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Optics and Photonics — Bulk absorption optical filters

Optique et photonique —

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Foreword

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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 03, *Optical materials and components*.

Introduction

The optical properties of a bulk absorption filter are characterized by spectrophotometric values. These values relate to the energy transported by electromagnetic waves (radiant or luminous) and they vary as a function of the wavelength. Additional influences can be caused by scattering.

NOTE 1 The functional spectral dependency is generally indicated by including the wavelength, λ, in parentheses as part of the symbol.

NOTE 2 The wavelength (λ) can be replaced by the wavenumber (σ) or the photon energy (hν). h = Planck constant; ν = frequency. The units recommended are the nanometre (nm) or the micrometre (µm) for the wavelength, the reciprocal centimetre (cm−1) for the wavenumber and the electron volt (eV) for the photon energy.

Bulk absorption filters are defined according to their function, i.e. according to the nature of the principal modification of the spectral transmission (see Table 1).

Optics and Photonics — Bulk absorption optical filters

1 Scope

This document specifies filter functions of uncoated bulk absorption filters for optical applications excluding ophthalmic optics (spectacles) and gives a standard form for their specification. Additionally, basic definitions and a description of the specification concerning optical bulk absorption filters are given. The standard specifies the optical properties of the filters and the test and measurement methods whenever necessary. This standard does not specify any material properties (inner quality, homogeneity, etc.) and it does not apply to any production method.

This document applies to both the raw material (filter glass, filter plastics, etc.) and the polished component.

NOTE 1 Colorimetric parameters for the description of the filter function are specified in e. g. ISO 11664 series.

NOTE 2 For filters where the spectral transmission characteristics are achieved by the application of optical coatings see ISO 9211 series.

2 Normative references

The following referenced documents are indispensable for the application 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 9211-1, *Optics and photonics — Optical coatings — Part 1: Vocabulary*

ISO 9211-2, *Optics and photonics — Optical coatings — Part 2: Optical properties*

ISO 4007, *Personal protective equipment — Eye and face protection — Vocabulary*

ISO 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

ISO 11664-2, *Colorimetry — Part 2: CIE standard illuminants*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9211-1 and 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 General

The terms are subdivided into sublcauses, namely “boundary conditions”, “optical properties”, “calculated parameters” and the “definition of bulk absorption filters by their function”.

3.2 Boundary conditions

3.2.1
optical surface
surface area, into which the radiation enters the bulk absorption filter or from which it leaves

Note 1 to entry: In general, bulk absorption filters are made as plane parallel plates and have two optical surfaces which are opposite to each other.

3.2.2
angle of incidence
angle between the normal to the surface and the incident ray

Note 1 to entry: Unless otherwise specified, the angle of incidence is equal to 0°; this means the incident rays are normal to the optical surface.

[SOURCE: ISO 9211-1]

3.2.3
thickness
d
geometrical length that the radiation passes through the bulk absorption filter at normal incidence

Note 1 to entry: At normal incidence onto a plano-parallel bulk absorption filter the path of the radiation is equal to the thickness d of the bulk absorption filter. All parameters and characteristic numbers of this standard are referenced to the case of normal incidence of the light, when the path and the thickness of the bulk absorption filter are the same.

Note 2 to entry: For the case of non-normal incidence of the light, the thickness does not correspond to the path of the light.

3.2.4
witness sample
sample, which represents the bulk absorption filter component and which is used for spectral measurements and environmental testing

Note 1 to entry: The details about the witness sample and the measurement (i.e. material, surface condition, geometry, amount per batch) may be subject of the negotiation between manufacturer and customer.

[SOURCE: ISO 9211-1, modified -- In the note “sampling procedures” has been replaced by “measurement”]

3.3 Optical properties

3.3.1
spectral transmittance
τ_λ
ratio of the spectral radiant flux transmitted to that of the incident radiant flux

Note 1 to entry: The spectral transmittance is dependent on the inner absorption properties, especially on the travel path of the light, as well as on the optical properties of the surface.

$$\tau(\lambda)=\frac{\Phi_{e\lambda,2}}{\Phi_{e\lambda,1}} \quad (1)$$

where

$\Phi_{e\lambda,1}$ is the incident spectral radiant flux;

$\Phi_{e\lambda,2}$ is the transmitted spectral radiant flux.

Note 2 to entry: See Figure 1.

Note 3 to entry: Wherever the Greek letter τ is mistakable T may be used.

Note 4 to entry: If necessary, the transmittance can be represented as an average over a wavelength range from λ_1 to λ_2 as follows:

$$\tau_{\mathrm{ave}}(\lambda_1 \text{ to } \lambda_2) = \frac{\int_{\lambda_1}^{\lambda_2} \tau(\lambda)\mathrm{d}\lambda}{\lambda_2 - \lambda_1} \approx \frac{\sum_{i=1}^{m} \tau(\lambda_i)\Delta\lambda}{\lambda_2 - \lambda_1} = \frac{\sum_{i=1}^{m} \tau(\lambda_i)}{m}$$

Where

$$\Delta\lambda = (\lambda_2 - \lambda_1)/m \, .$$

3.3.2
spectral internal transmittance
$\tau_{\mathrm{i}}(\lambda)$
ratio of the spectral radiant flux leaving the bulk absorption filter to that of the entered radiation

Note 1 to entry: The internal transmittance describes the properties inside the material, thus surface effects do not have an influence.

Note 2 to entry: The subscript "*i*" stands for "internal".

$$\tau_i(\lambda) = \frac{\Phi_{e\lambda,4}}{\Phi_{e\lambda,3}} \qquad (2)$$

where

$\Phi_{e\lambda,3}$ is the spectral radiant flux, which has entered the volume;

$\Phi_{e\lambda,4}$ is the spectral radiant flux, which is going to leave the volume.

Note 3 to entry: For bulk absorption filters with a homogeneous distribution of absorption within the material the following applies:

$$\tau_i = e^{-\alpha_1 d} \qquad (3)$$

where

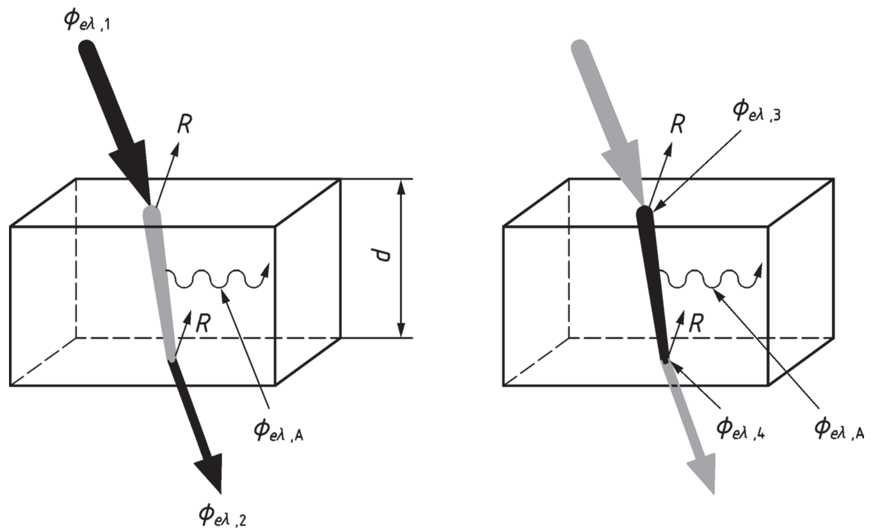
α_l is the absorption coefficient;

d is the thickness of the bulk absorption filter.

From this context, the internal transmittance can be calculated for different thicknesses of the bulk absorption filter (at normal incidence) by:

$$\tau_{i,d_1} = \left(\tau_{i,d_2}\right)^{\left(\frac{d_1}{d_2}\right)} \qquad (4)$$

Note 4 to entry: See Figure 1.



NOTE The light falls onto the surface at normal incidence, however, it is sketched at an angle in order to visualize the surface reflection *R*. That means, travel path of the light and geometrical thickness *d* are the same.

Figure 1 — Sketch for depicting the differences between transmittance and internal transmittance

3.3.3
cut-off wavelength of the internal transmittance
$\lambda_{i0,5}$
wavelength in the transition between a region of high and a region of low transmittance, where the transmittance has a value of $\tau_i = 0,5$

Note 1 to entry: The subscript “i” stands for “internal”.

3.3.4
cut-off wavelength of the transmittance
$\lambda_{0,5}$
wavelength in the transition between a region of high and a region of low transmittance, where the transmittance has a value of $\tau = 0,5$

Note 1 to entry: ISO 9211-2 defines $\lambda'_{0,5}$ and $\lambda''_{0,5}$ as the wavelength where the transmittance is half of τ_A or τ_M.

3.3.5
spectral absorptance
a(λ)
ratio of the spectral concentration of radiant flux absorbed to that of the incident radiation

3.3.6
refractive index
n(λ)
ratio of the velocity of propagation of electromagnetic radiation in vacuum to the velocity of propagation in a medium

[SOURCE: ISO 9211-1]

3.3.7
reflection factor
P(*λ*)

