INTERNATIONAL STANDARD

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Integrated optics — Interfaces — Parameters relevant to coupling properties

Optique intégrée — Interfaces — Paramètres caractérisant les propriétés de couplage

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14881 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 9, *Electro-optical systems*.

Integrated optics — Interfaces — Parameters relevant to coupling properties

1 Scope

This International Standard defines the relevant properties for coupling light into and out of integrated optical chips (IOC) and chips with optoelectronic integrated circuits (OEIC). This International Standard is limited to butt coupling via the waveguide endfaces. The definitions provide the basis for specifying the elements to be coupled (e. g. fibres, integrated optical chips) related to coupling properties.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 4288:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*.

ISO 11807-1:—[1)], *Integrated optics — Vocabulary — Part 1: Basic terms and symbols*.

ISO 11807-2, *Integrated optics — Vocabulary — Part 2: Terms used in classification*.

IEC 60793-1-2:1995, *Optical fibres — Part 1: Generic specification — Section 2: Measuring methods for dimensions*.

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 11807-1:— and ISO 11807-2 and the following apply.

3.1
anti-reflective coating of endfaces
thin surface coating designed to reduce the Fresnel loss

3.2
alignment structure
precise mechanical structure to enable coupling of optical and electro-optical elements without the need for adjustment

EXAMPLE Elements coupled may include optical fibres, fibre arrays, detectors, lasers, LEDs, integrated optical chips.

3.3
array block
mechanical alignment structure of micrometre or submicrometre precision for the reception of optical fibres

1) To be published.

NOTE 1 The alignment structures, which are generally arranged in a regular pattern, determine the position of the fibres with respect to each other. These positions are defined by the fibre's cladding diameter and the geometry of the alignment structures.

NOTE 2 An array block may have additional guiding structures for the alignment of the array with an integrated optical chip (see e. g. V-groove array).

3.4
V-groove array
array block structured with a number of V-grooves, generally equally spaced, with identical geometric dimensions

NOTE A silicon-V-groove array is commonly manufactured by anisotropically etching a silicon substrate. The angles of the silicon-V-grooves are well defined by the crystal orientation and the etching process.

3.5
fibre array
array block with inserted and fixed optical fibres, in which the fibre endfaces lie in one plane

3.6
fibre array coupling
coupling that connects several optical fibres simultaneously with several corresponding waveguide endfaces

NOTE The fibres are already adjusted and fixed with respect to each other by the array block. The pitch of the array corresponds to the pitch of the integrated optical chip. The kind of adjustment between the fibre array and the integrated optical chip and the kind of fixation depends on the type of the fibre array.

3.7
fibre array's coupling deviation
difference between maximum and minimum coupling losses of the single fibres of a fibre array

3.8
butt coupling
coupling of two waveguides with their endfaces in contact or nearly in contact

3.9
chip edge
edge formed by the chip surface and the chip endface

3.10
chip endface
chip-limiting plane, which contains the optical interface(s)

3.11
chip surface
plane parallel and closest to the plane of the waveguide(s)

3.12
coupling efficiency
η
ratio of the optical power coupled into the endface of an optical element j (e. g. fibre endface or chip endface) to the emitted optical power at the output endface of the element i

$$\eta = \frac{P_{m,j}}{P_{l,i}} , \quad P_{m,j} < P_{l,i}$$

where

$P_{m,j}$ is the power in optical element j at the input endface;

$P_{l,i}$ is the power in optical element i at the output endface.

3.13
coupling loss
α_c
loss of optical power obtained when the light is coupled from output endface of one optical element i (e. g. fibre endface or chip endface) into the endface of another element j on a logarithmic scale

$$\alpha_c = -10 \log \left(P_{m,j} / P_{l,i} \right)$$

where

$P_{m,j}$ is the power in optical element j at the input endface;

$P_{l,i}$ is the power in optical element i at the output endface.

[ISO 11807-1:—, 5.5.4.7]

NOTE 1 Coupling losses can be induced by e. g. radial, axial or angular misalignment or unmatched modefields. The coupling loss is the logarithmic value of the coupling efficiency.

NOTE 2 Coupling loss is expressed in decibels.

3.14
Fresnel loss
loss caused by reflections at the interface of two media with different refractive indices

3.15
index matching
interfacial layer in order to reduce Fresnel losses by matching the refractive indices n_1, and n_2 of two media (e. g. quarter-wave layer)

3.16
$\lambda/4$ **transformer**
optical coating with a thickness of $\lambda/(4n_S)$ for reducing the Fresnel loss by index matching, where $n_S = \sqrt{n_1 \cdot n_2}$ is the refractive index of the coating

NOTE (see 3.15).

3.17
optical axis
line connecting the centroids defined by the first spatial moment of the cross-sectional profile of the power density distribution of the guided wave at successive positions in the direction of propagation of the wave

3.18
pitch
P
distance between the centres of adjacent fibres or waveguides, which may vary across and with direction

NOTE P_x, P_y are defined as pitch in the x-, y-direction, respectively.

3.19
reference mark
mark used as reference in alignment of optical components

3.20
reflective coating of endface
coating of the waveguide endface applied and designed to obtain a desired reflectance

3.21
single-fibre coupling
coupling technique in which each optical fibre is adjusted and attached individually to the corresponding waveguide of the integrated optical chip

3.22
waveguide endface
area of the chip endface which is determined by the end of the waveguide

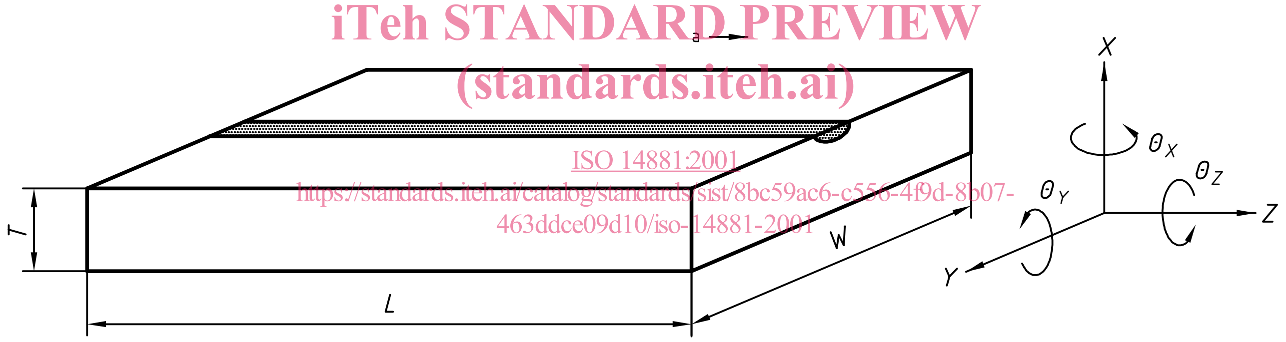
4 Properties relevant for coupling

4.1 General

In the following, the characteristics, reference systems, classes for tolerances, and losses are provided that are necessary for the unambiguous description of the properties of integrated optical chips, array blocks and optical fibres relevant for coupling.

4.2 Chip geometry (see Figure 1)

The dimensions listed in Table 1 as well as their tolerances shall be specified. If the endfaces have been inclined, e. g. to minimize reflection, the edge's angles shall also be specified. In addition, any deviation of the chip surface from flatness (e. g. bow) shall be specified. All deviations from flatness and facet roughness are examined in 4.4.



[a] Direction of propagation.

Figure 1 — Coordinate system and dimensions for integrated optical chips

Table 1 — Dimensions

Characteristic	Length	Width	Thickness
symbol	L	W	T
unit	mm	mm	mm

For the chip thickness, T, the preferred dimensions 0,15 mm, 0,35 mm, 0,525 mm, 0,625 mm, 1,0 mm and 2,0 mm are recommended, but not mandatory.

NOTE A definition of preferred dimensions for length and width seems not to be convenient at present, because of the different basic materials and chip sizes used.

4.3 Waveguide geometry (see Figure 2)

The dimensions listed in Table 2 as well as their tolerances shall be specified.

The tolerances, expressed in micrometres, of the values of the pitch, P, shall be referred to the reference mark for each single position.

The preferred dimensions 0,125 mm, 0,25 mm and 0,4 mm, are recommended for the pitch, P, but not mandatory.

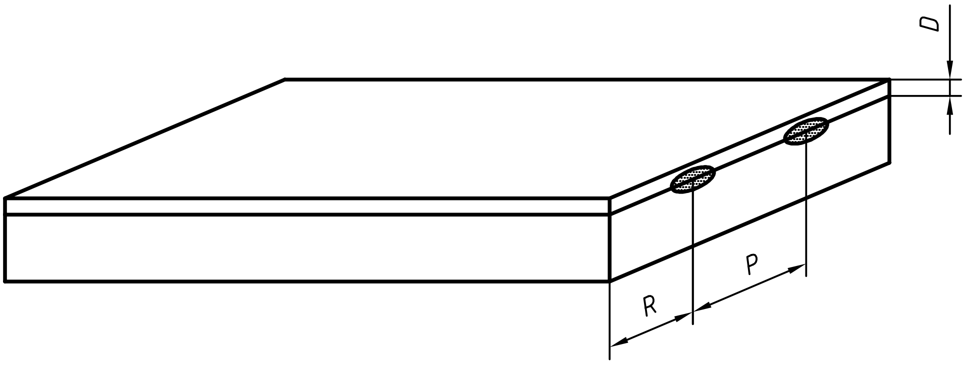


Figure 2 — Position of the waveguides in the chip

Table 2 — Dimensions to describe the position of the waveguide in the chip (related to the optical axis of the waveguide)

Characteristic	Distance to the reference mark	Pitch	Depth below the surface
symbol	R	P	D
unit	mm	mm	mm

4.4 Fibre tolerances

To reach the necessary low coupling losses with fibre arrays, it is normally necessary to use optical fibres with tolerances substantially lower than those specified by the producer. Thus, tolerances for the dimensions of optical fibres shall be specified (see Table 3).

Table 3 — Dimensions of optical fibres to describe deviations

Deviation	Cladding diameter tolerance	Non-circularity of cladding	Core diameter tolerance	Non-circularity of core	Concentricity error of core/cladding
unit	µm	µm	µm	µm	µm

Measurement shall be carried out in accordance with IEC 60793-1-2.

For polarization maintenance, the deviation of the core concentricity in this case describes the deviation of the near field centre from the geometrical centre of the fibre. Additionally, the spot size of the fibre according to 4.6 and the coupling loss shall be indicated.

4.5 Endface properties (see Figure 3)

Measurement of Ra shall be carried out in accordance with ISO 4288.

The dimensions, angles and radii listed in Tables 4 to 6 and their tolerances shall be specified.