International Standard

ISO 9211-1

Fourth edition

Optics and photonics — Optical coatings —

Part 1: **Vocabulary**

Optique et photonique — Traitements optiques —

Partie 1: Vocabulaire

PROOF/ÉPREUVE

Reference number
ISO 9211-1:2023(en)

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Foreword

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This document was prepared by Technical Committee ISO/TC 172, *Optics and photonic*, Subcommittee SC 3, *Optical materials and components*.

This fourth edition cancels and replaces the third edition (ISO 9211-1:2018), which has been technically revised.

The main changes are as follows:

— addition of the definition of spectral optical density;

— explanations of subscript for spectral average;

— explanations of average transmittance, reflectance, absorptance, and optical density over wavelength or wave number.

A list of all parts in the ISO 9211 series can be found on the ISO website.

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.

Introduction

The optical properties of a coated surface 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, the angle of incidence, and the state of polarization. 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 ($h\nu$). 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.

When a coating is used at an angle of incidence different from zero, its characteristics depend upon the state of polarization of the incident radiation and it can influence the polarization state of the emergent radiation. It might then be necessary to indicate the orientation of the electric field vector in relation to the plane of incidence.

The coatings are defined according to their function, i.e. according to the nature of the principal modification to the surface properties that they realize. A coating intended to realize a principal function as defined in Table 1 can also include one or more secondary functions. Their relative importance with regard to the principal function may be indicated.

A surface for visual applications can be characterized by colorimetric parameters. These depend on the reference illumination source, the reference observer, and the optical properties of the surface. Colorimetric parameters are not part of this standard.

Examples of coating imperfections are given in Annex A. Test methods for the surface imperfections are described in ISO 14997.

Optics and photonics — Optical coatings —

Part 1:
Vocabulary

WARNING — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

This document defines terms relevant to optical coatings. These terms are grouped in four classes: Terms and definitions, definition of coatings by function, definitions of common coating imperfections and other definitions.

This document identifies surface treatments of components and substrates excluding ophthalmic optics (spectacles) by the application of optical coatings and gives a standard form for their specification. It defines the general characteristics and the test and measurement methods whenever necessary, but is not intended to define the process method.

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 80000-7, *Quantities and units — Part 7: Light and radiation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145 and ISO 80000-7 and the following 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 https://www.electropedia.org/

3.1 Basic terms and definitions

3.1.1 General terms

3.1.1.1
surface treatment of components and substrates
application of a coating of material(s) intended to modify the optical, physical or chemical characteristics originally possessed by the surface of a component

Note 1 to entry: The substrates are considered to be geometrically perfect and optically homogeneous. In reality, an assembly made up of a substrate and a coating is identified and measured experimentally as an entity.

3.1.1.2
incident medium
medium from which the electromagnetic radiation enters a coating

3.1.1.3
emergent medium
medium into which the electromagnetic radiation exits a coating

Note 1 to entry: Besides acting as mechanical support, the substrate carrying the coating physically can constitute the incident medium and/or the emergent medium.

3.1.1.4
clear aperture
effective aperture
surface area to meet specifications

3.1.1.5
rim
surface area outside of the clear aperture

3.1.1.6
witness sample
sample that represents the actual coated component used for spectral and environmental testing

Note 1 to entry: The details of witness samples and measurements (e.g. material, surface texture, dimensions, number per batch, position in the coating chamber, etc.) is subject to agreement between manufacturer and customer.

3.1.2 Terms for optical properties of a coated surface

3.1.2.1
spectral transmittance
$\tau(\lambda)$
ratio of the spectral radiant or luminous flux transmitted to that of the incident radiant or luminous flux

Note 1 to entry: Spectral transmittance is related to spectral optical density $D(\lambda)$ by the formula: $\tau(\lambda) = 10^{-D(\lambda)}$.

Note 2 to entry: Wherever the Greek letter τ is mistakable $T(\lambda)$ may be used.

3.1.2.2
average spectral transmittance over wavelength
$\tau_{\text{ave}}(\lambda_1 \text{ to } \lambda_2)$
average of the spectral transmittance over a specified wavelength range

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

where

$$\Delta\lambda = \frac{\lambda_2 - \lambda_1}{m}$$

Note 1 to entry: The average spectral transmittance over wavelength has a different value than the average transmittance over wavenumber even if the range of wavelength is equivalent to the range of wavenumber.

Note 2 to entry: The range of wavelength and units $(\lambda_1 \text{ to } \lambda_2)$ may be given.

Note 3 to entry: The index "avg" may be used instead of "ave".

3.1.2.3
average spectral transmittance over wavenumber
$\tau_{ave}(\sigma_1 \text{ to } \sigma_2)$
average of the spectral transmittance over a specified wavenumber range

$$\tau_{ave}(\sigma_1 \text{ to } \sigma_2) = \frac{\int_{\sigma_1}^{\sigma_2} \tau(\sigma)\mathrm{d}\sigma}{\sigma_2 - \sigma_1} \approx \frac{\sum_{i=1}^{m} \tau(\sigma_i)\Delta\sigma}{\sigma_2 - \sigma_1} = \frac{\sum_{i=1}^{m} \tau(\sigma_i)}{m}$$

where

$$\Delta\sigma = \frac{\sigma_2 - \sigma_1}{m}$$

Note 1 to entry: The average spectral transmittance over wavelength has a different value than the average transmittance over wavenumber even if the range of wavelength is equivalent to the range of wavenumber.

Note 2 to entry: The average spectral transmittance over wavenumber is used mainly for large ranges, i.e. broadband filters in the Infrared.

Note 3 to entry: The range of wavenumber and units $(\sigma_1 \text{ to } \sigma_2)$ may be given.

Note 4 to entry: The index “avg” may be used instead of “ave”.

3.1.2.4
spectral reflectance
$\rho(\lambda)$
ratio of the spectral radiant or luminous flux reflected to that of the incident radiant or luminous flux

Note 1 to entry: Wherever the Greek letter ρ is mistakable $R(\lambda)$ may be used.

Note 2 to entry: Average spectral reflectance over wavenumber or over wavelength can be calculated in the same manner as that shown for spectral transmittance.

3.1.2.5
spectral absorptance
$\alpha(\lambda)$
ratio of the spectral radiant or luminous flux absorbed to that of the incident radiant or luminous flux

Note 1 to entry: Wherever the Greek letter α is mistakable $A(\lambda)$ may be used.

Note 2 to entry: The quantities defined in 3.1.2.1, 3.1.2.4 and 3.1.2.5 are interrelated as follows:

$$1 = \tau(\lambda) + \rho(\lambda) + \alpha(\lambda)$$

with

$$\tau(\lambda) = \tau_r(\lambda) + \tau_d(\lambda)$$

$$\rho(\lambda) = \rho_r(\lambda) + \rho_d(\lambda)$$

where

$\tau_r(\lambda)$	is the specular spectral transmittance (regular);
$\rho_r(\lambda)$	is the specular spectral reflectance (regular);
$\tau_d(\lambda)$	is the diffuse spectral transmittance (scattered);
$\rho_d(\lambda)$	is the diffuse spectral reflectance (scattered).

Note 3 to entry: Specular transmittance and specular reflectance are sometimes referred to as regular transmittance and regular reflectance, respectively.

Note 4 to entry: Average spectral absorptance and optical density over wavenumber or over wavelength can be calculated in the same manner as that shown for spectral transmittance.

3.1.2.6
spectral optical density
D(*λ*)
logarithm to the base 10 of the reciprocal of the *spectral transmittance* (3.1.2.1)

$$D(\lambda)=\lg\frac{1}{\tau(\lambda)}$$

[SOURCE: ISO 23364:2021, 3.3.1]

Note 1 to entry: Average spectral optical density over wavenumber or over wavelength can be calculated in the same manner as that shown for spectral transmittance.

3.1.2.7
spectral scattering
change of the spatial distribution of a beam of radiation spread in many directions by a surface or a medium without any change of frequency of the monochromatic components of which the radiation is composed

3.1.2.8
refractive index
n(*λ*)
ratio of the velocity of propagation of electromagnetic radiation in vacuum to the velocity of propagation of electromagnetic radiation in a medium

Note 1 to entry: The wavelength is defined in vacuum.

3.1.2.9
angle of incidence
Θ
angle between the normal to the optical 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.

3.1.2.10
plane of incidence
plane incorporating the normal to the surface and the incident ray

3.1.3 Terms for polarization

3.1.3.1
linear polarization
property of electromagnetic radiation in which the electric field vector oscillates along a fixed direction

Note 1 to entry: The oscillation is confined to a plane containing the direction of propagation of the radiation, in a homogeneous optical medium.

Note 2 to entry: A source is called “linearly polarized” if the degree of linear polarization is greater than 0,9 and the polarization direction is constant over time.

Note 3 to entry: S-polarization refers to linear polarization where the electric field vector is perpendicular to the plane of incidence.

Note 4 to entry: P-polarization refers to linear polarization where the electric field vector is parallel to the plane of incidence.