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Application News

Spectrophotometric Analysis No.A409

Absolute Reflectance Measurement of Anti-Reflective Film for Solar Cells Using the SolidSpec-3700

Solar cells, devices which convert light energy to electrical energy, are presently undergoing active research. Various innovations are being implemented to raise the conversion efficiency, and one of these is anti-reflective film which is used to increase the amount of sunlight reaching the cell. Anti-reflective film suppresses the reflection of incidence light from the surface of the solar cell, thereby preventing the loss of light energy. Therefore, measuring the reflectance of anti-reflective film is an effective means of evaluating the performance of the film. Here we introduce the measurement of absolute reflectance of anti-reflective film for solar cells using the SolidSpec-3700 ultraviolet-visible-near infrared spectrophotometer.

■ Solar Cell

There are various types of solar cells, including silicon, compound and organic types, however, the most commonly used type of solar cell is presently the silicon-based solar cell. The basic structure of this type of solar cell is shown in Fig. 1. The semiconductor part in the central region of the cell comprising n-silicon and p-silicon is where conversion of light energy to electrical energy occurs. The anti-reflective film is formed on the top to prevent the loss of light energy.
The smaller the degree of reflectance from this surface, the less will be the loss of light energy due to reflection.

■ Instrument, Attachment and Sample Used for Measurement

We conducted measurement of the absolute reflectance of the anti-reflective film deposited on top of the silicon wafer using a SolidSpec-3700 UV-VIS-NIR spectrophotometer equipped with a variable angle absolute reflectance attachment. A photograph of the SolidSpec-3700 is shown in Fig. 2, a photograph of the variable angle absolute reflectance attachment is shown in Fig. 3, and a photograph of the mounted sample is shown in Fig. 4. Use of the variable angle absolute reflectance attachment enables measurement of the absolute reflectance while freely adjusting the angle of incident light. (For details of the variable angle absolute reflectance attachment, refer to Application News No. A390.)

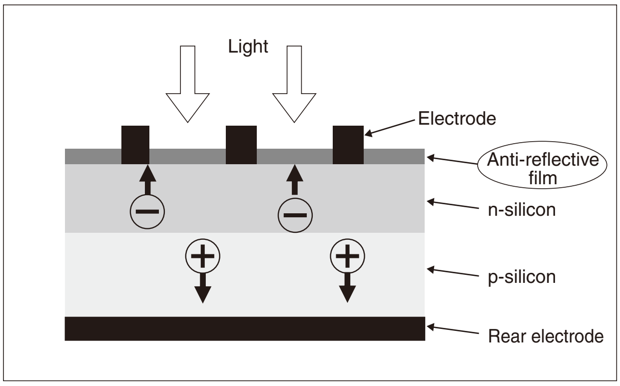

Fig.1 Basic Structure of Silicon Solar Cell

Fig.2 SolidSpec-3700 UV-VIS-NIR Spectrophotometer

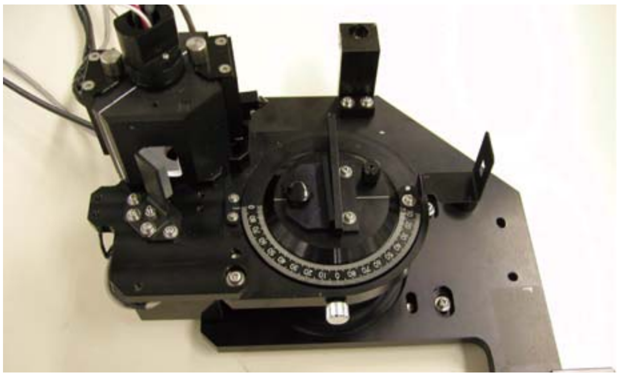

Fig.3 Variable Angle Absolute Reflectance Attachment

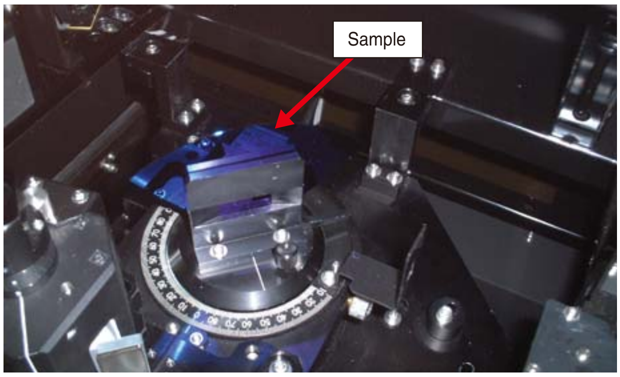

Fig.4 Sample Set on Variable Angle Absolute Reflectance Attachment

■ Absolute Reflectance Measurement of Anti-Reflective Film on a Solar Cell

The absolute reflectance of anti-reflective film (SiN film) used on top of the silicon wafer of a solar cell was measured with a variable angle absolute reflectance attachment using various angles of incidence (5˚/15˚/30˚/45˚/60˚). The results of measurement of the s-polarized light are shown in Fig. 5, and those for the p-polarized light are shown in Fig. 6. The analytical conditions are shown in Table 1. Here, the s-polarized light indicates a light component that vibrates vertically with respect to the plane of incidence, and the p-polarized light indicates a light component that vibrates parallel to the plane of incidence. (For details, refer to Application News No. A394.)
From Fig. 5 and Fig. 6, it is clear that this film sample suppresses reflectance chiefly in the visible light region, showing extremely small reflectance values in the wavelengths of 500 nm - 600 nm. In addition, Fig. 7 shows a magnified portion of the s-polarized light measurement results of Fig. 5. Extremely low reflectance of about 0.2% is seen at 575 nm using incident angles of 5˚ and 15˚, indicating that reflectance is greatly suppressed when the angle of incidence is close to vertical with this sample.
The above results indicate that one means of effectively evaluating anti-reflective films for use in solar cells is by measurement of absolute reflectance using a UV-VIS-NIR spectrophotometer.

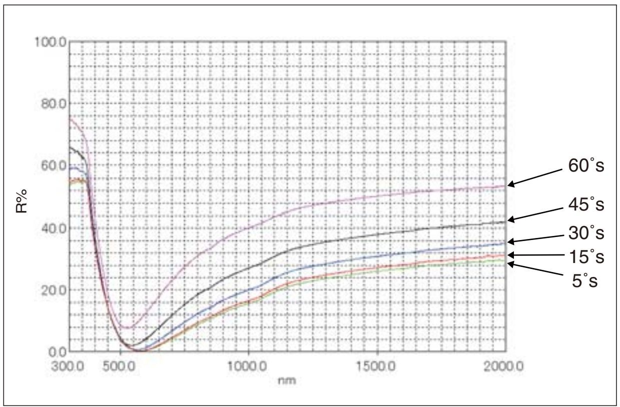

Fig.5 Absolute Reflectance Spectra Using s-Polarized Light at 5˚, 15˚, 30˚, 45˚ and 60˚ Incidence

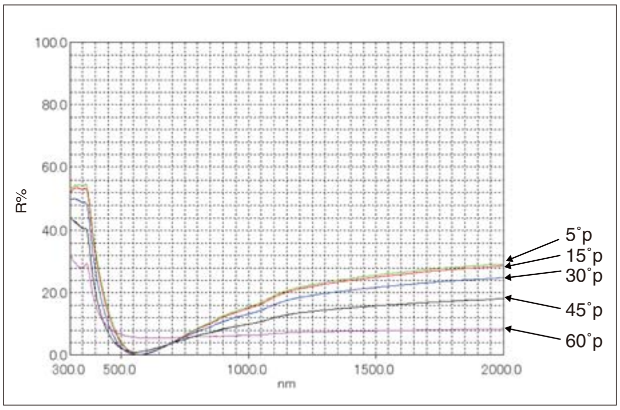

Fig.6 Absolute Reflectance Spectra Using p-Polarized Light at 5˚, 15˚, 30˚, 45˚ and 60˚ Incidence

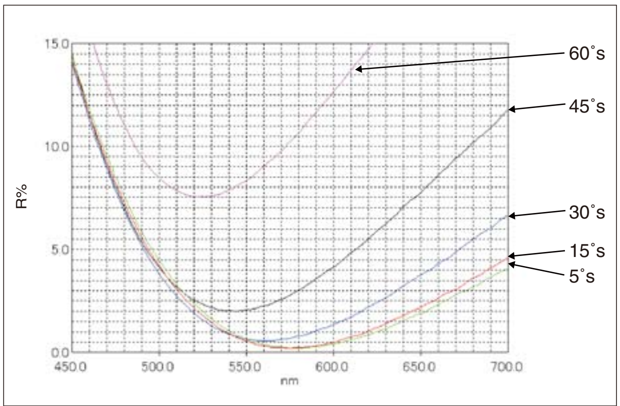

Fig.7 Spectra of Fig.5 Magnified in Range from 450 - 700 nm

Table 1 Analytical Conditions

Measurement Wavelength Range	: 300 nm to 2000 nm
Scan Speed	: Medium
Sampling Pitch	: 1.0 nm
Photometric Value	: Reflectance
Slit Width	: (32) nm
Lamp Switching Wavelength	: 310 nm
Grating Switching Wavelength	: 720 nm
Detector Switching Wavelength	: 870 nm, 1650 nm

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