INTERNATIONAL STANDARD

ISO 9211-1

Third edition
2018-09

Optics and photonics — Optical coatings —

Part 1: Vocabulary

Optique et photonique — Traitements optiques —

Partie 1: Vocabulaire

Reference number
ISO 9211-1:2018(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 ISO/TC 172, *Optics and photonics*, Subcommittee SC 3, *Optical materials and components*.

This third edition cancels and replaces the second edition (ISO 9211-1:2010), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the definitions of elliptical, circular and random polarization have been aligned with ISO 11145:2018;

— in Table 1, the code designation HR and PR have been added to the reflecting function;

— Figure A.7 has been replaced.

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 shall 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*

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 http://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 the coating

3.1.1.3
emergent medium
medium into which the electromagnetic radiation exits the 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
surface area to meet specifications

3.1.1.5
rim
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 sampling procedures (e.g. material, surface texture, dimensions, number per batch, position in the coating chamber, etc.) is subject to agreement between supplier and user.

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.

[SOURCE: ISO 80000-7:2008, 7-22.3, modified — The formula has been changed into a sentence without changing the contents.]

3.1.2.2
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.

[SOURCE: ISO 80000-7:2008, 7-22.2]

3.1.2.3
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.

[SOURCE: ISO 80000-7:2008, 7-22.1]

3.1.2.4
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

Note 1 to entry: The quantities defined in 3.2.2.1 to 3.2.2.4 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 regular spectral transmittance (specular);

$\rho_r(\lambda)$ is the regular spectral reflectance (specular);

$\tau_d(\lambda)$ is the diffuse spectral transmittance (scattered);

$\rho_d(\lambda)$ is the diffuse spectral reflectance (scattered).

Note 2 to entry: If necessary, these values can be represented as an average over a wavelength range from λ_1 to λ_2 as follows:

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

where

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

3.1.2.5
refractive index
$n(\lambda)$
ratio of the velocity of propagation of electromagnetic radiation in vacuum to the velocity of propagation of electromagnetic radiation in a medium

3.1.2.6
angle of incidence
Θ
angle between the normal to the surface and the incident ray

3.1.2.7
plane of incidence
plane incorporating the normal to the surface and the incident ray

3.1.3 Terms for polarization

3.1.3.1
linearly polarized radiation
polarization where the orientation of the electric field vector remains constant

Note 1 to entry: S-polarization refers to linear polarization where the electric field vector is perpendicular to the plane of incidence.

Note 2 to entry: P-polarization refers to linear polarization where the electric field vector is parallel to the plane of incidence.

3.1.3.2
elliptical polarization
property of electromagnetic radiation in which the electric field vector rotates about the direction of propagation at the radiation frequency and periodically oscillates in amplitude in a homogeneous optical medium

Note 1 to entry: The terminal point of the electric field vector describes an ellipse.

[SOURCE: ISO 11145:2018, 3.12.3]

3.1.3.3
circular polarization
property of electromagnetic radiation in which the electric field vector is of constant amplitude and rotates about the direction of propagation at a frequency equal to the radiation frequency in a homogeneous optical medium

[SOURCE: ISO 11145:2018, 3.12.2]

3.1.3.4
random polarization
state in which a beam of electromagnetic radiation is composed of two linearly polarized beams of electromagnetic radiation having orthogonal fixed polarization directions and having amplitudes that vary randomly over time with respect to each other

[SOURCE: ISO 11145:2018, 3.12.7]

3.1.3.5
unpolarized radiation
radiation which has been resolved into any pair of orthogonal electric field vectors with varied phase difference where the average magnitudes of the two orthogonal vectors are the same and their phase difference change is completely random

3.1.4 Phase related terms

3.1.4.1
phase change
dΦ
angle difference, $\Phi - \Phi_0$, represents the phase change between an electromagnetic wave and a reference wave with its electric field vector given by

$$E = A\cos\left(\frac{2\pi\nu t}{\lambda} - \Phi\right)$$

where

E is the electric field vector;

A is the amplitude vector;

v is the velocity of propagation in the medium;

T is the time;

λ is the wavelength in the medium;

Φ is the phase.

The electric field at a fixed point in space due to an electromagnetic wave can be described by a periodic function given by

$$E_0 = A\cos\left(\frac{2\pi vt}{\lambda} - \Phi_0\right)$$

3.1.4.2
phase retardation
$\Delta\Phi$
difference of phase change between the p- and s-components of the electric field vector given by

$$\Delta\Phi = \mathrm{d}\Phi_\mathrm{p} - \mathrm{d}\Phi_\mathrm{s}$$

where

$\mathrm{d}\Phi_\mathrm{p}$ is the phase change for the p-component

$\mathrm{d}\Phi_\mathrm{s}$ is the phase change for the s-component

3.2 Designations of coatings by principal function

3.2.1 Reflecting function

3.2.1.1
RE
coating which increases the reflectance of an optical surface over a specified wavelength range

3.2.1.2
HR
coating which creates a high reflectance of an optical surface over a specified wavelength range without defined transmittance

3.2.1.3
PR
coating which creates a defined (partial) reflectance and a defined transmittance of an optical surface over a specified wavelength range

3.2.2 Antireflecting function

3.2.2.1
AR
coating which reduces the reflectance of an optical surface over a specified wavelength range and usually increasing the transmittance