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Application News

No. A612B

Spectrophotometric Analysis

LiDAR Evaluation System:

Measurement of Transmittance/Reflectance of Optical Materials

LiDAR, an abbreviation for Light Detection and Ranging, is one type of optical sensor technology. The distance and angle to a remote measurement object and its nature can be measured by scanning laser light on the measurement object and measuring the scattered light and reflected light. LiDAR systems have already been installed in aircraft and satellites and used as a ranging technology for research in geology, seismology, and other fields. Recently, LiDAR has also attracted attention as a technology for use in self-driving automobiles.

Because LiDAR is used in place of a human driver in automated driving, the LiDAR system must operate the vehicle appropriately based on detection of traffic signals, the road width, oncoming vehicles, pedestrians, and other conditions. LiDAR is extremely important as a technology for sensing objects that may become obstructions during driving, and thus is a key technology for realizing automated driving.

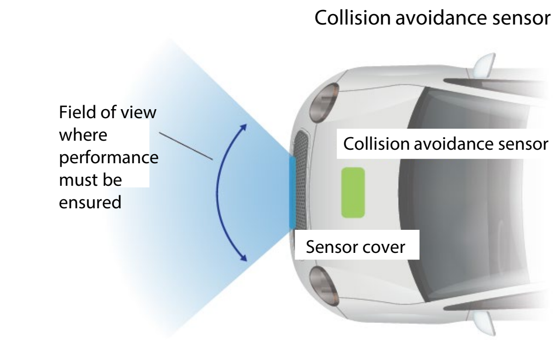

Fig. 1 Installation Positions of Collision Avoidance Sensor and Sensor Cover

Fig. 1 shows an example of the installation positions of the collision avoidance sensor and sensor cover. The laser light scanned from the LiDAR device is transmitted through a sensor cover and irradiated on remote measurement objects. Therefore, it is necessary to understand the optical properties of the materials, such as the transmittance of the sensor cover for the laser used in the LiDAR.

The viewing angle of LiDAR is also one important performance feature. For example, when a LiDAR device is mounted on the front of a vehicle, as in Fig. 1, the widest possible viewing angle is necessary so as to cover a wide area in front of the car.

The wavelength regions and quantity of laser light transmitted through the sensor cover change depending on the incident angle of the laser and the position of the sensor cover. In other words, because the optical properties of the cover material have a large effect on LiDAR performance, a wide range of measurements with different incident light angles and wavelength regions is necessary in a LiDAR evaluation system.

Here, the optical properties of two types of samples were evaluated using an ultraviolet-visible light (UV-VIS) spectrophotometer.

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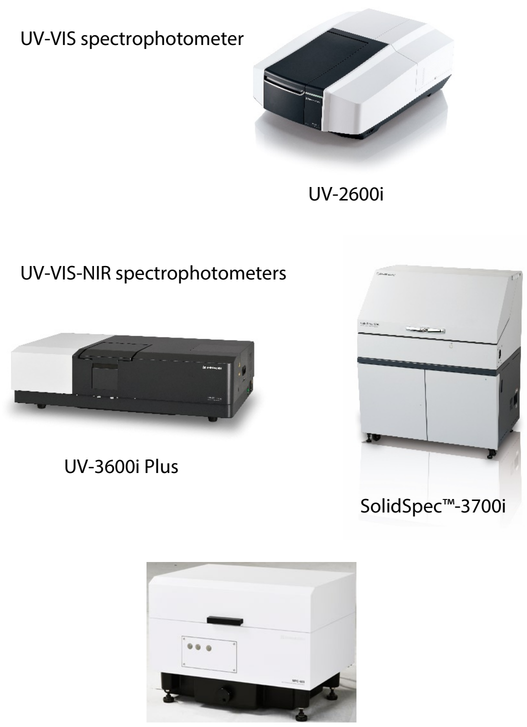
Spectrophotometers Supporting LiDAR Evaluation Systems

Because the wavelength regions that can be measured with UV-VIS spectrophotometers differ depending on the type of device, it is necessary to select a suitable device considering the wavelength of the laser light to be used in LiDAR. In addition, evaluation of the angular dependence of transmittance (incident angle: from 0°) and reflectance (incident angle: from 5°) is also possible by combining a large sample compartment and a variable angle absolute reflectance measurement unit. Table 1 shows the ranges supported by various Shimadzu spectrophotometers, and Fig. 2 shows the appearance of the devices.

Table 1 Ranges Supported by Various Devices

UV-VIS spectrophotometer	UV-2600i	UV-3600i Plus	SolidSpec-3700i
Wavelength region	185-900 nm	185-3,300 nm	240-2,600 nm
Reflectance measurement	Incident angle: 5° - 70°, acceptance angle: 10° - 140°		
Transmittance measurement	Acceptance angle: 0° - 90°		
Sample size	25 × 25 mm - 70 × 70 mm, thickness: max. 15 mm		

* With the UV-2600i and UV-3600i Plus, a large sample compartment (MPC-2600A or MPC-603A) is necessary in addition to a variable angle absolute reflectance measurement unit.



Large sample compartment/variable angle absolute reflectance measurement unit

Fig. 2 Appearance of Devices

Reflectance Measurement

Fig. 3 shows a Shimadzu sample compartment of SolidSpec™-3700i UV-VIS-NIR spectrophotometer equipped with a variable angle absolute reflectance measurement unit, and Fig. 4 shows the condition with the sample installed. Use of the variable angle absolute reflectance measurement unit makes it possible to measure transmittance/absolute reflectance with different incident angles of light on the sample. Because measurements are affected by the polarization property when the incident angle is large (approximately 15° or larger), a large polarizer set was used in measurements with angles of 20° or more in this experiment.

First, baseline correction was carried out by irradiating light on the sample side integrating sphere without a sample set in the device, followed by setting and measurement of the sample at an arbitrary angle. The positions of the sample and the detector can be adjusted (manually) in units of 1°. Table 2 shows the measurement conditions.

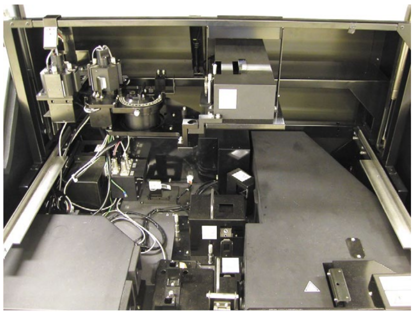


Fig. 3 Sample Compartment of SolidSpec-3700i Equipped with Variable Angle Absolute Reflectance Measurement Unit

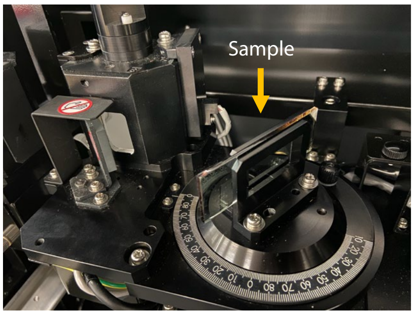


Fig. 4 Condition with Sample Set in Variable Angle Absolute Reflectance Measurement Unit

Table 2 Measurement Conditions

Instruments	:	SolidSpec-3700i UV-VIS-NIR spectrophotometer Variable angle absolute reflectance measurement unit Large polarizer set
Wavelength range	:	300 - 2,000 nm
Scan speed	:	Low
Data interval	:	1.0 nm
Slit width (automatic switching)	:	8 nm (UV - visible), 20 nm (near infrared)
Light source switching wavelength	:	310 nm

Fig. 5 and Fig. 6 show the results of a reflectance measurement of a glass base plate (thickness: 2 mm) with an infrared reflective film. The incident angles of the light were 10°, 20°, 40°, and 60°. Here, s-polarized light means light with an oscillation component perpendicular to the incident plane, and p-polarized light means light with a parallel oscillation component.

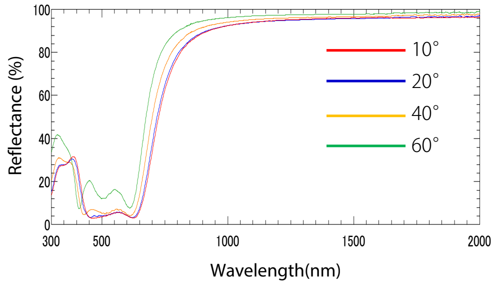


Fig. 5 Fig. 5 Plate with Infrared Reflective Film (s-Polarized Light (Polarizer: 0°))

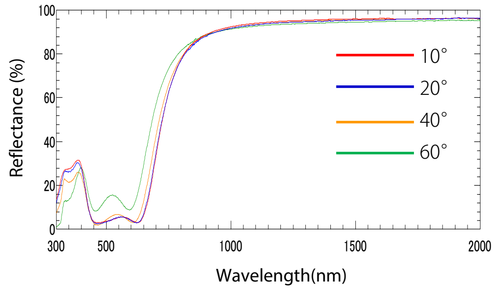


Fig. 6 Results of Reflectance Measurement of Glass Base Plate with Infrared Reflective Film (p-Polarized Light (Polarizer: 90°))

From Figs. 5 and 6, it can be understood that this material has high reflectance for 1,000 to 2,000 nm (near infrared light) and low reflectance for 300 to 800 nm (UV to visible light). In addition, since there is no change in the size of reflectance due to differences in the incident angle of the light, it can be said that this material has low angular dependence. This experiment also revealed that the polarization property is small, as no large difference could be seen in the results for s- and p-polarized light.

Transmittance Measurement

Fig. 7 shows the results of a transmittance measurement of an optical filter. The incident angles of the light were 20°, 40°, and 60°. Light in the 350 to 500 nm wavelength range (visible light) was not transmitted, and transmittance changed greatly depending on the incident angle, indicating high angular dependence.

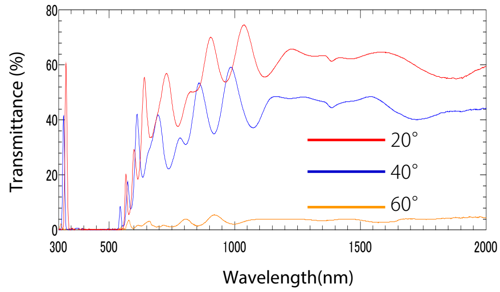


Fig. 7 Results of Transmittance Measurement of Optical Filter (s-Polarized Light)

Conclusion

A glass base plate with an infrared reflective film and an optical filter were measured using a SolidSpec-3700i UV-VIS-NIR spectrophotometer and variable angle absolute reflectance measurement unit. The optical properties of both samples could be evaluated by measuring reflectance and transmittance at various incident light angles.

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