Measuring the optical properties of patterned and light-scattering glass

Peter A. van Nijnatten [1], Jurgen de Wolf [1], Rupert Aries [2] and Patrick Courtney [2]

1) OMT Solutions BV, High Tech Campus 9, 5656AE Eindhoven, The Netherlands (www.omtsolutions.com)

2) Perkin Elmer LAS (UK), Chalfont Road, Seer Green, Beaconsfield HP9 2FX, UK (las.perkinelmer.com)

1 Introduction

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. 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 of light-diffusing materials however poses a challenge for smaller spheres.

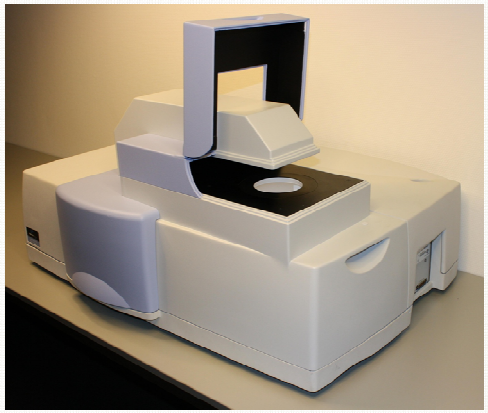

Figure 1 The 270 mm Integrating Sphere Accessory (UL270) /Lamda 1050 combination for measuring patterned and light scattering glass.

2 Diffuse Transmission and Reflection Measurements

When a diffuse sample is illuminated by the beam of the spectrophotometer, an area much larger than the beam diameter is transmitted 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 not measured.

For accurate transmittance measurements a sphere with a transmission port as large as 100 mm is required to capture all the transmitted light (see Figure 2).

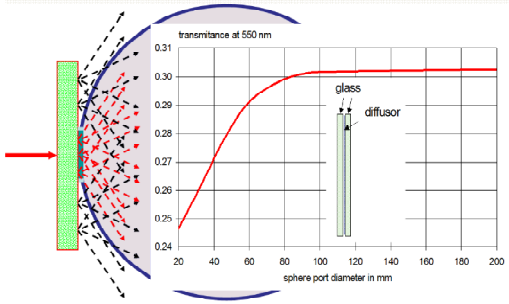

Figure 2 The effect of sphere entrance port size on the transmission of a light diffusing sample.

Another challenge lies in the ordinate calibration for Transmittance. This is achieved by measuring the 100% transmittance level without a sample present in the beam.

During calibration with traditional spheres the beam will hit a flat target at the reflection port, from which it is scattered in all directions within the sphere (see Figure 3). The detector can only capture radiation that is reflected off the sphere wall and is prevented from directly capturing the radiation reflected off the target by the presence of a small baffle that obscures the view of the reflection port. A similar baffle is present to block the detector's view of the sample port for the same reason.

Placing a diffusing sample in front of the integrating sphere however results in illumination of the sphere wall that has a different average reflectance compared to the flat target used for calibration. This introduces an error in the sample measurement.

Furthermore, part of the transmitted radiation that is reflected off the sphere wall is directly seen by the detector while another part will first hit the reflection target that is hidden from the detector which introduces further error.

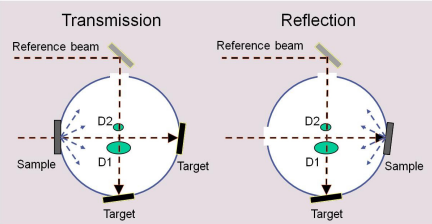

Figure 3 Traditional 150 mm sphere design shown in Transmission and reflection modes. D1 and D2 are the UV/Vis and NIR detectors.

3 Our new Integrating Sphere design

The issues described in the previous section have been addressed in our new sphere design by a single large sample port and a baffle design that prohibits the detector from directly observing the sample but not the opposite sphere wall. Collectively these sphere design characteristics eliminate the systematic sphere errors in ordinate calibration.

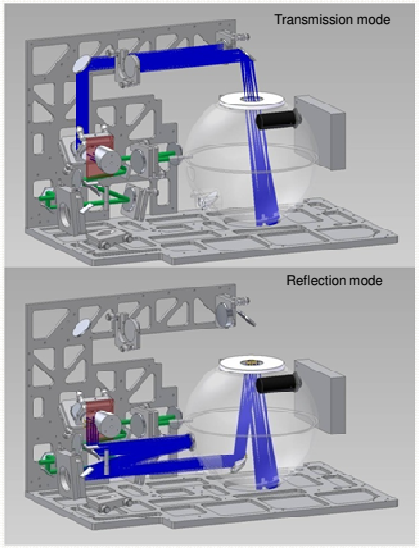

Figure 4 The UL270 shown with the sample beam in Reflection and Transmission modes. The same entrance port is used as sample position in both cases

4 Key features

- 270mm Spectralon® sphere with interchangeable ports (100mm and 50mm) allows accurate transmission and reflection measurements of light-diffusing materials.
- Wavelength independent 20mm beam size provides adequate pattern sampling ensuring representative spectra
- Horizontal (upward-facing) port facilitates measurement for larger samples.
- Automated redirection of the light beam between transmission and reflection positions which permits unattended measurement of key spectral characteristics

5 Comparison with other spheres

Figure 5 shows a comparison of different spheres:
Blue curves: Standard 150 mm sphere on Lambda 950
Red curves: 680 mm reference sphere facility (single beam spectrometer)
Black curves: 270 mm sphere on Lambda 950

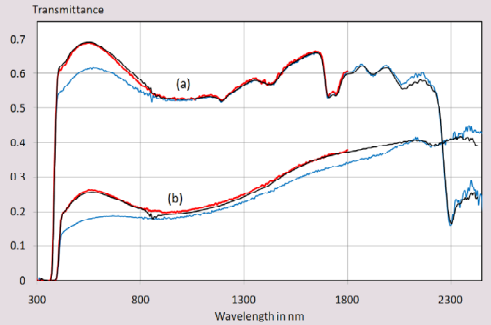

Figure 5 Comparison of different spheres for (a) glazing with diffuse PVB foil laminated between two glass panes and (b) glazing with a ceramic frit, showing excellent agreement between the UL270 and the 630 mm sphere.

6 Conclusion

Working in collaboration with PerkinElmer, OMT Solutions has developed a new Integrating Sphere accessory; the UL270. This accessory enables light-diffusing materials to be measured more reliably and accurately than ever before.

Specifications: UL270 (PerkinElmer part number L6310220)	
Integrating Sphere	Spectralon® 270mm Internal Diameter
Wavelength Range	200–2500nm
Beam diameter	fixed ∅20mm (independent of wavelength)
Detectors	UV/Vis – Photomultiplier Tube NIR - 3-stage Peltier cooled InGaAs
Sample size	Up to 430mm x 250mm x 50mm with standard cover Larger samples possible with customized covers
Sampling Modes	Automated switching between %T and %R
Ordinate Accuracy	Less than 0.2T% and 0.5R% for a specular sample
Angle of incidence	8 degrees in both transmission and reflection
For optimum performance it is recommended that a LAMBDA 1050 is used with this accessory.	