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Measuring the daylight, solar energy and thermal radiation properties of coated glazing

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Abstract

This paper gives an update on state-of-the-art techniques for the optical characterization of architectural and automotive glazing products. It discusses the use of spectrophotometers and accessories for so-called routine measurements in quality control and for measuring glazing specifications according to international standards. We introduce a new improved 150 mm integrating sphere accessory for the solar energy range. We also present new accessories capable of measuring square metre sized samples. These unique tools provide a means for determining the daylight, solar energy and thermal radiation properties of tempered glass sheets.

Keywords: spectrophotometry, solar energy properties, thermal emissivity, coated glazing

1. Introduction

The measurement of optical properties of materials in the glazing industry is a key market area for manufacturers of spectrophotometers, covering a wide range of wavelengths. The basic optical properties for the calculation of solar energy transmittance and daylight properties of coated glazing according to EN410 and ISO9050 [1, 2] are spectral reflectance and transmittance. The standard procedure is to measure the transmittance and reflectance of small samples using a UV/Vis/NIR spectrophotometer equipped with an Integrating Sphere attachment. Using the procedures described in the standards [1,2], the measured spectra are combined to obtain the reflectance and transmittance spectra for an entire double or triple glazing unit. The visible daylight and solar energy properties of the glazing unit are then calculated from these spectra by taking a weighted average. In these calculations the solar energy distribution, the human eye sensitivity and other spectral distributions are used as weighing functions.

A key property in determining the energy-saving capability of coated glazing is the emissivity of the coating. European manufacturers determine the emissivity according to the

standard EN 673 [3] using an IR spectrophotometer equipped with a specular reflectance accessory or other suitable reflectance attachment.

In this paper we discuss a new Integrating Sphere module for the UV/Vis/NIR range with enhanced sensitivity and other tools that were specially developed for measuring the daylight, solar energy and thermal radiation properties coated glass.

2. Available measurement tools

2.1 Standard measurements

Measurements of coated glazing in the UV/Vis/NIR range are generally performed in the wavelength range 250 - 2500 nm, which completely covers the UV, visible light and solar energy ranges. The transmittance measurements are performed under normal incidence. In the case of reflectance, a small angle close to the normal is being used (near-normal incidence).

The PerkinElmer LAMBDA 950 and 1050 UV/Vis/NIR spectrophotometers are currently the industry standard for ultra high performance, flexibility and convenience and are designed for analysis of coatings and component performance in both research and manufacturing of glazing products. The new LAMBDA 1050 is the highest performing UV/Vis/NIR spectrophotometer to date. With its enhanced performance in the NIR range it offers the highest sensitivity and resolution, ideal for the measurement of high performance glass and coatings. It features two large sampling compartments and a variety of snap-in modules and accessories.

Another new development is a 150 mm Integrating Sphere module (see Fig. 1) which uses an InGaAs detector for the NIR region. Like all our Integrating Sphere modules, once aligned it simply snaps into the spectrometer and is ready to be used without further adjustment.

The advantage of this new Integrating Sphere model is that its higher sensitivity results in faster measurements



Fig. 1. The L6020322 Integrating Sphere (InGaAs) snap-in Module for the LAMBDA 1050.

2.2 Measurements under oblique incidence

The standard measurement described in the previous section is not always sufficient and the need for reliable measurement techniques for measurements at oblique incidence is growing. In the past decade, considerable progress has been made in the development and of accurate tools for this purpose [4, 5]. An example of a tool that is now in use in over 35 labs in the glass industry is the Directional RT accessory shown in Fig. 2. Another tool that was recently developed for this purpose is the Automated Reflectance / Transmittance Analyser (ARTA) described in another paper in this conference[6].

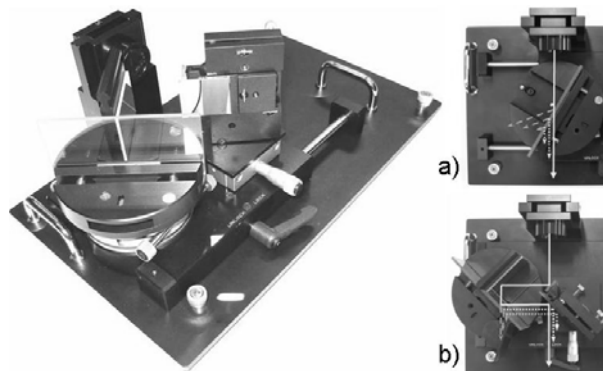


Fig. 2. The Directional Reflectance / Transmittance accessory (part nr. L631-0231) for the Lambda 800/900 and 850/950/1050 spectrophotometers: a) transmittance mode; b) reflectance mode.

2.3 Measurements on large samples

One of the problems that the glass industry is confronted with nowadays is the need to characterize large samples of tempered coated glazing. The tempering process of this glass occurs after the coating is applied and may affect the optical properties of the materials due to the high temperatures involved. Since tempering small samples is not possible and tempered samples cannot be cut without breaking into very small pieces, optical measurements on these samples require a special tool (see Fig. 3).

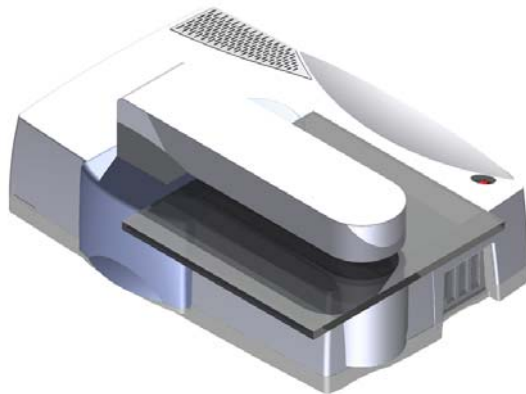


Fig. 3. Large Sample tool for measuring the UV/Vis/NIR characteristics of entire panes of coated glazing.

The set-up shown in Fig. 3 is capable of measuring both reflectance and transmittance of square metre size panes and even complete double and triple glazing units with thickness up to 45 mm. Switching between reflectance and transmittance modes is automated and both measurements are performed as a single task.

2.4 Measuring diffuse and patterned glazing

The optical properties of diffuse samples are probably the most difficult to measure with a spectrophotometer. One of the problems is that accurate measurements often require a very large integrating sphere with almost ideal properties. Since the detector area only occupies a few cm^2 of the sphere wall, a larger sphere means less energy to detect. For this reason, commercial integrating spheres for spectrophotometers are usually limited to a maximum size of 150 mm (although some special customized spheres up to 230 mm diameter have also been produced).

When a diffuse sample is illuminated by the beam of the spectrophotometer, an area much larger than that of the beam diameter is transmitting due to internal scattering. A test with a large integrating sphere that has an adjustable sample port shows that the transmittance strongly depends on the port diameter when the port is too small [6]. Only for a large enough port all transmitted radiation can be collected.

Other problems occur in measurements on substrates with a 3D surface structure. With these samples, light is deflected rather than scattered. If the pattern is sufficiently smooth ("flat"), only a slight distortion of the transmitted light occurs and measuring the transmittance and reflectance with an integrating sphere produces accurate results. However, if the glass surface shows a distinctive pattern it is extremely difficult to get accurate measurement results.

We are currently working on solving these problems and the first tests with a 250 mm sphere with a large 85 mm diameter port (see Fig. 4) are quite promising.

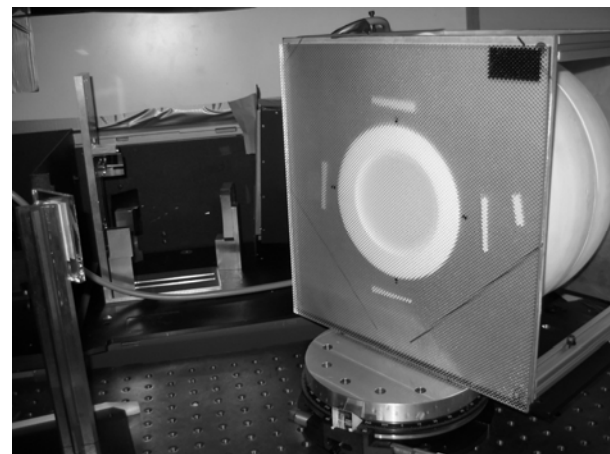


Fig. 4. Experimental set-up for testing a prototype Large Sphere tool for the Lambda 850/950/1050 systems. A patterned glass sample is positioned at the 85 mm entrance port.

We build the set-up with this sphere to measure directional transmittance of diffuse and patterned glazing. The reference beam was coupled into the sphere using a fiber bundle, similar to the ARTA [5]. A typical application for this set-up is the characterisation of greenhouse cover materials, where the transmittance for a wide range of incident angles is important (see Fig. 5). Another application is for Solar Panel cover glass.

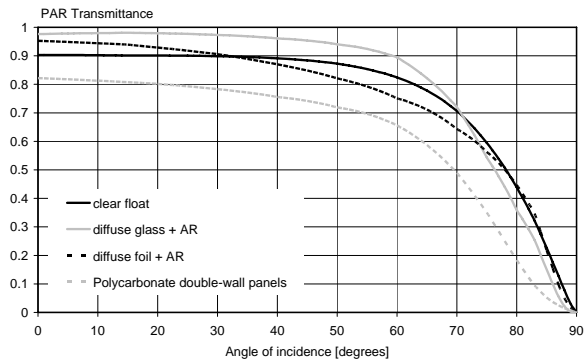


Fig. 5. Transmittance for Photosynthetically Active Radiation (PAR) measured on some greenhouse cover materials, measured with our 250 mm sphere directional transmittance set-up.

2.5 Measuring the emissivity of coated glazing

Based on the recommendations of the EU funded THERMES project [7], a tool was developed that provides a complete solution for State-of-the-Art measurement of the emissivity of coated glazing products according to EN673 and EN12898.

Basis of this tool is a unique reflectance accessory customized to fit into the accessory bay of the PerkinElmer Spectrum 100 FTIR Spectrophotometer (see Fig. 6.).

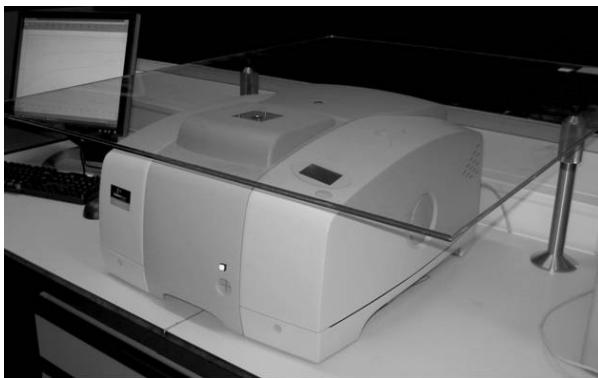


Fig. 6. Transmittance for Photosynthetically Active Radiation (PAR) measured on some greenhouse cover materials

The accessory is equipped with a 3-point sample support for maximum stability and accuracy. A stable horizontal sample positioning for large panes (> square meter size) is obtained with the help of two separate supports, height adjustable, to be positioned on the same table as the instrument. A laser alignment system is built in to enable checking and adjusting the alignment of large panes. This

makes it the only tool available on the market to do this type of measurements on coated toughened glass. Another advantage is that all optical components of the tool are protected against damage and contamination by a closed cover.

The tool is accompanied by a set of reference standards that guarantees traceability to international standards and all necessary procedures for measurement and calibration including software for calculations.

The usable wavelength range of the accessory is that of the Spectrum 100 configuration equipped with a KBr or CsI beamsplitter. The accessory is designed to measure direct reflectance of specular samples at an angle of incidence of 6 degrees (see picture below). The minimum sample size is 50 x 50 mm (with a special sample holder, this can be reduced to <15 mm). The maximum sample size is > 1 – 2 square metres (only limited by weight and handling capability).

3. Conclusion

Many of the new products of the glass and coating industry require dedicated measurement solutions. One of the current problems is how to perform the standardised measurements on large samples (tempered glass sheets). Another problem is imposed by the patterned and diffuse glazing products which are extremely difficult to measure and for which no standard measurement solution exists.

New tools have been described that provide adequate solutions for determining the daylight, solar energy and thermal radiation properties of these products.

References

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