Solar Cells Characterization Polycrystalline with Sun Simulator System Using Light Halogen Bulb

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Abstract. Current-voltage characteristic curves of solar cells provide information about the efficiency of solar cells to convert sunlight directly into electricity. The effect of temperature, irradiation levels, as well as a raw material manufacturer will cause changes in the characteristic curve. Sun simulator that uses a halogen lamp is used as a substitute function bulm the sun as well as the source of irradiation used a halogen lamp as the light source and is focused in the box that all sides made the dark. By varying the distance and the amount of irradiated radiation that falls on the solar cell, solar cell characterization. Retrieved suitability output measurement results in the form of solar cell characteristics I_{sc}, V_{oc}, P_{max}, I_{maks}, and V_{max} with the product factory specification. From the results obtained $V_{oc=}$8,59V, I_{sc}=0,00539A, and P_{max}=0,0217008W in light intensity is 24,6Watt / m^2.

Keywords: Sun simulator, Solar cells, Halogen bulb.

1 Introduction

Solar cells are electronic devices that can convert solar radiation energy directly into electrical energy [1]. The solar cell is an energy source that will never run out, as long as the sun emits light to the earth [2]. It is estimated that solar cells will become the mainstay of electricity generation sources in the future because their use is very practical [3], especially for energy supply in remote areas difficult to reach [4]. In addition, the energy source is environmentally friendly because the conversion process produces no pollutants at all [5].

Work solar cells can be measured by looking at the output power generated from the solar cell [6]. Solar cells‘ work is influenced by several things such as the materials used, internal resistance, temperature, and solar radiation levels [7]. Research on the characterization of solar cells is still being conducted to date, including the results of measurements of current and voltage (I-V) on a solar cell that is by varying the distance irradiation and the amount of irradiation falling on the solar cells as well as the characterization of solar cells [8], obtained suitability output measurement results cell characteristics solar form of I_{sc}, V_{oc}, P_{max}, I_{max} and V_{max} with the product factory specification [9].

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The system indispensable equipment in research activities related to the development of solar cells is a system of measuring the characteristics of solar cells and the procedure determination of the parameters of the characteristics of solar cells based on existing data for measuring results he gets [10]. This research has made the development of measuring system parameters characteristic of the solar cell and the procedures determination the parameters of solar cell characteristics under irradiation conditions.

2 Methods

The method used in this study is an experiment, using an electronic circuit as shown in **Figure 1**.

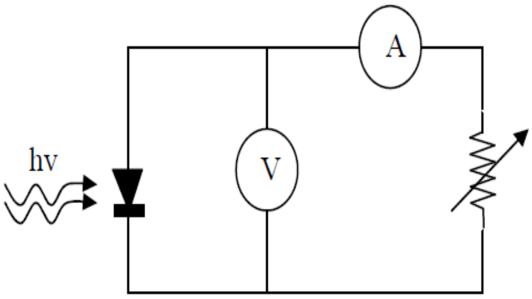

Fig 1. The circuit will be used to measure the characteristics when irradiated

For the measurement of I-V characteristics of solar cells in both the irradiated and without the irradiated state, has developed a system of simple equipment. The design of the characteristic parameter measurement system solar cells is made and used as shown in **Figure 2**. The measuring system is made of aluminum material with a size (of 16x16x35) cm^3 and connected to an electronic circuit. The top of the lamp is placed to measure the I-V characteristics in a state by irradiation.

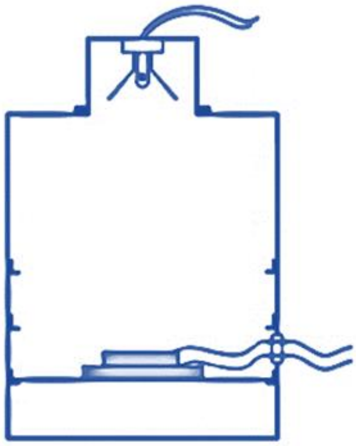

Fig 2. The design of the measuring system of solar cell characteristics

Data were obtained by firing light from the halogen lamp directly to the solar module and carried in the box reflector. The intensity of the incoming light is absorbed and converted into a solar module output in the form of current and voltage.

Current-voltage relationship for a solar cell can be written as follows:

$$I = \frac{V-IR_s}{R_{sh}} + I_{0R}\left(exp\left(\frac{q(V-IR_s)}{2kT}\right) - 1\right) + I_{0D}\left(exp\left(\frac{q(V-IR_s)}{kT}\right) - 1\right) \quad (1)$$

Where IL is the light-generated electrical current, its value does not depend on the voltage. With this formula, the I-V characteristics of solar cells under these conditions appear similar to the I-V characteristics in dark conditions but are translated into four quadrants. The main parameters that can be determined from the behavior of solar cells when irradiated are Voc (open circuit voltage), Isc (short circuit current), FF (Fill Factor), and η (conversion efficiency). Fill Factor value determined by the equation:

$$FF = \frac{I_m V_m}{I_{sc} V_{oc}} \quad (2)$$

Where I_m and V_m are the electric current and voltage to the optimum working point, that produces maximum output power. While the conversion efficiency (η) is calculated by the equation:

$$\eta = \frac{FF V_{oc} I_{sc}}{P_{in}} x\ 100\% \quad (3)$$

3 Result and Discussion

The measurement results of I-V characteristics of the irradiation and different spacing showed changes in efficiency that are interconnected. When the intensity of the halogen lamp of 24.6 W/m^2 at a distance that changed between the 25cm, 20cm, and 15cm, indicating that the greater the distance irradiation, I_{sc} and V_{oc} generated will be smaller. This is because when the solar cells are subjected to a halogen lamp, the intensity of irradiation received by the solar cell becomes greater. Characteristics measurement results of solar cells using a sun simulator at the source intensity of 24.6 W/m^2 with variations in the distance is:

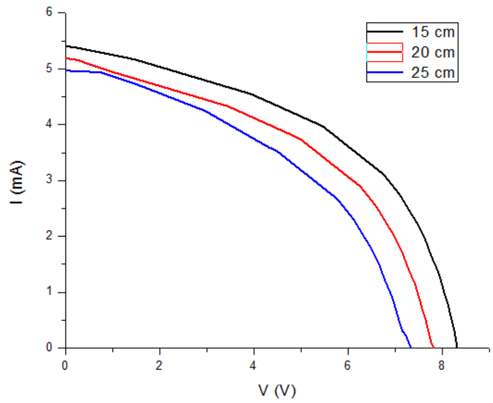

Fig 3. Characteristics measurement results of solar cells with variations in distance

Characterization of I-V solar cells under irradiation based on the measurement results is shown in Figure 4. Based on the images obtained by the I_{sc}=0,00539A and V_{oc}=8,59V. While V_m and I_m respectively voltage and current at the optimum operating point. I_mV_m value obtained from the maximum area under the curve I-V as shown in **Figure 4.** Based on the calculation, the value of V_mI_m=0.0217008 Watt. The value of the fill factor (FF) and efficiency (η) is then determined from equation (2) and (3).

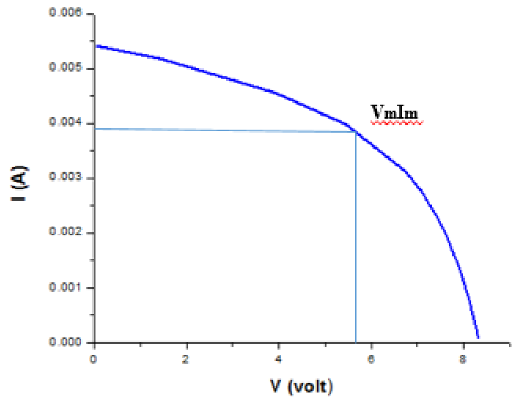

Fig 4. I-V characteristic curves of solar cells in a state of irradiation

The value of the fill factor (FF), which is the ratio of maximum power (V_mI_m) produced by solar cells on the multiply of I_{sc} and V_{oc} obtained at 0.4686, and the value of conversion efficiency of 12.25%. The value of the acquired solar cell efficiency is considered feasible for solar cells based on polycrystalline silicon material, based on the studies that have been performed on polycrystalline silicon, the efficiency of the measured range (12 to 13.6) %.

From the test results of XRD is known that the constituent materials are polycrystalline solar panels, it is evident from the peak is formed only one because the characteristics of polycrystalline XRD test is when the peak is formed only one or more but still in the same family.

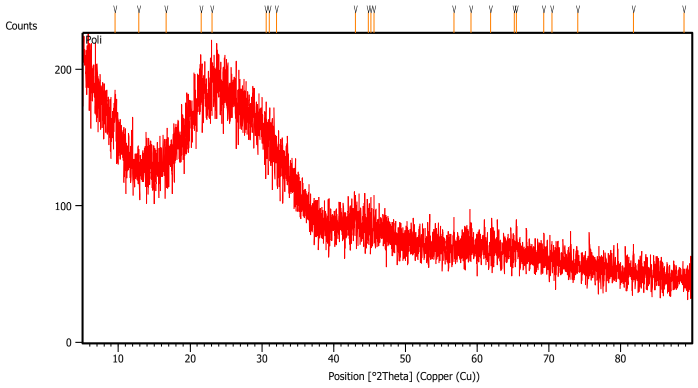

Fig 5. Curve XRD results

For the test results Optical Microscopy clearly visible crystals making up solar panels in the form of plural crystals that are arranged randomly and irregularly.

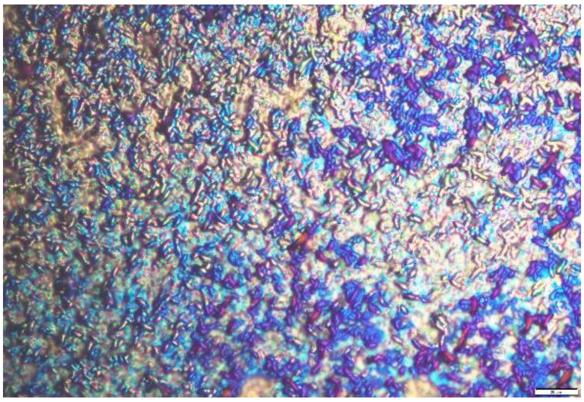

Fig 6. Results optical microscopy

These results indirectly suggest that systems developed equipment and procedures that determine the parameters of the characteristics of solar cells have been used quite well and have the potential to be used as a measurement system for lab activities and research related to solar cell characterization.

4 Conclusion

The parameters of silicon solar cell characteristics were obtained based on the measurement of the irradiation conditions obtained values of I_{sc}=0.00539 Ampere, V_{oc}=8,59 Volt, FF = 0.4686, and η = 12.25%. These values are very close values of the parameter characteristics of polycrystalline silicon solar cells. This shows that the system of measurement equipment developed has a good potential to be used as a practical tool and a research tool.

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