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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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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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This second edition cancels and replaces the first edition (ISO 14881:2001), which has been technically revised. The main changes compared to the previous edition are as follows:

— Terminologies that have not been frequently used over the last 5 to 10 years are revised to those matching to current trends.

— In the revision process, terminologies and definitions are compared to similar terminology definitions in IEC and harmonized.

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

The aim of this document is to clarify the terms of the field of "integrated optics" and to define a unified vocabulary. It is expected that this document will be revised periodically to adopt the requirements of customers and suppliers of integrated optical products. At a later stage, it is planned to add definitions from other International Standards which deal with integrated optics.

Some of the definitions are closely related to definitions given in IEC 60050-731. Wherever this can lead to misunderstanding, integrated optics or integrated optical waveguide should be used together with the defined term.

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Integrated optics — Interfaces — Parameters relevant to coupling properties

1 Scope

This document defines the relevant properties for coupling lightwaves into and out of integrated optical chips (IOC) and chips with photonic integrated circuits (PIC). This document mainly focuses on 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 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 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

ISO 11807-1:2021, *Integrated optics — Vocabulary — Part 1: Basic terms and symbols*

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

IEC 60793-1-20, *Optical fibres — Part 1-20: Measurement methods and test procedures — Fibre geometry*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11807-1 and ISO 11807-2 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/

Note 1 to entry A list of relevant terms and symbols can be found in Annex A.

3.1
adiabatic coupling
coupling of fibre and tapered waveguide or two waveguides one of which, at least is tapered to utilize mode coupling without optical power loss for maximum *coupling efficiency* (3.9)

3.2
anti-reflective coating of endfaces
thin film coating on the endfaces of optical chips designed to reduce the *Fresnel loss* (3.15)

3.3
array block
mechanical alignment structure of micrometre or submicrometre precision for the reception of optical fibres adopted in *single-fibre coupling* (3.21) and *fibre array coupling* (3.12)

Note 1 to entry: 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.

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Note 2 to entry: 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, fixed alignment structure).

3.4
beam axis
line connecting the centroids defined by the first spatial moment of the cross-sectional profile of the power density distribution of the guided lightwave at successive positions in the direction of propagation of the lightwave

3.5
butt coupling
coupling of waveguide and fibre, two waveguides, or two fibres with their endfaces in physical contact or nearly in physical contact

3.6
chip endface
optical facet
chip-limiting plane, which contains the optical interface(s)

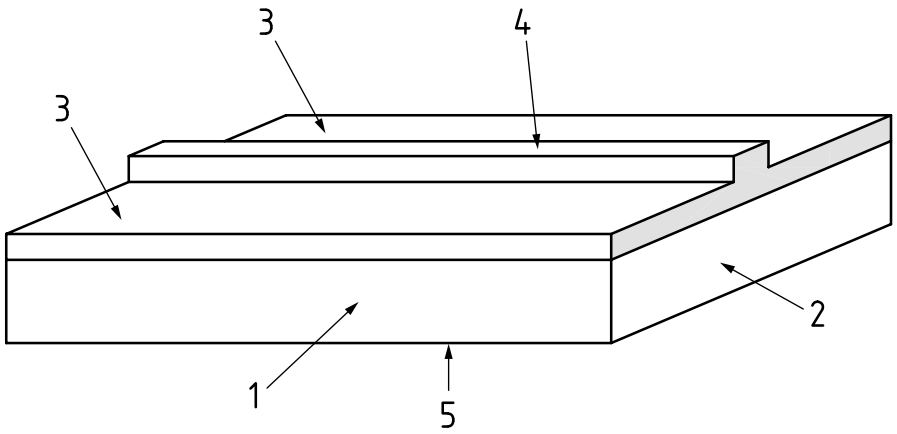
Note 1 to entry: See Figure 1.

3.7
chip side facet
chip-limiting plane, which contains no optical interface(s)

Note 1 to entry: See Figure 1.

3.8
chip surface
plane on the top or bottom of the chip parallel to the plane of the waveguide(s)

Note 1 to entry: See Figure 1.



Key

1	chip side facet	4	waveguide surface (top)
2	waveguide endface/optical facet	5	chip surface (bottom)
3	chip surface (top)/optical facet		

Figure 1 — Integrated optical chip structure

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3.9
coupling efficiency
η
ratio of the optical power coupled into the endface of an optical element 2 (e. g. fibre core or waveguide endface) to the emitted optical power at the output endface of the element 1 (e.g. fibre and waveguide)

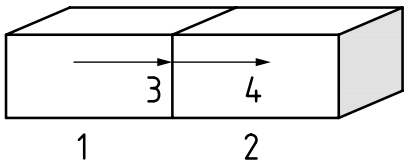
$$\eta = P_2 / P_1$$

where

P_2 is the optical power into optical element 2 at the input endface;

P_1 is the optical power from optical element 1 at the output endface;

Note 1 to entry: See Figure 2.



Key

1	element 1	3	P_1
2	element 2	4	P_2

Figure 2 — Schematic of two-endface coupling

3.10
coupling loss
α_c
loss of optical power obtained when the lightwave is coupled from the output endface of one optical element 1 (e.g. fibre core or *chip endface* (3.6)) into the input endface of another optical element 2

$$\alpha_c = -10 \lg(P_2 / P_1)\,\mathrm{dB}$$

where

P_2 is the optical power in optical element 2 at the input endface;

P_1 is the optical power from optical element 1 at the output endface;

Note 1 to entry: Coupling losses can be caused by e. g. radial, axial or angular misalignment or unmatched mode fields. The coupling loss is the logarithmic value of the coupling efficiency.

Note 2 to entry: Coupling loss is expressed in decibels (dB).

[SOURCE: ISO 11807-1:2021, 3.6.5, modified —Note 1 to entry was added.]

3.11
fibre array
array block (3.3) with inserted and fixed optical fibres, in which the fibre cores are aligned in one plane

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3.12
fibre array coupling
coupling that connects several optical fibres simultaneously with several corresponding waveguide endfaces

Note 1 to entry: The fibres are already arranged and fixed in the array block. The pitch of the array corresponds to the pitch of the integrated optical chip. The method of alignment between the fibre array and the integrated optical chip and the way of fixation depend on the type of the fibre array.

3.13
fibre arrays coupling deviation
difference between maximum and minimum *coupling losses* (3.10) of the single fibres in a *fibre array* (3.11)

3.14
fixed 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, and integrated optical chips.

3.15
Fresnel loss
loss of optical power caused by reflection at the interface of two media with different refractive indices

3.16
index matching
refractive index adjustment by inserting at least one of the interfacial layers between two media (e.g. waveguide endface) with different refractive indices in order to reduce *Fresnel losses* (3.15) (e. g. *λ/4 layer* (3.18))

3.17
pitch
p
distance between the centres of adjacent fibre or waveguide cores, which may vary along the beam axis

Note 1 to entry: p_x, p_y are defined as pitch in the *x*-, *y*-direction, respectively.

3.18
***λ/4* layer**
optical coating with a thickness of $\lambda/(4n_S)$ to minimize (ideally vanishing) the interference by reflection, where $n_s = \sqrt{n_1 \cdot n_2}$, is the refractive index of the coating when the refractive indices of two media are n_1 and n_2

Note 1 to entry: λ/4 layers are usually used at optical interfaces (e.g. waveguide endfaces) to air as an alternative to index matching.

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

3.20
reflective coating of endface
thin film applied on the waveguide endface to give a desired reflectance

Note 1 to entry: λ/4 layer is one of the examples of anti-reflective coating of endface.

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3.21
single-fibre coupling
coupling that connects each optical fibre to the corresponding waveguide of the integrated optical chip individually

3.22
V-groove array
array block (3.3) structured with a number of V-grooves, generally equally spaced, with identical geometric dimensions

Note 1 to entry: A silicon V-groove array is commonly manufactured by anisotropic etching of the silicon substrate. The angles of the silicon V-grooves are well defined by the crystal orientation and the etching conditions.

3.23
waveguide surface (top)
chip-limiting plane on the top of the waveguide

Note 1 to entry: See Figure 1.

Note 2 to entry: Two waveguide surfaces on different waveguides should be in direct contact or aligned with very close proximity for adiabatic coupling.

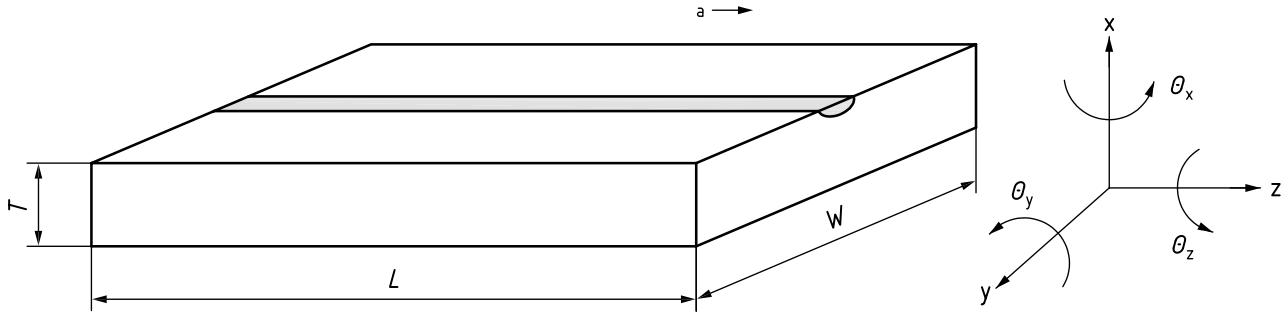
4 Properties relevant to coupling

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 to coupling.

4.2 Chip geometry (see Figure 3)

The dimensions of length, *L*, width, *W*, and thickness, *T*, as well as their tolerances shall be specified in millimetres. If the chip endfaces (optical facets) have been inclined, e.g. to minimize reflection, the inclined angles shall also be specified. Deviations of the chip endfaces, fusets, and surfaces from flatness (e.g. bow) shall be specified. All deviations from flatness and facet roughness are examined in 4.5.



[a] Direction of propagation.

Figure 3 — Coordinate system and dimensions for integrated optical chips

4.3 Waveguide geometry (see Figure 4)

The dimensions of distance of the reference mark, *R*, pitch, *p*, and depth below the surface, *D*, as well as their tolerances shall be specified in millimetres.

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