Calibration Method of Solar Simulator for Measuring Performance of Dye-Sensitized Solar Cells

Seigo Ito,[a] Takayuki Kitamura,[b] Yuji Wada,[b] and Shozo Yanagida[b*]

[a]*Venture Business Laboratory, Osaka Univ., Suita, Osaka 565-0871, Japan.*

[b]*Material and Life Science Engineering Department, Graduate School of Engineering, Osaka Univ., Suita, Osaka 565-0871, Japan.*

Dye-sensitized solar cells (DSC) have recently emerged as a promising inexpensive alternative to conventional p-n junction solar cells. The DSC is based on large band gap semiconductors sensitized to visible light with dyes. Optimization of DSC designs requires a solar simulator with a spectral irradiance that closely matches AM 1.5 in visible light region. However, the calibration error can generally result from a mismatch between the spectrum of a simulator and that of AM 1.5, and from a mismatch between the action spectrum of the reference cell and that of the test cell.

In a case of evaluation of amorphous Si solar cells that are similar to DSC in the action spectra, photocurrents under the natural sun are measured using a crystal Si solar cell (c-Si) capped by an IR-cut filter as a reference cell. For the calibration of a solar simulator the power of the solar simulator was adjusted with the photocurrents of the reference cells. This procedure can lower the spectral mismatch, since the action spectra of IR-cut c-Si is similar to that of an amorphous Si solar cell. Action spectra of an amorphous Si solar cell and DSC are similar each other, and this calibration method for an amorphous Si solar cell can be applied to DSC. In this work, we carried out the measurements of DSC by using a solar simulator calibrated by c-Si with/without an IR-cut filter (KG-5) and concluded that the calibration method of a solar simulator for an amorphous Si solar cell was suitable for the measurements of DSC.

Short-circuit photocurrents of the natural sun were measured for a reference c-Si ($I_{\mathrm{c-Si}}$) and a reference c-Si with IR-cut filter ($I_{\mathrm{IR-cut-c-Si}}$). Figure 1 shows linearity in the relation of power of the natural sun and photocurrent ratio of the reference cells ($I_{\mathrm{c-Si}}$ /$I_{\mathrm{IR-cut-c-Si}}$). This linearity comes from the spectral mismatch between the reference cells. This method measuring the different natural sun light provides $I_{\mathrm{c-Si}}$ and $I_{\mathrm{IR-cut-c-Si}}$. Energy conversion efficiencies of DSC can be measured using the natural sun and a solar simulator adjusted by $I_{\mathrm{c-Si}}$ and $I_{\mathrm{IR-cut-c-Si}}$.

Figure 2 shows energy conversion efficiencies of DSC adjusted using $I_{\mathrm{c-Si}}$ and $I_{\mathrm{IR-cut-c-Si}}$. The efficiencies of DSC using the solar simulator adjusted by $I_{\mathrm{c-Si}}$ were higher than by $I_{\mathrm{c-Si}}$. Hence, the irradiance in the visible region of the solar simulator adjusted by $I_{\mathrm{c-Si}}$ was higher than by $I_{\mathrm{IR-cut-c-Si}}$.

Figure 3 shows mismatches between a solar simulator and the natural sun in measurements of DSC. Measurement errors due to spectral mismatch between a solar simulator and the natural sun can be lowered by using $I_{\mathrm{IR-cut-c-Si}}$ than using $I_{\mathrm{c-Si}}$ to modify spectral irradiance, and then the error was only ~2%. This information includes the relative spectral response of the reference cell, the relative spectral response of the cell under test, and the relative spectral irradiance of the simulator (over the spectral range of the cell response).

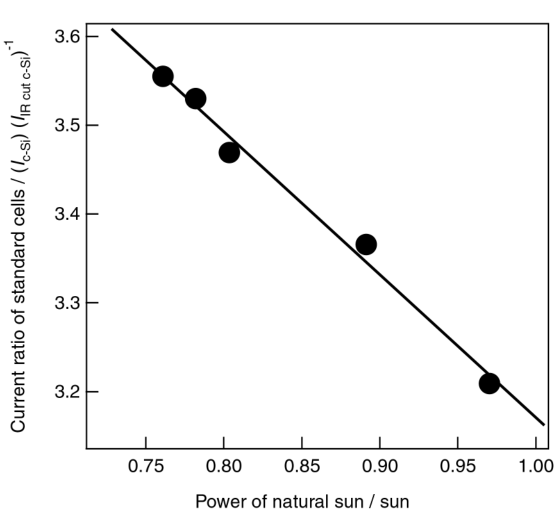

Fig. 1. Relation between the power of natural sun and the photocurrent ratio of reference cells: c-Si and IR-cut c-Si.

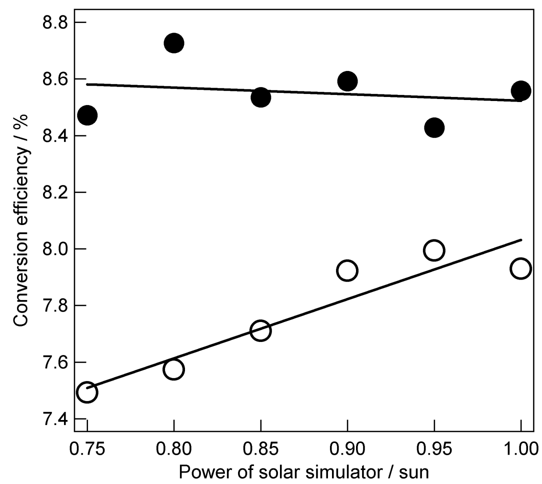

Fig. 2. Differences of DSC conversion efficiencies calibrated using $I_{\mathrm{c-Si}}$ (●) and $I_{\mathrm{IR-cut-c-Si}}$ (○). Each data was an average of four DSC.

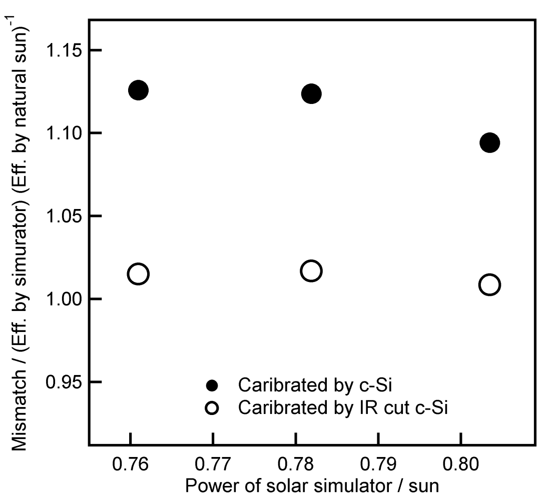

Fig. 3. Mismatches between a solar simulator and the natural sun in the measurements of DSC.