CHARACTERISTIC I-V OF Cu/Cu_2O SOLAR CELLS WITH BELIMBING WULUH (AVERRHOA BILIMBI L.) ELECTROLYTE USING SUN SIMULATOR

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ABSTRACT

Characteristic I-V of Cu/Cu_2O solar cells with belimbing wuluh (Averrhoa bilimbi l.) electrolyte have been determined using sun simulator data by varying the resistor value (R). The resistor of 1-10 kΩ was applied. The Cu_2O layer as a p-type semiconductor is formed by thermal oxidation plate Cu at a temperature of 550 °C. The thermal oxidation time is 80, 100, 120 minutes. Sun simulator measurement result showed that the addition of thermal oxidation time improved the current (I) values, where the most improvement occurred in Cu/Cu_2O-100. Furthermore, the current dropped with increasing voltage (V) indicating increase the resistor value. Optimal power (P_{out}) increases with increasing applied time the thermal oxidation of the Cu plate at 100 minutes. Plotting characteristic I-V give the efficiency (η) of solar cells from samples, and it was found that the Cu/Cu_2O-100 reached the highest value, i.e.,, 2.84 %. In general, the more layers of Cu_2O are formed, the higher the efficiency of solar cells.

Keywords: Characteristic I-V; Cu/Cu_2O; Belimbing Wuluh Electrolyte; Sun Simulator; Efficiency Solar Cells.

Introduction

Indonesia is one of the countries with a tropical climate which is located on the equator, so that the intensity of sunlight is quite large by the surface of the earth, especially in Aceh. Solar radiation energy is 4.5-5.1 kWh/m²/day.[1]

Kupro oxide or Cu_2O is a p-type semiconductor having an energy band gap 2 eV with high absorption coefficient and good carrier mobility.[2] Cu_2O is an alternative material that attracts attention to solar cell devices, in addition, it is environmentally friendly, non-toxic, and easy to process in production.[3] Non-vacuum techniques can be applied to produce Cu_2O, such as electrochemical deposition (ECD) and thermal oxidation from Cu sheets.[2] Metal oxide-based solar cells have been investigated with electrolyte media, e.g., Cu_2O/Cu using Gel Na_2SO_4,[4] and Cu_2O/ZnO with H_2SO_4.[5] In addition, in 2017 Cu/Cu_2O solar cells were investigated with electrolytes, such as seawater media by Setiawan F[1] and NaCl+water by Uranus H.[6] The belimbing wuluh electrolyte in Cu/Cu_2O solar cells, however, have not been studied particularly regarding of characteristic I-V.

This article reports the characteristic I-V of Cu/Cu_2O solar cells with belimbing wuluh electrolyte. Characteristic I-V data was used to determine the efficiency of solar cells. Study of the characteristic I-V of the Cu/Cu_2O solar cells with belimbing wuluh electrolyte will expand their analysis prospects.

Methods

The experiments used commercial Cu sheets. The Cu_2O layer samples were prepared using a thermal oxidation method

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from Cu sheets. Solar cell samples were prepared with dimensions 5 mm × 5 mm and 1 mm thickness which is compatible with the dimension for sun simulator testing. The thermal oxidation was carried out at a temperature of 550 °C[7] with a variation of the heating time (for 80, 100, 120 minutes). Solar cell electrolytes using belimbing wuluh extract were obtained in Langsa city, Aceh. Belimbing wuluh was squeezed to take the liquid, then filtered. Cu_2O layer plate is placed on a Cu plate with a distance of 10 mm, then put in a glass container containing electrolytes from belimbing wuluh extract.

Sun simulator is prepared with dimensions 100 mm × 100 mm and 150 mm height. In addition, the top side is given a hologen bulb lamp as a light source. The sun simulator is used for the characteristics I-V of solar cell connected to electronic circuits.[8] The results were analyzed to obtain the fill factor (*FF*) and efficiency (η) of the solar cell using the equation[9]:

$$FF = \frac{I_{mak}.V_{mak}}{I_{sc}.V_{oc}} = \frac{P_{out}}{I_{sc}.V_{oc}} \quad (1)$$

$$\eta = \frac{P_{out}}{P_{in}} = \frac{FFV_{oc}I_{sc}}{P_{in}} \quad (2)$$

where V_{oc} is open-circuit voltage, I_{sc} is short-circuited current, P_{in} is the total input power of light radiation cell/module, dan P_{out} is the optimal electrical power output cell/module.

Result and Discussion

Figure 1 shows a sun simulator using hologen lamps. The resulting spectrum of light bulb hologen lamp approaching the solar spectrum.[8,10] Power generated light bulb hologen lamp on average, which is 9.9 W/m² measured using a solar power meter SM206. This value with a sample area of solar cells, which is 0.0025 m² produced input power (P_{in}) in solar cells Cu/Cu_2O of 24.75 mW.

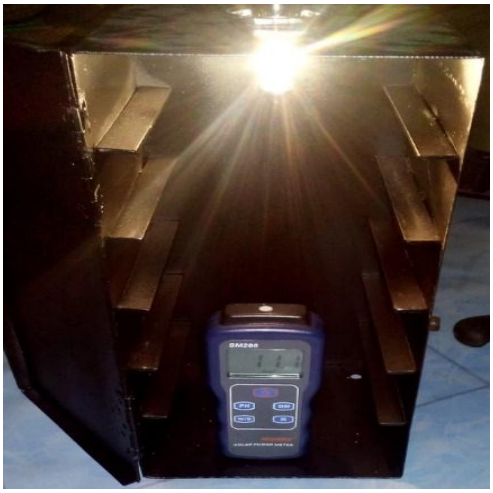

Figure 1. Sun simulator using hologen bulb lamp.

Figure 2 shows the thermal oxidation results of the Cu plate. The Cu_2O layer is more dominantly formed by thermal oxidation for 120 minutes and 100 minutes as compared with 80 minutes. This result is due to the length of the thermal oxidation process on the Cu plate so that the thickness of the Cu_2O layer increases.[6] In addition, impurities found in the Cu_2O-120 layer as compared with the Cu_2O-100.

Figure 3 shows the current plots for all samples as a function of voltage. Current on I_{sc} (0 mV) increases when the Cu plate in thermal oxidation for 120 minutes compared with a sample of Cu/Cu_2O-80. The current value for Cu/Cu_2O-100 samples even higher, i.e.,, 1.7 mA. In addition, the overall current value for all samples decreases with increasing voltage. The decrease is a result of the resistor (*R*) variation given to all samples,

ie 0-10 kΩ. The Cu/Cu_2O-80 samples show a decreasing voltage at about 10 mV as compared to the Cu/Cu_2O-120 which has decreased by around 45 mV. It is also found that the Cu/Cu_2O-100 show greater current values than the Cu/Cu_2O-80 and Cu/Cu_2O-120 at all voltage. The results of the calculation of P_{out} (current × voltage) on the graph characteristic I-V produce an optimal value, thus determining the value of I_{mak}, V_{mak}, and R_{opt}. Detail parameters of the solar cell Cu/Cu_2O extracted from the I-V characteristics are listed in Table 1, i.e., I_{sc}, V_{oc}, I_{mak}, V_{mak}, and P_{out}.

(a) (b) (c)

Figure 2. Thermal oxidation of the Cu at a temperature 550 °C for, a) 80 minutes, b) 100 minutes, dan c) 120 minutes

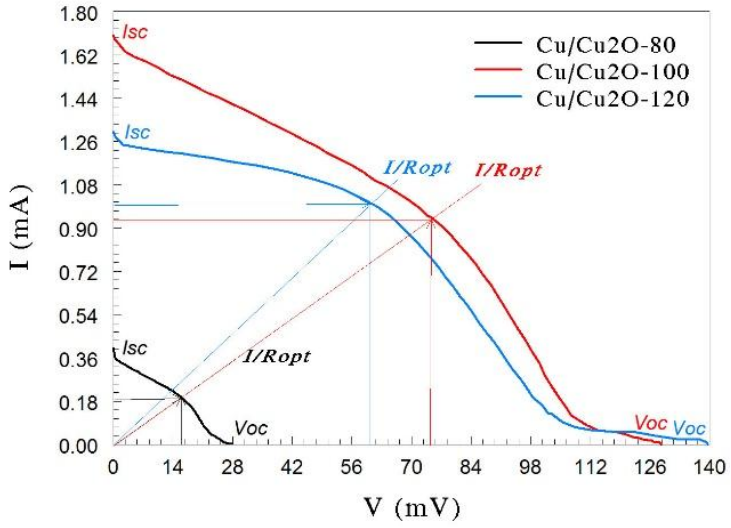

Figure 3. Characteristic current and voltage of Cu/Cu_2O solar cells as a variation of the applied resistor.

Table 1. Characteristic I-V and efficiency to the Cu/Cu_2O solar cells

Sample	I_{sc} (mA)	V_{oc} (mV)	I_{mak} (mA)	V_{mak} (mV)	P_{out} (mW)	FF	η (%)
Cu/Cu2O-80	0.40	27.70	0.20	15.70	3.14	0.28	0.13
Cu/Cu2O-100	1.70	128.60	0.95	73.90	70.21	0.32	2.84
Cu/Cu2O-120	1.30	139.50	1.00	60.80	60.80	0.34	2.46

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The FF value is determined from the values of I_{sc}, V_{oc}, and P_{out}. Cu/Cu_2O-120 has a higher *FF* value than Cu/Cu_2O-100 and Cu/Cu_2O-80. This result is due to the nanostructures are formed on the layer of Cu_2O.[11] The FF values of solar cells are shown in Tabel 1.

Table 1 present the P_{out} value and η solar cells for all the Cu/Cu_2O samples. The initial analysis in determining the η of the solar cells is P_{out} and P_{in}. Note that the Cu/Cu_2O-80 has P_{out} value of 3.14 mW. In general, P_{out} value increases with increasing applied thermal oxidation time. The η solar cells value of the Cu/Cu_2O-100 is higher than that of the Cu/Cu_2O-120. This show that the Cu_2O layer formed on the Cu plate through thermal oxidation affects the diffusion of electrons to the hole in the solar cell. In addition, impurities in Cu plate prevent the formation of Cu_2O layer.[7] The efficiency of solar cells using belimbing wuluh electrolytes increased compared to seawater media of 1.71 %.[1]

Conclusion

Sun simulator can measure current and voltage as characteristic I-V. The P_{out} value increases as the addition of thermal oxidation time, but not for the Cu/Cu_2O-120 sample. The highest value is owned by Cu/Cu_2O-100 (i.e., 70.21 mW) compared Cu/Cu_2O-120 (i.e., 60.80 mW) and the lowest is owned by Cu/Cu_2O-80 (i.e., 3.14 mW). Then these values and *FF* can be analyzed further value η solar cells. The η solar cells value increased with the addition of thermal oxidation time, i.e., 2.84 % for Cu/Cu_2O-100 and Cu/Cu_2O-120 is 2.46 %.

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