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Optics and photonics — Test method for total scattering by optical components

Optique et photonique — Méthodes d'essai du rayonnement diffusé par les composants optiques

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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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 172, *Optics and Photonics*, Subcommittee SC 9, *Laser and electro-optical systems,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 123, *Lasers and photonics*, in accordance with the agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 13696:2002), which has been technically revised.

The main changes are as follows:

— In the Scope, measurement range outlined in more detail and limited to 250 nm. For measurements in the deep ultraviolet between 190 nm to 250 nm, specific methods are considered and are described.

— In 3.1.6, additional Note 2 inserted for high volume scattering of the specimen and additional Note 3 inserted for comprehensive illustration of the term total scattering.

— In 3.1.7, Note extended concerning diffuse reflectance standard for wavelengths below 250 nm down to the deep ultraviolet.

— In 3.2, New symbols for total scattering, σ_{TS}, forward scattering, τ_{TS}, and backward scattering, ρ_{TS}, in Table 1.

— In Figure 1 and 4.2.5, lock-in amplifier optional. For fast data acquisition modules, no Lock-in technique may be necessary.

— In 4.2.2, calibration of the monitor detector is not necessary. The power at the sample surface shall be measured by a calibrated detector.

— In 4.2.4, additional Note 1 inserted concerning aging of the diffuse reflecting material on the inner walls of the sphere.

— In 4.2.5, additional Note inserted concerning optional components for a phase sensitive detection scheme with lock-in amplifier.

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— In 5.3, change of measurement sequence starting with power measurement calibration procedure, and determination of the signal of the unloaded sphere prior to the measurement of the specimen.

— In 6.1**,** adaptation of Formulae (1) (2) and (5) to (8) (in the denominator $V_c(r_i)$ was adapted to V_c).

— Correction of Formula (C.2).

— Annex E inserted concerning alternative method for calibrating total scatter measurements using a calcium fluoride diffuser disk.

— In Bibliography, ISO 31-6:1992 was replaced by current version ISO 80000-7, same for ISO 11146 with ISO 11146-1 and ISO 11146–2, ISO 11554 and ISO 12005 no longer cited dated. Also replacement of former citations "[5]" by latest edition of SEMI MF1048-0217[6].

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

In most applications, scattering in optical components reduces the efficiency and deteriorates the image-forming quality of optical systems. Scattering is predominantly produced by imperfections of the coatings and the optical surfaces of the components. Common surface features, which contribute to optical scattering, are imperfections of substrates, thin films and interfaces, surface and interface roughness, or contamination and scratches. These imperfections deflect a fraction of the incident radiation from the specular path. The spatial distribution of this scattered radiation is dependent on the wavelength of the incident radiation and on the individual optical properties of the component. For most applications in laser technology and optics, the amount of total loss produced by scattering is a useful quality criterion of an optical component.

This document describes a testing procedure for the corresponding quantity, the total scattering value, which is defined by the measured values of backward scattering or forward scattering. The measurement principle described in this document is based on an Ulbricht sphere as the integrating element for scattered radiation. An alternative apparatus with a Coblentz hemisphere, which is also frequently used for collecting scattered light, is described in Annex A.

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Optics and photonics — Test method for total scattering by optical components

1 Scope

This document specifies procedures for the determination of the total scattering by coated and uncoated optical surfaces. Procedures are given for measuring the contributions of the forward scattering or backward scattering to the total scattering of an optical component.

This document applies to coated and uncoated optical components with optical surfaces that have a radius of curvature of more than 10 m. Measurement wavelengths covered by this document range from the ultraviolet above 250 nm to the infrared spectral region below 15 µm. For measurements in the deep ultraviolet between 190 nm to 250 nm, specific methods are considered and are described. Generally, optical scattering is considered as neglectable for wavelengths above 15 µm.

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 11145, *Optics and photonics — Lasers and laser-related equipment — Vocabulary and symbols*

ISO 14644-1, *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness by particle concentration*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145 and the following apply.

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

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

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

3.1.1
scattered radiation
fraction of the incident radiation that is deflected from the specular optical path

3.1.2
front surface
optical surface that interacts first with the incident radiation

3.1.3
rear surface
surface that interacts last with the transmitted radiation

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3.1.4
backward scattering
fraction of radiation scattered by the optical component into the backward halfspace

Note 1 to entry: Backward halfspace is defined by the halfspace that contains the incident beam impinging upon the component and that is limited by a plane containing the front surface of the optical component.

3.1.5
forward scattering
fraction of radiation scattered by the optical component into the forward halfspace

Note 1 to entry: Forward halfspace is defined by the halfspace that contains the beam transmitted by the component and that is limited by a plane containing the rear surface of the optical component.

3.1.6
total scattering
ratio of the total power generated by all contributions of *scattered radiation* (3.1.1) into the forward or the backward halfspace to the power of the incident radiation

Note 1 to entry: The halfspace in which the scattering is measured should be clearly stated.

Note 2 to entry: The sum of the measured forward and backward scattering does not include the contribution of the bulk material in the optical component. In case the volume scattering of the component is not negligible, the total scatter losses may exceed the sum of forward and backward scattering.

Note 3 to entry: Total scattering is equal to forward or backward scattering, and is neither the sum of both nor the sum of all scattering contributions.

3.1.7
diffuse reflectance standard
diffuse reflector with known total reflectance

Note 1 to entry: Commonly used diffuse reflectance standards are fabricated from barium sulfate or polytetrafluoroethylene powders (see Table 2). The total reflectance of reflectors freshly prepared from these materials is typically greater than 0,98 in the spectral range given in Table 2, and it can be considered as a 100 % reflectance standard. For increasing the accuracy, diffuse reflectance standards with lower reflectance values can be realized by mixtures of polytetrafluoroethylene powder and powders of absorbing materials, see Reference [6]. Further concepts for diffuse reflectance standards include optical surfaces with specially prepared microstructures, metal-coated diffusers or diffuse transparent reference samples. A versatile method on the basis of a calcium fluoride diffuser disk for the wavelength range from 250 nm down in the ultraviolet range is described in Annex E.

3.1.8
range of acceptance angle
range of scattering angles in the reflecting or transmitting hemisphere, which are collected by the integrating element

Note 1 to entry: The maximum polar acceptance angle with respect to the sample normal is 85°.

Note 2 to entry: The radiant power around the specular transmitted or reflected beam is not collected by the integrating element in a cone with an opening angle of 2° or less.

3.1.9
angle of polarization
angle between the major axis of the instantaneous polarization ellipse 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 which 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.

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