Power Transistor 2N3055 as a Solar Cell Device

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***Abstract*— The abundance power radiated by the sun can be converted into alternative electric energy. The proposed method in this paper is by utilizing the transistor waste type 2N3055. The transistor contains photocell that can convert energy radiated by the sun into electricity. The 2N3055 type of transistor composed by Aluminum (Al) 45.55%, Carbon (C) 32.40 %, Nb (Niobium) 13.42 %, Zr (Zirconium) 7.02 %, and O (Oxygen) 1,61 %, this data is provided by SEM-EDX analysis. The experiment was conducted at 10.00 AM, 12.00 PM and 02.00 PM. The experimental results show that the maximum energy is acquired at 12.00 PM since at 12.00 PM the position of the sun and the earth are at the smallest angle. The maximum power conversion is obtained when the sun is perpendicular to the earth position at 12.00 PM. The maximum power acquired is 3.55 watt during the radiation intensity of 51729 lux.**

Keywords—solar cell, transistor, efficiency, intensity

I. Introduction

The decreasing availability of conventional fossil fuel has insisted researchers to find the energy alternative to substitute fossil fuel. Solar energy from the sun is one of the best alternatives for Indonesia, however, the installation of solar panels are still too expensive. The alternative material for solar cells can come from electronics waste, such as the 2N3055 transistor. This type of transistor can be found in many electronics wastes since a transistor is semiconductor device has a wide range of function such as gain, circuit breaker, switching, voltage stabilizer, signal modulation, etc [1,2].

In electronics application, transistor consumes electricity, however, in this research 2N3055 transistors are designed to produce energy by converting the sun ray's to be electricity. The 2N3055 transistors used doesn't have to be the new ones, they can be acquired from electronics waste, therefore, this research also aims to recycle the electronics waste that has became a problem too [3-5].

Researchers conducted research entitled "Research Prospect" and Application of Photovoltaics as Alternative Energy Sources in Indonesia". This research showed the simplest solar cells were made of two type of semiconductor, P and N. Semiconductor material is crucial in determining the efficiency of energy conversion, therefore, it is necessary to select the material with energy bandgap less than valance band energy. Arranging semiconductor material in tandem also helps in increasing the efficiency of energy conversion [6,7].

A research entitled "Making Solar Cell Using NPN Type 2N3055 Transistor to Produce 12 volt Voltage" was conducted. The experiment was conducted in 3 days, from 10.00 AM – 01.00 PM with the highest energy intensity at 3rd days, 19261 lux. The highest output voltage produced was 14.16 volt, the highest current was 0.21 mA, and therefore, the maximum power was 2.9736 Watt [8-10].

II. Experimental

The solar panel is very important the conversion process from solar energy to electricity. The main factor is the size of the installed solar panels, and the numbers of transistor used. The working principle of this experiment is by exposing solar panel directly under the sun, connects the solar panel to control panel, and turns both panels on. The conversion process is automatically as the sunlight is absorbed by transistor photocell, then it is converted into electricity. The converted electricity is saved in an accumulator and experiment process was design by connecting the panels in series and parallel.

The materials and equipment used in this 2N3055 transistors electronics waste solar panels are below:

1. 2N3055 transistors as the main material for solar panel.
2. PCB as the medium to connect 2N3055 transistors.
3. Socket and jack to connect between solar modules.
4. Digital multimeter to measure the voltage and current.
5. Mini voltmeter to measure voltage in control panel
6. Ampere meter to measure current in the control panel.
7. 3 volt AC lamp, USB socket and switch as the load.
8. Cables as connectors.
9. Transformator to step up and down voltage.
10. Inverter to convert DC current to AC.
11. 12 volt battery to accumulate the electricity produced by the solar panel.
12. Thermo-couple as temperature sensor at solar panel.

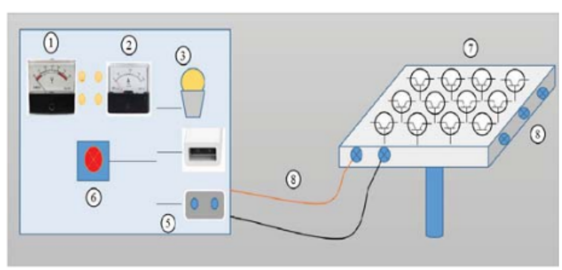

Figure 1. 2N3055 transistors solar panel design

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Note:

1. Volt meter DC
2. Ampere meter Dc
3. DC 12 Volt lamp
4. USB
5. 6 – 12 Volt DC Motor
6. Transformator
7. 2N3055 transistors
8. Cables

Figure 2. The 2N3055 Transistor based solar panel design

Experimental procedures of this research are listed below:

1. Expose solar panels directly under the sun.
2. Connect solar panel to control panel using connector cable.
3. Turn on both solar panel and control panel.
4. Expose the solar panel for 1 hour before measuring data.
5. Take the note of the output shown in current and voltage display.
6. When the experiment is finished, turn off both solar panel and control panel.
7. The data is measured every hour from 10.00 AM to 13.00 PM.
8. Analyse the optimum condition from the measured data

III. Results and Discussion

A. 2N3055 Transistors Characteristic

The material in designing the solar panel is 2N3055 transistors composed of semiconductor and conductor functioning as the main material for solar cell. To find out the composition material of 2N3055 transistors, the SEM-EDX analysis was conducted.

The result of SEM-EDX is required to obtain the characteristic of solar panel material based on the forming structure on the surface of panel area, and information of the pores on the surface functioning as solar absorber is achieved.

Table 1 shows the result of SEM-EDX analysis of 2N3055 transistors.

Table 1. The result of SEM-EDX analysis of 2N3055 transistors

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
Al	13	K-series	46.55	45.55	35.87	2.16
C	6	K-series	33.10	32.40	57.30	6.07
Nb	41	L-series	13.71	13.42	3.07	0.61
Zr	40	L-series	7.18	7.02	1.64	0.37
O	8	K-series	1.64	1.61	2.13	0.62
		Total:	102.18	100.00	100.00	

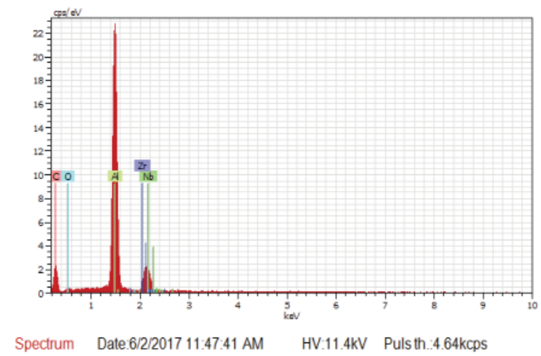
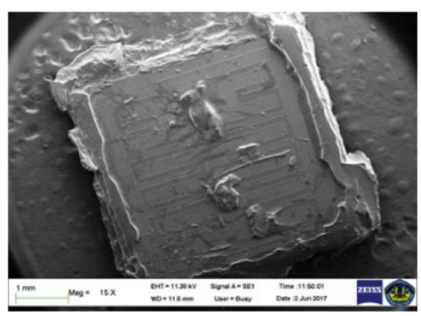


Figure 3. The SEM-EDX analysis result of 2N3055 transistors

The analysis result shows the dominant elements of 2N3055 transistors are Al (Aluminum) with the percentage of 45.55 % as the conductor and C (Carbon) with the percentage of 32.40% as the semiconductor. In the periodic table, Al is in IIIA group, with the characteristic of very light, one-quarter of bronze, white-silver color, melting point at 657^{o}C, and the boiling point at 1800^{o}C. As the conductor, the purity of Al is up to 99.5% and other 0.5% consists of ferrous, silicon, bronze, and the remelted Al can contain zinc too. Al is the material having 237 W/m2.K thermal conductivity and 0.78 W/m2 thermal resistance at the average temperature of 30^{o}C where thermal conductivity exhibits a heat-dissipating capability whereas electrically conductive conductivity conduct electricity at 3.8 × 107 Ω.m and resistivity 2.75 × 10-8 Ω.m.



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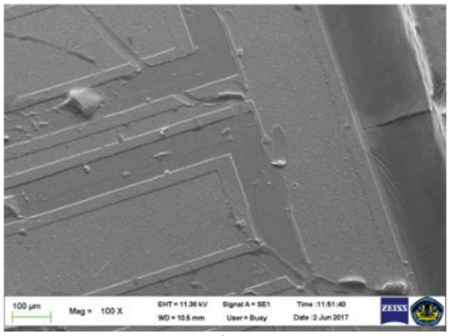

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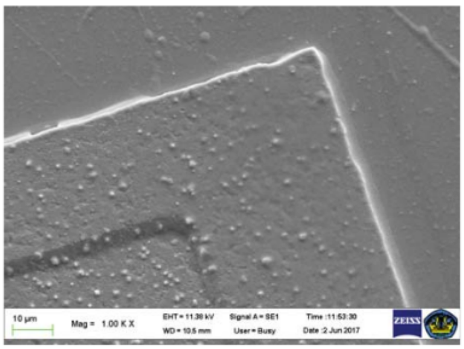

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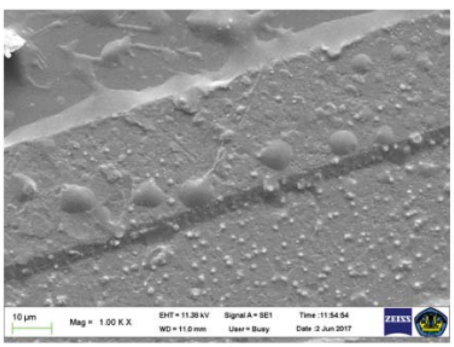

d

Figure 4. Photocell transistor topography with
(a) Transistor *Photocell* 15× enlargement
(b) Transistor *Photocell* 100 ×enlargement
(c) Transistor *Photocell* 1,00K ×enlargement (WD 10,5 mm)
(d) Transistor *Photocell* 1,00K ×enlargement (WD 11,0 mm)

Fig. 4 shows the SEM test results in the form of enlarged photocell surface. The enlargements were conducted 4 times, where at the last enlargement photo shows the uneven surface of the photocell. The uneven surface caused by the element of photocell which is not mixed completely.

B. *Solar Panel efficiency analysis*

The solar panel is the main component of the solar energy conversion system. The designed panel has the length of 53.5 cm, width 45.2, and cross-sectional area of 2418 cm^2 or 0.24m^2 wherein there are 8 PCB, and each PCB contains 12 transistors, therefore the total transistors used are 96 pieces. The transistor circuit used is the base-collector in the jumper (+) emitter output (-), the connection is selected since basically the base terminal in the transistor is prone to break and this circuit is able to produce higher current.

The estimation of temperature and humidity in June based on Climatology Station data is shown in Figure 5 [11].

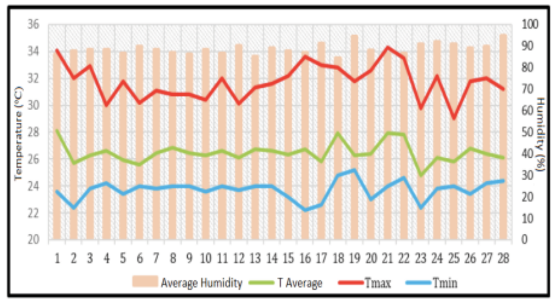

Figure 5. Temperature and humidity forecast

The solar panel was conducted on June 2-10, 2017, with local temperature forecast is 30-32 °C.

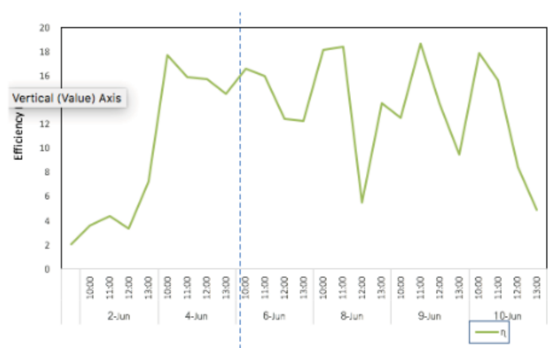

Figure 6. Solar panel efficiency fluctuation

The efficiency is obtained by defining the ratio of output power and input power, where the input power is the converted irradiance into the intensity of solar radiation.

$$P_{input} = Ir \times A \quad \ldots(1)$$

$$P_{out} = V_{max} \times I_{max} \quad \ldots(2)$$

Therefore the solar panel efficiency (η) is given by

$$\eta = \frac{P_{out}}{P_{in}} \times 100\ \% \qquad \ldots(3)$$

The experiment was conducted from June 2 to 10, 2017. It can be seen in Fig. 5, the lowest efficiency is on June 2 at 12 PM, e.g. 2.4% and the highest on June 9 at 11 AM e.g. 18.6%. The fluctuation of solar cell panel efficiency is influenced by several factors, namely solar cell temperature, solar intensity, shading and electrical resistance. The electricity generated by the solar panel is not always stable due to the intensity of sunlight. The ideal time when the sun position is perpendicular to the earth, and the day is sunny without a cloud, the solar panel performance is maximized. However, in the morning or a cloudy day, the solar panel electricity production decreases.

C. The effect of Solar Panel Surface Temperature on Power

Solar panel temperature is one of the factors that affect the performance of solar cells panel. Ideally, solar panels work in standard temperature 25-35°C, however, in the real condition, solar panels are exposed to more than standard temperature. Indonesian temperature is around 25°C – 35°C that can cause the reduction of solar panel's electricity production or power for every temperature's increment.

Temperature effect to power production is shown in Fig. 6 where on 10.00-11.00 AM with temperature of 28°C - 29°C, the electricity production is 1.70 – 2.00 watt compare to 12.00 AM – 01.00 PM with temperature 30.3°C – 31°C, the electricity production is 1.50 – 1.58 watt.

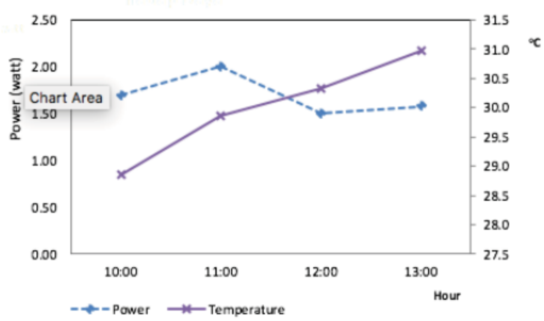

Figure 7. Solar panel surface temperature effect on electricity production

The effect of the surface temperature of the solar panel is very influential to the power produced, this shows that the surface of the transistor panel used gives a response that corresponds to the panel surface temperature range at 25°C - 35°C.

D. Effect of Sunlight Intensity of Electricity Production

The intensity of the sun or the intensity of solar radiation is the size of the angle of sunlight coming on the surface of the earth. The amount received is directly proportional to the angular magnitude of the incident angle.

Efficiency and effectivity of this research is in the range of 3.33-18.60% and depending to solar radiance fluctuation. This result is still below the efficiency of commercial solar panel, 19.7% with output power of 330 watt for solar panel type HIT N330 produced by Panasonic [12].

The relationship of solar radiation intensity to the performance of solar cell or power produced is the greater the intensity of solar irradiance, the higher the power generated (proportional) as shown in fig. 8. The experiment results show that the intensity and the resulting power is directly proportional, except on June 2 where at an intensity of 22645 Lux or 33.16 W/m^2 the produced power is 0.4 watt due to the cloudy day condition. Fig. 8 also shows that that the highest intensity during the test that is on June 8 with the intensity of 39326 Lux or 57.58 W/m^2 produce 2 watts of power.

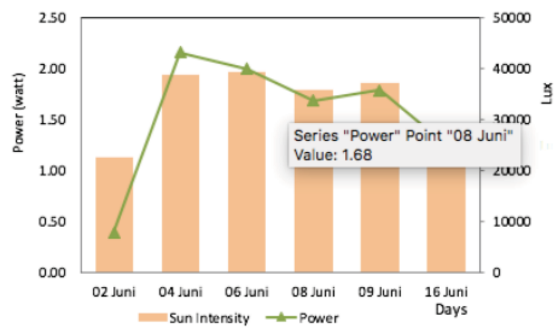

Figure 8. Effect of Sunlight Intensity of Electricity Production

E. Exposure time effect on Power Production

The electric power generated from the solar panel is influenced by the factors below:

a. The distance of the sun, every change of the distance between the earth and the sun changes the incident recipient on earth.
b. The intensity of sun radiation indicated by the angle of incident coming to the earth surface.
c. Sun duration, the time from sunrise to sunset.
d. Atmosphere effect, the sunlight comes through the atmosphere will be partially absorbed by gas, dust, and water vapor, reflected back, emitted and the rest forwarded to the earth's surface.

There are 3 types of solar radiation coming to the surface of the earth,

1. Beam/Direct Radiation is the radiation that reaches the earth without changes in direction or radiation received by the earth in the parallel to the direction of the coming rays
2. Diffuse Radiation, the radiation of the sun that comes to the surface of the earth after reflected or scattered by the atmosphere.

3. Global Radiation is the sum of direct radiation and diffuse radiation. However, the factors affecting global radiation are not limited only to direct and diffuse radiation.

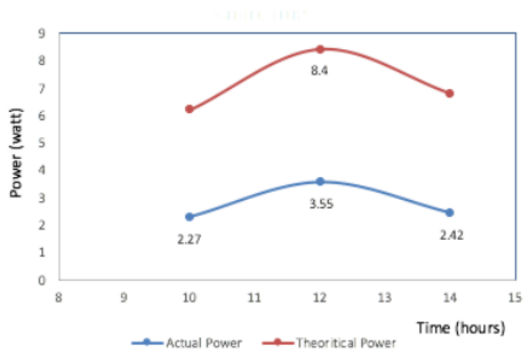

Figure 9. The affect of time exposure to the generated power

Fig. 9 shows that maximum power absorbed by solar cells are obtained at 12.00 PM due to the perpendicular position of the sun. If the angle between the sun ray and the earth are bigger, therefore, the absorbed energy is smaller. This condition occurs during the morning and late afternoon. Otherwise, the smaller the angle between the sunray and the earth, the intensity of global radiation increases and more energy absorbed and converted into electricity due to the perpendicular position of the surface of solar cells, this occurs in the daytime at 12.00 PM with power produced is 3.55 watts with an intensity of 51729 lux.

IV. Conclusion

This research used the 2N3055 transistor as the main material to design a solar panel. Based on SEM-EDX (Scanning Electron Microscopy-Energy Dispersive X-Ray) analysis test on the 2N3055 transistor, it contains the Al 45.55 % and C 32.40 %.

The maximum solar energy absorbed by the solar panel is based on the intensity of solar radiation. The angle of the sunray's and the surface of the earth affect the absorbed solar energy. If the angle between the sunray and the earth are bigger, therefore, the absorbed energy is smaller. This condition occurs during the morning and late afternoon. Otherwise, the smaller the angle between the sunray and the earth, the intensity of global radiation increases and more energy absorbed and converted into electricity due to the perpendicular position of the surface of solar cells, this occurs in the daytime at 12.00 PM with power produced is 3.55 watts with an intensity of 51729 lux.

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