SHIMADZU APPLICATION NEWS

LAAN-A-UV-E011

● SPECTROPHOTOMETRIC ANALYSIS

No.A394

Variable Angle Absolute Reflectance System for SolidSpec-3700

– Absolute Reflectance Measurement of Silicon Wafer Surface at Any Incident Angle –

Use of a variable angle absolute reflectance attachment allows measurement of the absolute reflectance at any desired angle of incidence (5˚ to 70˚). This Application News introduces the measurement results of the absolute reflectance of a silicon wafer's mirror-polished surface at various incident angles using the SolidSpec-3700 UV-VIS-IR spectrophotometer with an installed variable angle absolute reflectance attachment (Fig.1).

■ Absolute Reflectance Measurement

In reflectance measurement, the reflectance of s-polarized light and p-polarized light are different when using a large angle of incidence. The vibrating component of an electric field vector vertical to the incidence plane is called s-polarized light, and the vibrating component parallel to the incident plane is called p-polarized light. (see Fig.2) The absolute reflectance angle relative to various metals and optical glass is shown in Fig.3. When the incident angle is small, there is not a large difference between the reflectance of s-polarized light and p-polarized light; however, as the incident angle increases, this difference in reflectance becomes increasingly large. Therefore, when absolute reflectance measurement is conducted at a large angle of incidence, it is necessary not only to fix the incident light to s-polarization/p-polarization using a polarizer, but to measure each independently as well.

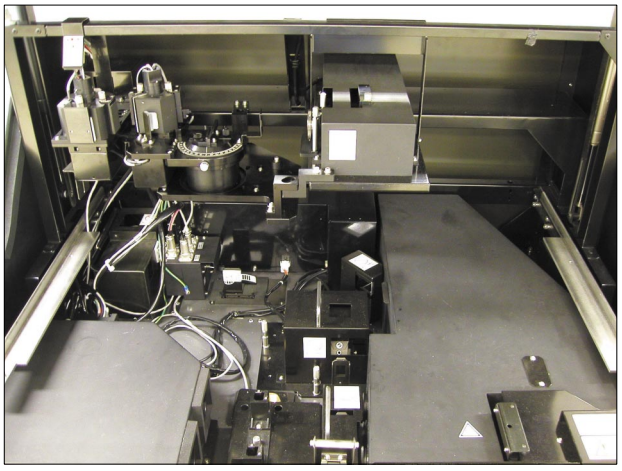


Fig.1 Variable Angle Absolute Reflectance Attachment Mounted in the SolidSpec-3700

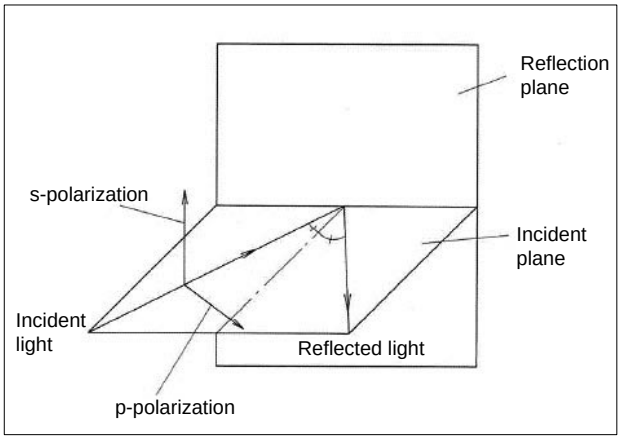
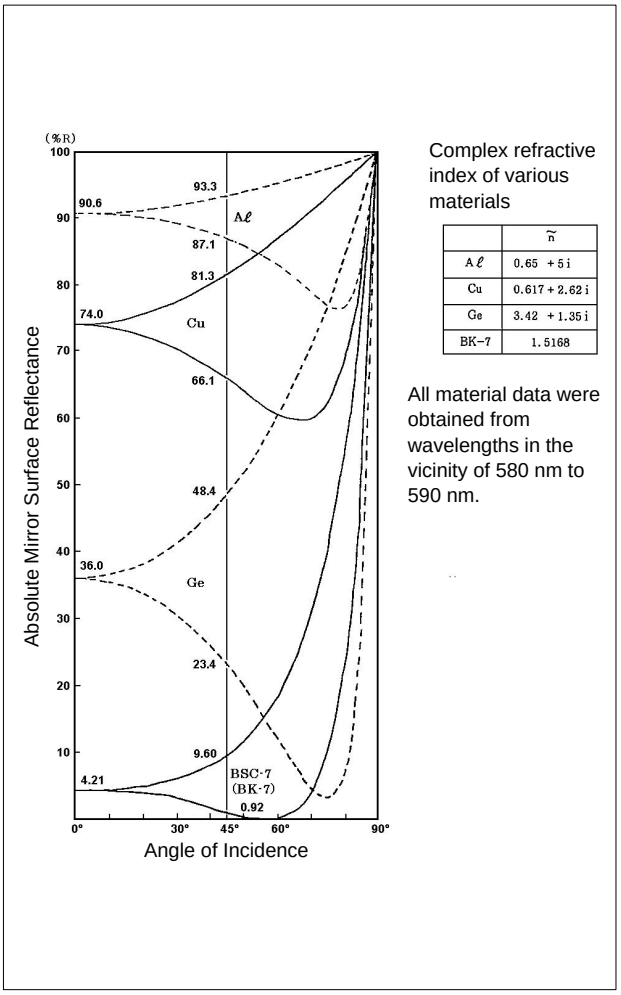


Fig.2 s-Polarization and p-Polarization



	$\tilde{n}$
Aℓ	0.65 + 5i
Cu	0.617 + 2.62i
Ge	3.42 + 1.35i
BK-7	1.5168

Fig.3 Reflectance of Various Materials

■ Absolute Reflectance of a Silicon Wafer Measured at Various Incident Angles

We conducted measurement of the absolute reflectance of a silicon wafer's mirror-polished surface at various angles (5 ˚/12 ˚/20 ˚/45 ˚/60 ˚) using a variable angle absolute reflectance measurement attachment. Those results are shown in Fig.4 and Fig.5.It is evident from the results that as the incident angle became larger, s-polarization reflectance increased, while p-polarization reflectance decreased. Generally, a polarizer is unnecessary for reflectance measurement when using a small incident angle, while a polarizer is used for reflectance measurement with a large incident angle, and that boundary is in the range of 10 ˚ to 15 ˚. With a 5 ˚ incident angle, the reflectance of s-polarized light and p-polarized light is in agreement within the measurement accuracy of the instrument. The reflectance measurement result at a 12 ˚ incident angle is shown in Fig.5, and a difference of about 1.5 % is seen in the reflectance of the s-polarized light and p-polarized light. When conducting measurement with an incident angle of 10 ˚ to 15 ˚, the necessity of a polarizer should be judged according to the measurement objective and the required accuracy. The measurement parameters used in this measurement are shown in Table 1.

The absolute reflectance of a silicon wafer was calculated at 600 nm using the n and k values of the complex refractive index (n+ik) of silicon (Si).* Those calculation results and the measurement results are shown in Fig.6 (◯ indicates calculated result). The actual measured value and calculated value correspond well at the respective incident angles, proving the correctness of the data obtained using this measurement system.

* Applied Optics (written by Tadao Tsuruta, Baifukan)

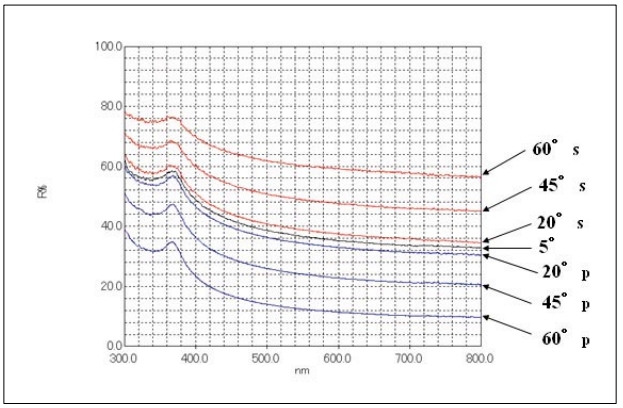


Fig.4 Absolute Reflectance Spectra of a Silicon Wafer Measured at 5 ˚, 20 ˚, 45 ˚ and 60 ˚

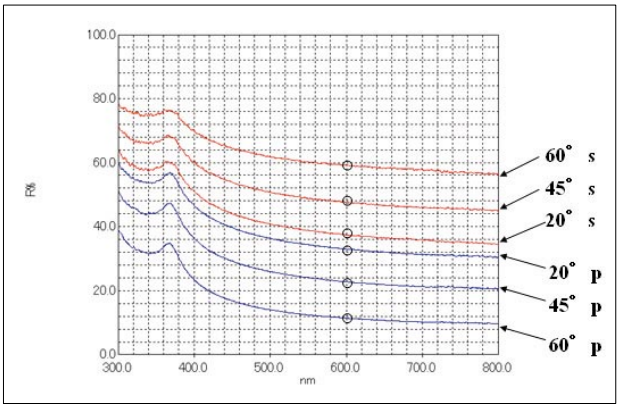


Fig.6 Calculated Values (◯) at 600 nm and Measurement Data

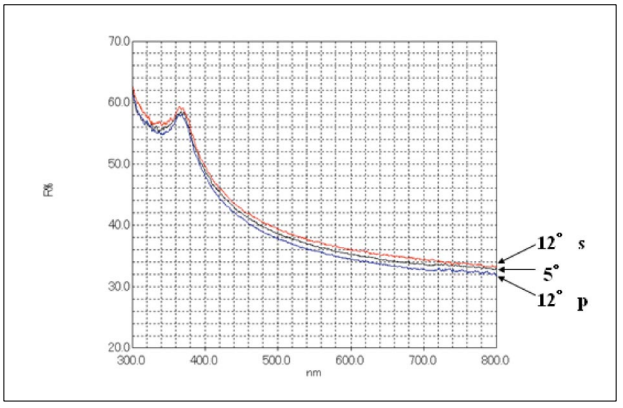


Fig.5 Absolute Reflectance Spectra of a Silicon Wafer Measured at 5 ˚ and 12 ˚

Table 1 Measurement parameters

Wavelength range	: 300 nm to 800 nm
Scan speed	: Medium
Sampling pitch	: 0.5 nm
Measurement mode	: Reflectance
Slit width	: 5.0 nm
Lamp switching WL	: 310 nm
Grating switching WL	: 720 nm
Detector switching WL	: 870 nm, 1650 nm

NOTES:

*This Application News has been produced and edited using information that was available when the data was acquired for each article. This Application News is subject to revision without prior notice.

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