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Reduction of Operating Temperature in 25 Series-Connected 820X CPV

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1. Introduction

Under the concentration conditions, it is important to manage the operating temperature of concentrator photovoltaic (CPV) module, because the high density solar energy is emitted to the solar cell. G. Peharz et. al. reported the IV curves of CPV module at various temperature [1]. The temperature coefficient of short circuit current (Isc) is positive, and that of open circuit voltage (Voc) and fill factor (FF) are negative. The operating temperature is a dominant factor for the efficiency of CPV module.

Generally, the CPV module is composed of optics, solar cell and metal chassis. The solar cell is fixed on the chassis. The temperature of module back surface is different from the actual cell temperature because of the thermal diffusion and/or radiation from the chassis. It is necessary to measure the actual cell temperature in order to evaluate and understand the field operation of CPV module.

In this report, we measured the cell temperature and analyzed the temperature distribution dependence on the output of the 820X CPV module.

2. Experimental Methods

An 820X CPV module was prepared by Daido Steel Co., Ltd. A CPV module consisted of 25 pairs of Fresnel lens (200 mm x 200 mm) and triple-junction solar cell (7 mm x 7mm), and an Al chassis was used. The module was modified to measure the temperature and output of each receiver. Figure 1 shows a cross-sectional diagram around solar cell. The solar cell was connected on a copper ribbon electrode with a high thermal conductive solder. In order to keep the insulation quality, an aluminum alloy was adopted, and the copper ribbon was applied on it with an insulation layer. In order to detect the temperature of solar cells in the CPV module, temperature sensors (Pt100) were embedded just below the solar cells. We used two type back chassis. One was 2 mm thick aluminum chassis. The other was 4 mm thick aluminum chassis. The current - voltage (IV) characteristics were measured using an I-V curve tracer (EKO, MP-160).

3. Results and Discussions

On 24 - 25 November, 2011, we measured the outdoor-characteristics of 820X CPV module. The weather of the experiment period was clear. The wind speed was low and did not have the big change. During the evaluation, the meteorological conditions were stable.

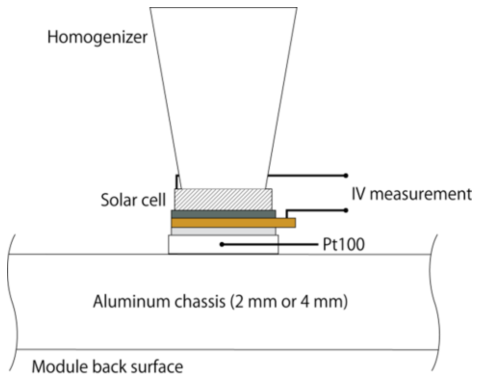

Fig. 1. Cross-sectional diagram around solar cell.

Figure 2 shows the receiver temperature distribution of 820X CPV module with (a) 2 mm and (b) 4 mm thick back chassis at 14:00, 24 November, 2011, respectively. The ambient temperature and direct normal irradiance (DNI) were 14.6°C and 886.6 W/m^2, respectively. The maximum temperature of 2 mm back chassis module was 70.1°C. The central receiver temperatures were high, and the edge receiver temperatures were low. The difference between center and edge was approximately 15°C. In contrast, the temperatures of 4 mm thick back chassis module were drastically reduced due to the thermal diffusion on chassis. As shown in Fig. 2 (b), the maximum temperature was 56.3°C and decreased by 13.8°C in comparison with 2 mm chassis. The difference of temperature between center and edge was also reduced.

Figure 3 shows the I-V curve of CPV module connecting 25 receivers at 14:00, 24 November, 2011. The short circuit current (Isc) and open circuit voltage (Voc) of 4 mm thick back chassis module were higher than that of 2 mm thick back chassis module.

Figure 4 shows the relationship between the operating temperature and Voc for each receiver. The temperature coefficient was −3.26 mV/°C, and this value agreed well with previous work [2]. There was no difference between 2 mm and 4 mm thick back chassis. The lower receiver temperature influenced Voc directly (as shown in Fig. 3).

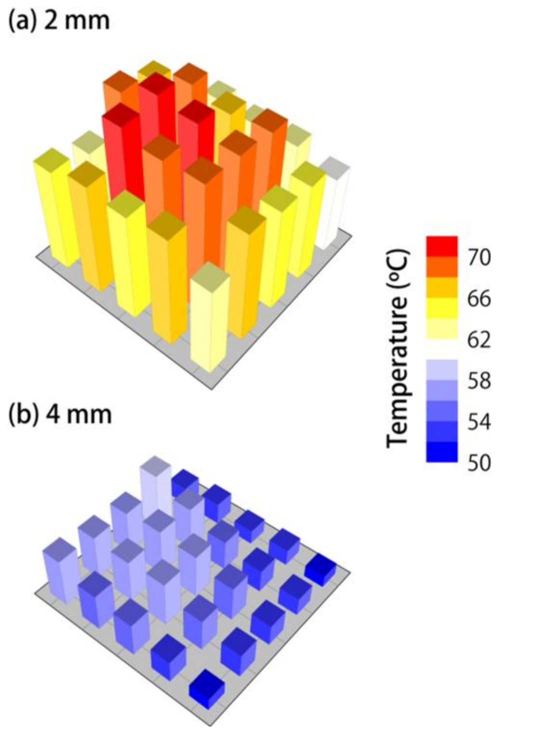

Fig. 2. Receiver temperature distribution of 820X CPV module with (a) 2 mm and (b) 4 mm thick back chassis

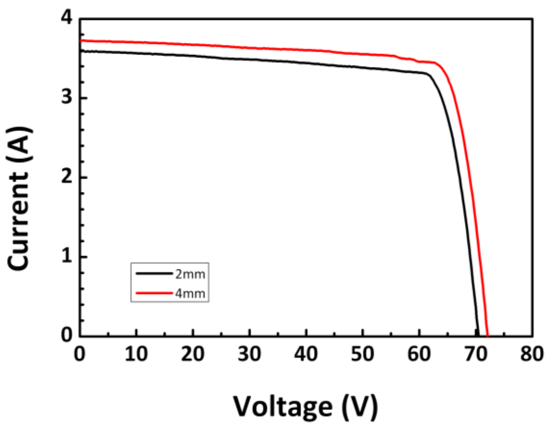

Fig. 3. I-V curve of CPV module connecting 25 receivers.

Figure 5 shows the relationship between the operation temperature and Isc for each receiver. Isc was normalized by DNI. In general, Isc increased with increasing temperature. On the other hand, it is considered that the strain of the chassis is occurred by the temperature distribution. This strain changes the alignment of the optical system in CPV module. As the result, the misalignment causes the decrease in optical efficiency and Isc. In the Fig. 5, the maximum Isc of 2 mm thick back chassis was low in comparison with 4 mm. The lower Isc caused the decrease in Isc of CPV module connecting 25 receivers (as shown in Fig. 3). A reason for the lower Isc is higher strain due to the ununiformity of temperature distribution. The distribution of operating

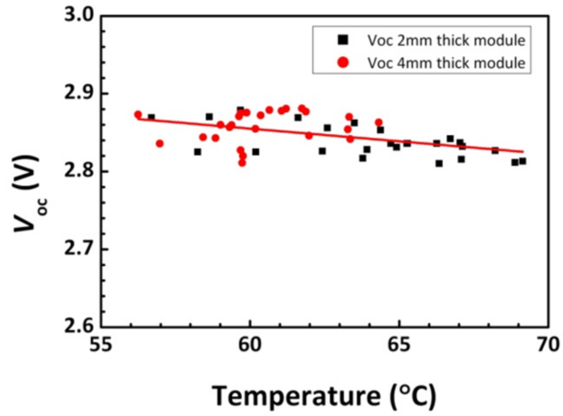

Fig. 4. Relationship between operating temperature of cell and Voc for each receiver

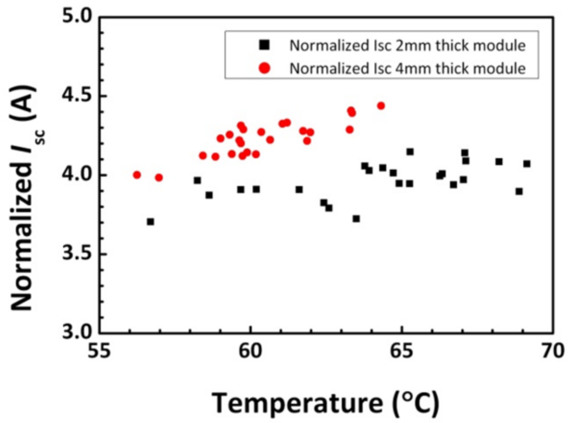

Fig. 5. Relationship between operation temperature of cell and Isc for each receiver.

temperature is important for Isc and module efficiency of CPV module.

4. Conclusion

We analyzed the temperature distribution in 820X module. There was a correlation between operating temperature and Voc. The temperature coefficient was estimated as −3.26 mV/°C. The maximum Isc of 2 mm thick back chassis was low in comparison with 4 mm. A reason for the lower Isc is higher strain due to the ununiformity of temperature distribution. The distribution of operating temperature became a dominant factor for Isc and module efficiency.

Acknowledgements

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