 4.

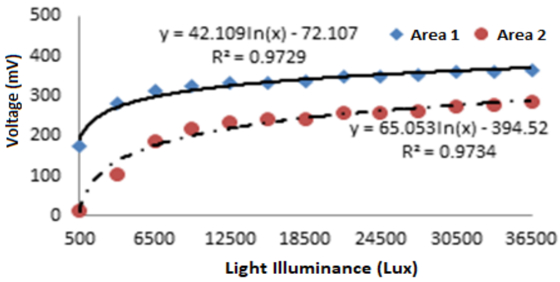


Figure 4. The relationship between area of sensor design and output voltage

The graph shows determination coefficient value (R2) of each regression result or transfer function is nearly 1. It means the voltage variable can be explained by illumination variable [13]. As regression equation of 1 cm2 design sensor shows the number of R2 = 0,97291, means 97% of variation output voltage can be explained by the illumination variation (3% is explained by another variable). Another variable is probably because temperature, the performance of tools and materials.

3.2.3 The Influence of Area Sensor Design to Output Current

Based on the data of median value using five times measurement to the design is shown in Figure 5.

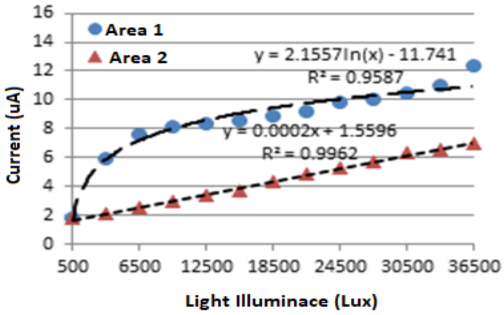


Figure 5. The relationship between area of sensor design and output current

Based on the result, it shows that determination coefficient value (R2) of each regression result or transfer function is nearly 1. It means the current variable can be explained by illumination variables. This design can be concluded the increasing illumination, then the sensor output current goes up as well both on area 1 and area 2 of the sensor.

4. CONCLUSION

According to the design and measurement of the optical sensor based on customized DSSC material, it can be concluded this sensor has electrical parameter including output voltage and current. The sensor was measured with different light illuminance and different temperature as well. Increasing light intensity produces higher electrical parameter output both current and voltage. This sensor has potential prospect to be used as light sensor and to be competitive cost for fabrication.

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