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Application News

No. A556

Spectrophotometric Analysis

Evaluation of Transmittance/Reflectance Spectra of Dielectric Multilayer Films - Utilizing a Variable Angle Measurement Unit -

Dielectric multilayer films are coated on various optical elements such as lenses, mirrors and filters. They are also applied to items familiar to us such as cameras and binoculars. In addition, they are often utilized in photometers and are a very important optical element.

Here, we describe using a UV-VIS spectrophotometer with a variable angle measurement unit to measure the transmittance and reflectance spectra of filters coated with dielectric multilayer films.

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Sample Measurement Using a Variable Angle Measurement Unit

Fig. 1 shows the sample compartment of the MPC-2600A multi-purpose large sample compartment with a variable angle measurement unit mounted. Fig. 2 shows the structure of the variable angle measurement unit which employs a goniometer system that rotates the sample mounting stage and the detector (integrating sphere) coaxially. An arbitrary incident angle of light to a sample can be set. Transmittance measurement of a sample at an arbitrary incident angle is performed by rotating the sample mounting stage while keeping the integrating sphere position set at 180 degrees. In addition, the absolute specular reflectance can be measured by setting the incident angle of light to the sample (5 to 70 degrees) by rotating the sample mounting stage while also changing the detector position (10 to 140 degrees).

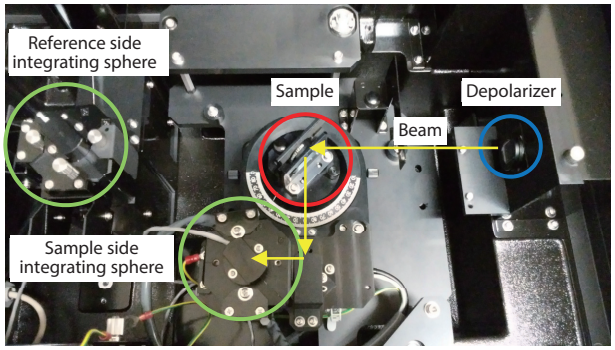

Fig. 1 Sample Compartment of MPC-2600A with Variable Angle Measurement Unit Mounted

Table 1 Analytical Conditions

Instrument Used	: UV-2600, MPC-2600A, Variable angle measurement unit, Quartz depolarizer*1
Measurement Wavelength Range	: 350 to 800 nm
Scanning Speed	: Medium speed
Sampling Pitch	: 1.0 nm
Slit Width	: 5.0 nm

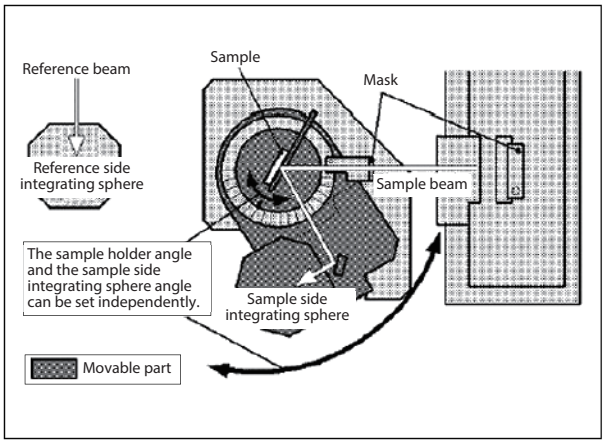

Fig. 2 Structure of Variable Angle Measurement Unit

Transmittance Spectra Measurement of Dielectric Multilayer Films

Two commercial band-pass filters which can selectively transmit light of a specific wavelength range by means of dielectric multilayer films were measured. The center wavelength of these filters was 500 nm and 730 nm respectively. Fig. 3 and 4 show the transmittance spectra measured by changing the incident angle of light to the band-pass filters. Table 1 shows the analytical conditions. A quartz depolarizer was used to depolarize any polarized light during measurement.

When the incident angle of light was 0 degrees, it was confirmed that light was transmitted at the center wavelength. In addition, when the incident angle increased, the transmitted wavelength region shifted to the blue and transmittance also decreased. It is assumed that light is not transmitted in regions other than the center wavelength because it is either absorbed or reflected. We therefore then measured the reflectance spectra with both filters.

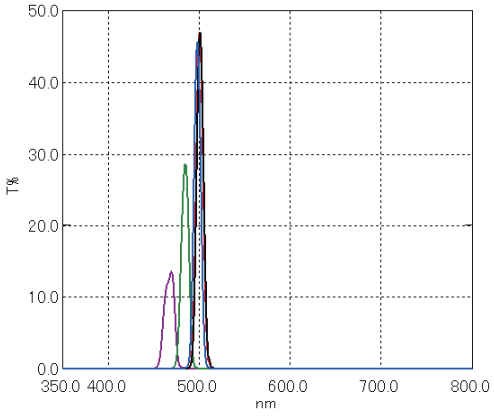

Fig. 3 Transmittance Spectra (Center Wavelength: 500 nm) Incident Angle of 0 ° (black), 5 ° (red), 12 ° (blue), 30 ° (green), 45 ° (purple)

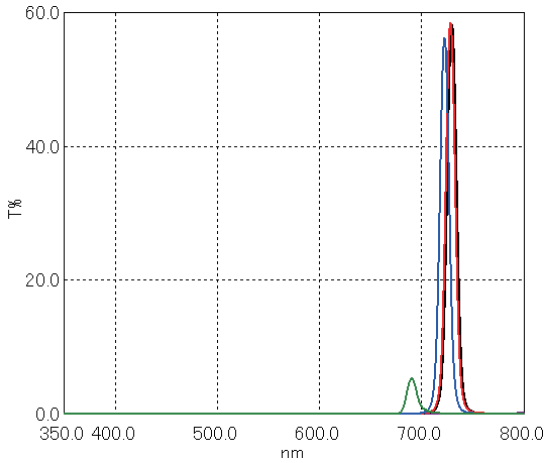

Fig. 4 Transmittance Spectra (Center Wavelength: 730 nm) Incident Angle of 0 ° (black), 5 ° (red), 12 ° (blue), 30 ° (green), 45 ° (purple)

Reflectance Spectra Measurement of Dielectric Multilayer Films

Reflectance spectra were measured with the same samples using the conditions shown in Table 2. Fig. 5 and 6 show the obtained absolute specular reflectance spectra for which the reflection angle of light was the same as the incident angle. A quartz depolarizer was used to depolarize any polarized light during measurement. For details on S/P polarization in reflectance measurement, please refer to Application News No. A394.

Table 2 Analytical Conditions

Instrument Used	: UV-2600, MPC-2600A, Variable angle measurement unit, Quartz depolarizer*1
Measurement Wavelength Range	: 350 to 800 nm
Scanning Speed	: Medium speed
Sampling Pitch	: 1.0 nm
Slit Width	: 5.0 nm

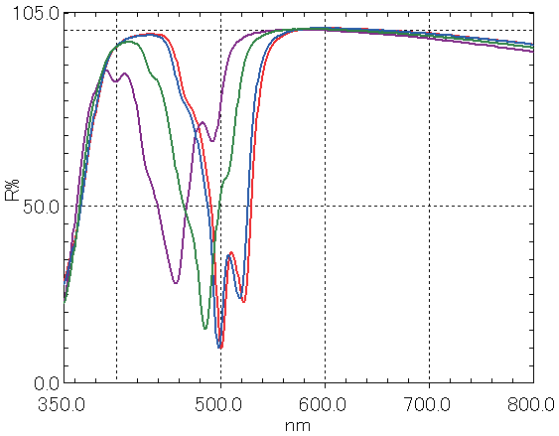

Fig. 5 Absolute Specular Reflectance Spectra (Center Wavelength: 500 nm) Incident Angle of 0 ° (black), 5 ° (red), 12 ° (blue), 30 ° (green), 45 ° (purple)

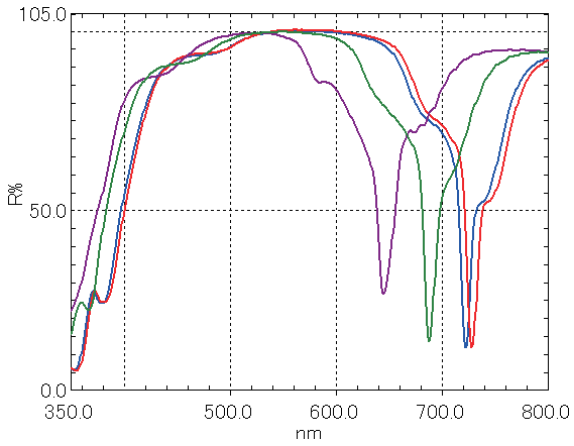

Fig. 6 Absolute Specular Reflectance Spectra (Center Wavelength: 730 nm) Incident Angle of 0 ° (black), 5 ° (red), 12 ° (blue), 30 ° (green), 45 ° (purple)

It was confirmed that the lowest reflectance is observed at the center wavelength with both band-pass filters. In addition, likewise with the transmittance spectra, it was confirmed that the wavelength at which reflectance decreases shifted to the blue as the incident angle increased. The transmittance spectra showed that the filters do not transmit light except at the center wavelength. With the reflectance spectra, however, low reflectance is observed in the ultraviolet region (less than 400 nm) and high reflectance is observed in other wavelength regions, except at the center wavelength. These results indicate that there are regions that do not transmit light by absorbing light and regions that do not transmit light by reflecting light.

Summary

The transmittance and reflectance spectra of dielectric multilayer films were measured at several incident angles using the UV-2600 and the MPC-2600A with a variable angle measurement unit mounted.

From the transmittance spectra of when the incident angle of light was 0 degrees, it was confirmed that light was transmitted at the center wavelength. In addition, when the incident angle increased, the center wavelength shifted to the blue. It was also confirmed from the reflectance spectra that the lowest reflectance is observed at the center wavelength. Also, likewise with the transmittance spectra, it was confirmed that the center wavelength shifts to the blue when the incident angle is increased. The obtained transmittance and reflectance spectra indicate that the wavelength regions where light is not transmitted are generated by the reflection and absorption of light.

*1: DEQ-2OP manufactured by Sigma Koki. Creates pseudo depolarized light.

First Edition: Oct. 2017

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