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Optics and photonics — Spectroscopic measurement methods for integrated scattering by plane parallel optical elements

Optique et photonique — Méthodes de mesure spectroscopique pour la diffusion intégrée par des éléments optiques à plans parallèles

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Introduction

Light scattering by optical components reduces the efficiency of optical systems and degrades the quality of image formation. Imperfections of the coatings and optical surfaces of the components predominantly produce light scattering. These imperfections involve surface and interface roughness; contamination; scratches; and defects of substrates, thin films and interfaces. Imperfections divert a fraction of the incident radiation from the optical path. The spatial distribution of this scattered radiation is dependent on the power spectral density function of the surface and interface's roughness, on the wavelength of the incident radiation and on the individual optical properties of the component. The wavelength dependence of the scattered radiation is indispensable information for characterizing optical components.

This document proposes a simple spectroscopic method for probing minute scattered radiation using a conventional double-beam spectrophotometer (hereafter, double-beam spectrophotometer) that is widely used for evaluating optical components.

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Optics and photonics — Spectroscopic measurement methods for integrated scattering by plane parallel optical elements

1 Scope

This document specifies procedures for determining the spectroscopic forward scattering characteristics of coated and uncoated optical surfaces over a specified wavelength range between 350 nm and 850 nm using a double-beam spectrophotometer with an integrating sphere. This document is also applicable to the forward scattering properties at a single wavelength.

This document is applicable to spectroscopic forward scattering measurements with collection angles larger than 2,7 degrees. ISO 13696 provides a measurement method for smaller collection angles.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 291, *Plastics — Standard atmospheres for conditioning and testing*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1.1
rear surface
surface that interacts last with the transmitted radiation

[SOURCE: ISO 13696:2002, 3.1.3]

3.1.2
forward scattered radiation
fraction of incident radiation scattered by an optical component into the forward half-space excluding that within a cone with a specified angle about the normal direction

Note 1 to entry: The forward half-space is defined by the half-space that contains the beam transmitted by the component that is limited by a plane containing the rear surface of the optical component.

3.1.3
forward scattering
ratio of the power of the forward scattered radiation to the power of the incident radiation

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3.1.4
diffuse reflectance standard
diffuse reflector with known total reflectance

Note 1 to entry: Diffuse reflectance standards are usually fabricated from barium sulfate or polytetrafluoroethylene powders. The total reflectance of reflectors freshly prepared from these materials is typically greater than 0,98 within the range from 350 nm to 850 nm, and it can be considered as an 100 % reflectance standard.

[SOURCE: ISO 13696:2002, 3.1.7, modified — deleted NOTE and added Note 1 to entry.]

3.1.5
remaining scattering
ratio of the radiant power detected without a specimen to the radiant power of the incident radiation

3.1.6
minimum scattering collection angle
MCA
minimum angle from which an integrating sphere collects scattered radiation

3.1.7
angle of polarization
angle between the major axis of the instantaneous elliptical polarization state of the incident radiation and the plane of incidence

Note 1 to entry: For non-normal incidence, the plane of incidence is defined by the plane that contains the direction of propagation of the incident radiation and the normal at the point of incidence.

Note 2 to entry: The angle of polarization, γ, is identical to the azimuth, Φ (according to ISO 12005), if the reference axis is located in the plane of incidence.

[SOURCE: ISO 13696:2002, 3.1.9, modified — changed the word of "ellipse" to "elliptical polarization state" and deleted γ as term.]

3.2 Symbols

Symbols used in this document are listed in Table 1.

Table 1 — Symbols

Symbol	Term
λ	Wavelength, expressed in nanometres
λ_{start}	Measurement starting wavelength
λ_{end}	Measurement ending wavelength
$S_f(\mathrm{MCA}, \lambda_i)$	Forward scattering at λ_i, MCA
$\overline{S_f\left(\mathrm{MCA}, \lambda_{start} - \lambda_{end}\right)}$	Mean forward scattering at MCA
$\tau_{st}(\lambda_i)$	Signal value of specimen transmittance as a measurement value of the spectrophotometer
$\tau_{rs}(\lambda_i)$	Signal value of remaining scattering as a measurement value of the spectrophotometer
$\tau_{ss}(\lambda_i)$	Signal value of scattering with specimen (including remaining scattering) as a measurement value of the spectrophotometer

4 Principle

The fundamental principle (see Figure 1) of the measurement apparatus is based on the collection and integration of the forward scattered radiation. For this purpose, an integrating sphere with a diffusely

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