Measurement procedure for bifacial PV devices

Y. Hishikawa, H. Shimura, Y. Ishii, M. Yoshita

Research Center for Photovoltaics, National Institute of Advanced Industrial Science and Technology (AIST), Japan
OUTLINE

• Review: Present characterization procedure at AIST
  (separately front and back sides)
• Confirmation of basic feature of bifi PV: Is the $I_{sc}$ of bifi cell sum of the front and rear values? Is $I_{sc}$ proportional to irradiance?
• Use of linear extrapolation for evaluating performance at > 1sun can simplify the bifi measurement.

Detailed data to be presented at PVSEC-26, (Oct. 2016) Singapore
Measurement configuration
~ effect of reflected light ~

\[
\frac{I_{sc,\text{back}}}{I_{sc,\text{front}}} \approx \frac{\int T(\lambda) R(\lambda) E_{\text{front}}(\lambda) S_{\text{back}}(\lambda) d\lambda}{\int E_{\text{front}}(\lambda) S_{\text{front}}(\lambda) d\lambda}
\]

\( S_{\text{front}}(\lambda) \): SR of front side
\( S_{\text{back}}(\lambda) \): SR of back side

Measurement configuration
~ correction of IV ~

\[ I_2(V) = I_1(V) - C \cdot I_{sc,front} \]

Determination of front and back side performances
⇒ Estimation of bifacial performance
(Linearity is assumed. However,

Nonlinearity of c-Si solar cells

Linearity is **not** guaranteed even for monofacial operation

![Diagram showing spectral response vs. wavelength with a comparison between with and without white bias, and experimental results versus irradiance. The graph indicates that spectral response is affected by irradiance, with a notable difference between with and without white bias.]
Nonlinearity of bifi solar cells

Precise evaluation by superposition of light method

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<tr>
<th>1</th>
<th>0.8</th>
<th>0.6</th>
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<td>0.2</td>
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<td>1 + 0.2</td>
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Nonlinearity of bifi solar cells

Precise evaluation by superposition of light method

Precise control & monitor
(typical value)
Lamp voltage: ±0.02%~±0.04%
Lamp current  ±0.02%~±0.04%
Lamp temperature  240 ± 1 °C
(lamp box)
Irradiance  ±0.05%
Nonlinearity of bifi solar cells

- Front and back IV curves are practically identical when the $I_{sc}$ and T are specified.
- $I_{sc}$ vs. irradiance is practically linear (nonlinearity is estimated to be $< 0.06\%$ at $0.1 - 1.2 \text{ kW/m}^2$) (preliminary results for the present samples)

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SUMMARY

• Present characterization procedure at AIST (separately front and back sides)
• **Linearity** of bifi PV should be confirmed for precise performance evaluation. ($I_{sc}$ nonlinearity of the present study is estimated to be $< 0.06\%$ at $0.1 – 1.2\ kW/m^2$) (preliminary results for the present samples)
• **Linear extrapolation**: Precise estimation of bifacial IV curve ($F&B$ $0 – 1.2\ kW/m^2 + \alpha$) from front and back IVs at two irradiance levels is possible.
• Module I-V: further confirmation needed (shading by J-box etc.)

This work was supported by NEDO under METI