

UV/Vis/NIR Spectroscopy

Key Features

- 270 mm Spectralon® sphere allows the most accurate transmission and reflection measurements of light-diffusing materials
- Interchangeable ports (100 mm and 50 mm) enables measurements to be optimized for different diffuse sample types
- 20 mm beam size ensures representative sampling of patterned glasses providing more precise data
- Upward-looking port facilitates convenient measurement of larger samples
- Automated redirection of the beam between transmission and reflection positions permits unattended measurement of key glass properties

Upward Looking 270 mm Integrating Sphere Accessory

Introduction

The PerkinElmer® UL270 integrating sphere is a unique accessory that allows new accuracy to be achieved in the measurement of light-diffusing materials. The accessory is available for the PerkinElmer LAMBDA™ 1050 and LAMBDA 950 UV/Vis/NIR spectrophotometers.

The use of light-diffusing samples such as patterned cover glasses used in solar cells and textured/coated glasses used in buildings and greenhouses is increasing. In solar cell applications, patterned glass better captures and traps the light within the structure ensuring maximum cell efficiency. In greenhouses, the use of diffuse glass optimizes distribution of light for improved plant growth. The ability to accurately measure the transmission and reflection properties of these materials is a key requirement in the development and manufacture of high efficiency solar cells and light-diffusing glazing.

Integrating spheres are widely used for the reflectance and transmittance of light-diffusing samples. For many applications including diffuse reflection measurements, small sphere accessories are an excellent choice. The increasing demand for accurate diffuse transmittance measurements, however, poses a challenge for smaller spheres.

Working in collaboration with PerkinElmer, OMT Solutions BV™, an R&D led technology company specializing in the characterization of optical materials for the glass and solar industry, has developed an accessory to meet these demanding measurement needs. This accessory, the UL270, enables light-diffusing materials to be measured more reliably and accurately than ever before.

UL270 Accessory

The UL270 is an upward-looking 270 mm Spectralon® dual-compartment integrating sphere accessory for the PerkinElmer high-performance LAMBDA 1050/950 UV/Vis/NIR spectrophotometers (Figure 1).

The accessory utilizes a sensitive photomultiplier in the UV/Vis and an InGaAs detector in the NIR region to provide accurate transmission and reflection measurements rapidly across the entire UV/Vis/NIR 250-2500 nm range. Two port sizes are provided (100 mm and 50 mm) for samples of different diffusivity. A second surface reference mirror calibrated at 8° incidence across the range 250-2500 nm is optionally available for reflectance measurement.

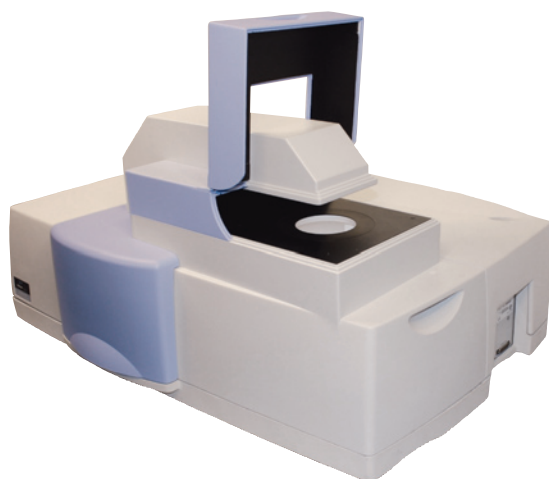


Figure 1. UL270 integrating sphere accessory in the LAMBDA 1050 spectrophotometer.

Improving Accuracy of Diffuse Transmission Measurements

Improving the accuracy of diffuse transmission measurements requires an understanding of the behavior of light-diffusing materials and careful design of the characteristics of the integrating sphere. When a diffuse sample is illuminated by the beam of the spectrometer, the transmitted light exits the sample over an area much larger than the beam diameter due to internal scattering. With the standard port sizes of ca. 20 mm much of the transmitted radiation falls outside the port area and is lost. So for accurate transmittance measurements, a sphere with a transmission port as large as 100 mm is required to capture all the transmitted light (Figure 2).

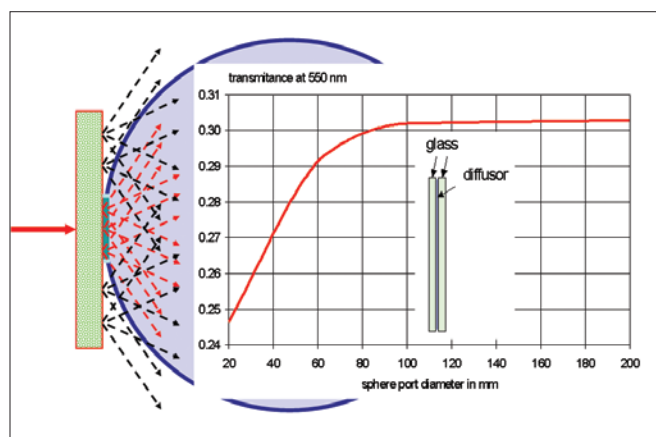


Figure 2. Schematic showing why there is a need for large port diameter when measuring light-diffusing materials (See reference 1).

Another major systematic error occurs due to the way baffles are implemented to prevent the detectors from seeing the sample at the transmittance and reflectance ports directly. In a perfect integrating sphere the light will inter-reflect on the sphere wall sufficient times to produce a uniform illumination. Ideally the detector should only see a uniform illuminated sphere wall in order to make the measurement insensitive to the way the light is distributed. Light coming directly from the sample and light reflected off the area where the transmitted beam hits the sphere wall has a greater intensity towards the detector than the light reflected off the rest of the sphere wall. For this reason, baffles are introduced to prevent the detector from seeing the transmission and reflection ports of the sphere. In the case of the reference measurement without sample, the beam first hits the target which – due to its almost Lambertian properties – illuminates the entire sphere. When a light-diffusing sample is put in front of the sphere the transmitted beam not only hits the target but also the surrounding area that is not screened from the detector. As a result, the transmittance of the sample will be overestimated.

In the UL270 these issues have been addressed by using a larger sample port and a baffle design that prohibits the detector from directly observing the sample. In addition, by using the same port for reflectance as well as transmittance measurements, only the sphere wall opposite the sample port is illuminated. Collectively these sphere design characteristics eliminate all errors in ordinate calibration.

Representative Sampling

Many light-diffusing glasses have a large pattern and consequently demand a large beam size to ensure representative sampling of the glass. The UL270 uses a 20 mm circular beam diameter unlike smaller spheres that typically use an 8 x 3 mm rectangular beam. The 20 mm beam diameter provides ca. 10 times the surface area ensuring a more representative sampling of the glass pattern.

Measurement Accuracy

Figure 3 shows a comparison of different sphere sizes. Good agreement is shown between the 620 mm sphere (red curve) and the 270 mm sphere (black curve) for both light-diffusing materials.

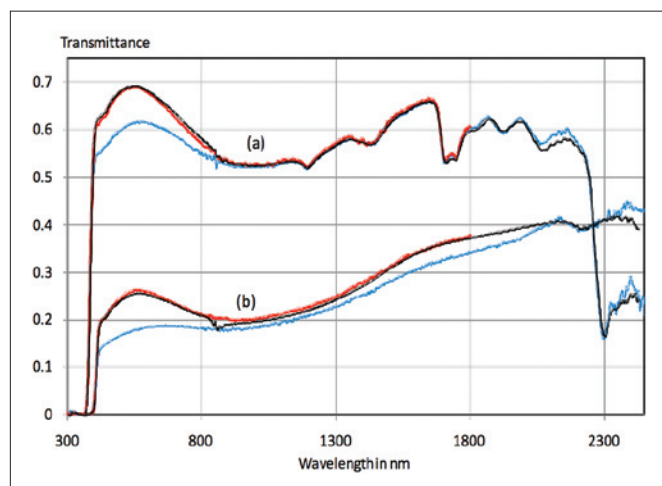


Figure 3. Comparison of transmittance measurements of two different light-diffusing materials using two different integrating spheres. (a) Glass laminate with light-diffusing PVB film laminated between two glass panes (b) Glass pane with white ceramic frit The blue curves were obtained with a standard 150 mm sphere unit, the black curves with the new 270 mm sphere and the red curves with a 620 mm sphere facility from the Fraunhofer Institute for Solar Energy Systems ISE in Germany (Reference 2).

Measurement Flexibility

In addition to accurate measurement of diffuse transmission, the UL270 also provides the opportunity to measure the diffuse reflectance without moving the sample. Two mirrors are moved under software control to divert the beam into the reflectance configuration (Figure 4). This permits unattended data collection of both modes of measurement, significantly improving productivity and sample throughput.

The ability to measure both %T and %R on the same sample allows calculation of glass properties such as the absorption loss ($\%A = 100 - \%R - \%T$). Reflection measurements also allow the optical characterization of coatings, for example anti-reflection coatings, on the glass such as film thickness as well as properties of individual layers in multi-layer coatings.

The large horizontal sample area permits the analysis of samples as large as 400 mm x 250 mm x 50 mm using the standard covers, and larger samples with customized covers.

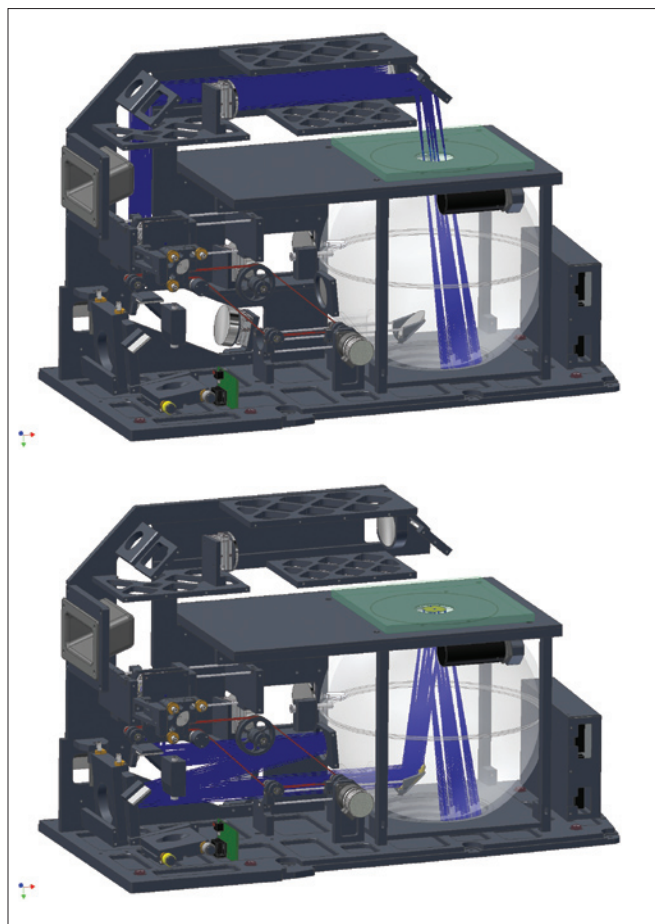


Figure 4. Transmission and Reflectance measurement configurations.

Specifications

Integrating sphere	Spectralon® 270 mm Internal Diameter
Wavelength range	250 – 2500 nm
Beam diameter	20 mm (independent of wavelength)
Detectors	UV/Vis – Photomultiplier Tube NIR – 3-stage Peltier cooled InGaAs
Sample size	Up to 430 mm x 250 mm x 50 mm with standard cover Larger samples possible with customized covers
Sampling modes	Automated switching between %T and %R
Ordinate accuracy	Less than 0.2%T and 0.5%R for a specular sample
Angle of incidence	8 degrees in both transmission and reflection

For optimum performance of the accessory, a LAMBDA 1050 is recommended. This instrument has a source-doubling mirror which provides 40% more energy at the sample than the LAMBDA 950.

The UL270 upward-looking integrating sphere accessory was developed in collaboration with OMT Solutions BV™, PO Box 775, 5600AT Eindhoven, The Netherlands.

References

1. P.A. van Nijnatten, Measuring the daylight and solar energy properties of glazing, Glass Performance Days 2007, Proceedings of the 10th International conference in Tampere, Finland (<http://www.glassfiles.com/publications/53.htm>).
2. H.R. Wilson & P. Nitz. "Eine 220 mm-Ulbrichtkugel für das Lambda-900-Spektrometer: Designüberlegungen und Messergebnisse", COSPO4 Colloquium Optical Spectrometry, Berlin, Germany, 13-14 Sept. 2004.