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D E C I S I O N
of 18 November 1999

Case Number: T 0448/99 - 3.4.2

Application Number: 94105510.5

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Title of invention:
Optical waveguide device

Applicant:
Sumitomo Electric Industries, Limited

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
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Boards of Appeal

Chambres de recours

Case Number: T 0448/99 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 18 November 1999

Appellant: Sumitomo Electric Industries, Limited
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 23. December 1998
refusing European application No. 94 105 510.5
pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: E. Turrini
Members: M. A. Rayner
V. Di Cerbo

Summary of Facts and Submissions

I. The present appeal is against the decision of the examining division to refuse European patent application 94 105 510.5 (EP-A-634 677) for lack of inventive step. Reference was made in the decision to documents including the following:

D5: GB-A-2 213 954
D6: EP-A-0 411 607
D8: EP-A-0 519 475
D9: EP-A-0 509 236.

In the decision under appeal, the examining division reasoned with reference to document D5 and particularly figures 6, 9, 10 thereof that the left part is a waveguide region, the tapered portion is a connection region and an insertion region with a groove is provided at the space between parts 17. Alternatively to document D5, the division considered a similar disclosure to be present in figures 4c-4e and related text of D6. The division acknowledged that documents D5 and D6 did not explicitly refer to an "integrated" waveguide structure, but considered transfer of the teaching of D5 or D6 to integrated structures to lack an inventive step because integrated structures such as disclosed in document D8 or D9 would benefit from overcoming problems associated with misalignment, just as do the waveguides of documents D5 or D6. Furthermore, provision of an unspecified length of waveguide of constant width in the insertion region does not solve any technical problem and therefore does not involve an inventive step.

- II. In its notice of appeal, the appellant (= patent applicant) requested that the decision be set aside and a patent granted. On an auxiliary basis, the appellant requested oral proceedings.
- III. The appeal board issued a summons to oral proceedings expressing doubts that difference in dimension between the waveguides according to documents D8 and D9 and those according to documents D5 and D6 would have prevented the skilled person from realising that problems associated with poor precision of position could also be mitigated in an integrated waveguide structure by use of a taper because the underlying problem and solution are not affected by this difference. Use of ferrules according to the teaching of document D5 was not particularly relevant in this connection as the taper eases the positioning problem compared with a waveguide without a taper even if a ferrule is used in both cases. Moreover, since according to document D6 reduction of the core diameter of an optical fibre causes the spot size thereof to be enlarged, arguments concerning decreasing cross section would not seem persuasive as to inventive step. Furthermore, since document D5 explains that refractive index profile is modified by causing dopant ions from the cladding to diffuse into the core, it seemed very doubtful whether features pertaining to refractive index decrease, which in fact results from diffusing TiO_2 into the cladding, could be considered to introduce any inventive step.
- IV. During the oral proceedings, the appeal board drew attention to grooves known from document D9 and observed that in the absence of dimensions, no

collimating effect could be defined in the insertion region. The appellant requested grant of a patent based on a set of claims according to a main or two auxiliary requests, respectively, filed during the oral proceedings. During the oral proceedings the appellant also filed

D10: Chapter 59 of the Communications Handbook,
CRC Press 1997.

The wording of the independent claim according to the main request and two auxiliary requests is as follows:

Main Request

1. Optical waveguide device constituted by:
a waveguide substrate (11),
at least one cladding layer (13) covering said waveguide substrate (11),
optical waveguides formed as light transmission paths (A) having at least two input/output end faces, disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), and
at least one optical element (2) effecting the propagated light through the respective optical waveguide
characterized by
an insertion region (B) with at least one input/output end face, disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), having a mode field width of light propagation therein larger than the mode field width of light propagating in said light transmission

part (A),
at least one optical connection region (C), disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), having a first input/output end face directly connected to an input/output end face of said light transmission path (A) and a second input/output end face directly connected to an input/output end face of the insertion region (B), wherein the mode field width of light propagating in said optical connection region (C) changes such that there is a continuous change of the mode field width between the connected light transmission path (A) and the insertion region (B), and a groove at a corresponding portion of the insertion region for inserting the optical element.

First Auxiliary Request

1. Optical waveguide device constituted by a waveguide substrate (11), at least one cladding layer (13) covering said waveguide substrate (11), optical waveguides formed as light transmission paths (A) having at least two input/output end faces, disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), and said optical waveguide having an optical waveguide region having at least two input/output terminals, characterized by an insertion region, disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), having at least one input/output terminal and a mode field width of light

propagating therein larger than that of light propagating at a predetermined portion of said optical waveguide region,
wherein a groove is provided at a corresponding portion of the insertion region for inserting an optical element which affects the propagated light through the respective optical waveguide,
a first optical connection region, disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13),
having a first input/output terminal directly connected to one input/output terminal of said optical waveguide region and a second input/output terminal directly connected to said input/output terminal of said insertion region, said first optical connection region adapted to be a region for changing a mode field width of light propagating therein, wherein
said first input/output terminal of said first optical connection region has the same core size as that of said one input/output terminal of said optical waveguide region, and
said second input/output terminal of said first optical connection region has the same core size as that of said input/output terminal of said insertion region, the core size of said second input/output terminal being smaller than that of said first input/output terminal and smaller than a core size that minimizes a mode field width of light propagating in said first optical connection region.

3. Optical waveguide device constituted by
a waveguide substrate (11),
at least one cladding layer (13) covering said waveguide substrate (11),

optical waveguides formed as light transmission paths (A) having at least two input/output end faces, disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), and said optical waveguide having an optical waveguide region having at least two input/output terminals, characterized by

an insertion region, disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), having at least one input/output terminal and a mode field width of light propagating therein larger than that of light propagating at a predetermined portion of said optical waveguide region, wherein a groove is provided at a corresponding portion of the insertion region for inserting an optical element which affects the propagated light through the respective optical waveguide,

a first optical connection region, disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), having a first input/output terminal directly connected to one input/output terminal of said optical waveguide region and a second input/output terminal directly connected to said input/output terminal of said insertion region, said first optical connection region adapted to be a region for changing a mode field width of light propagating therein, wherein the refractive index difference between a core and a cladding layer in a region including said insertion region and said first optical connection region is smaller than a refractive index difference between a core and a cladding layer at a predetermined portion of

said optical waveguide region.

Second Auxiliary Request

1. Optical waveguide device constituted by a waveguide substrate (11), at least one cladding layer (13) covering said waveguide substrate (11), optical waveguides formed as light transmission paths (A) having at least two input/output end faces, disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), and at least one optical element (2) effecting the propagated light through the respective optical waveguide characterized by an insertion region (B) with at least one input/output end face, disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), having a mode field width of light propagation therein larger than the mode field width of light propagating in said light transmission part (A), at least one optical connection region (C), disposed between said waveguide substrate (11) and said cladding layer (13) or disposed within said cladding layer (13), having a first input/output end face directly connected to an input/output end face of said light transmission path (A) and a second input/output end face directly connected to an input/output end face of the insertion region (B), wherein the mode field width of light propagating in said optical connection region (C) changes such that there is a continuous change of the

mode field width between the connected light transmission path (A) and the insertion region (B), and a groove at a corresponding portion of the insertion region for inserting the optical element; said second input/output end face of said first optical connection region (C) having the same core size as that of said input/output end face of said insertion region (B); said insertion region (B) comprising a section of constant width extending along the optical axis of said insertion region (B).

V. The arguments of the appellant in support of the appeal can be summarised as follows:

In the application, the feature pertaining to a groove being provided at a corresponding portion of the insertion region for inserting the optical element means by virtue of use of the word "portion" that the optical element cannot take up the whole of the insertion region. The insertion region is shown in the figures as extending to the connection region and the "non-portion" parts of the insertion region have a collimating effect.

Document D5 employs a groove comprising a cut which offers no suggestion of an insertion region as claimed. Figure 6 shows doping being used for producing a profile. Furthermore, the insertion process of document D5 cannot be applied with a micron or submicron precision appropriate to the very small dimensions of an integrated waveguide. Consequently, there was a technical prejudice against applying the teaching of document D5 to integrated waveguides. Even if either document D5 or D6, where the problem is an alignment

problem, is taken as a starting point, there is no collimation in the part of the insertion region other than the portion because the fibre abuts directly on the optical component. Moreover post published document D10 demonstrates that, in fact, expanded optical beam connectors have not found acceptance. Document D6 relies on diameter variation produced by heating and stretching.

The closest prior art is, in fact, reflected by document D8 or D9, where a mirror is realised in the integrated structure. This is expensive and causes limitation of the possible components. The invention solves these problems by allowing insertion of an optical element without excessive loss. The groove disclosed by document D9, if it is taken to be the trapezoidal cross section in Figure 6B, is filled during the production stage or, if it is taken to be groove 109 in Figure 4, is left empty, differing from the application, where "insertion" signifies that the optical component is not formed as part of the integrated structure but occurs afterwards in a subsequent procedural step.

According to claim 1 of the first auxiliary request, the mode field width of light is increased by decreasing the cross section of the optical waveguide. According to claim 3 of the first auxiliary request, mode field width is increased by decreasing the refractive index difference between the core and cladding layer. These measures have shown advantageous effects in order to minimise losses caused by diffraction and poor positioning.

Claim 1 of the second auxiliary request renders even more precise the structure of the insertion region and is not obvious over the prior art.

VI. At the end of the oral proceedings, the appeal board gave its decision.

Reasons for the Decision

Admissibility

1. The appeal complies with the provisions mentioned in Rule 65(1) EPC and is therefore admissible.

Main Request

2.1 Document D5 concerns alignment of optical waveguides when an optical element is to be inserted in the optical waveguide path. In particular, document D5 discloses an optical waveguide device (see for example the waveguide comprising optical fibre 1 in Figure 9 and 10) and an optical element (see for example element 16 in Figures 9 and 10). An optical component is inserted in the region between the optical fibre portions marked with lead lines 5 in Figure 6. The mode field in this region is larger than that in the waveguide regions to the left and right of Figures 6, 9 and 10 because the core has a widening taper from these regions connecting towards the region where the element is inserted, the taper being achieved by varying dopant profile along the length of the waveguide. The element 16 is shown in Figure 10 mounted in a partial cut 19 in

- ferrule 19.
- 2.2 According to the teaching of document D6 (see in particular Figure 4e), reduction of core diameter by heating and drawing causes spot size to be increased (see the tapered portion 11 and page 3, line 5). The substrate 3 and the optical fibre 1 are machined to form a groove 31 where the optical element is inserted.
- 2.3 Document D8 discloses an integrated waveguide structure with mirrors formed by etched grooves such as 10a in Figure 4. Document D9 discloses an integrated waveguide structure (see for example Figure 4) comprising a waveguide substrate (113, 114 in Figure 4) with cladding layers (112, 115 in Figure 4). An optical element with a groove 109 is made in regrown layer 117 and 118 in the coupler region 108.
- 3.1 In view of its dealing with alignment of waveguides with an inserted optical element, the board considers document D5 to represent the closest prior art. The features of claim 1 which are novel with respect to the disclosure of document D5 involve reference to the waveguide substrate and thus pertain to an integrated waveguide structure, the groove for insertion of the optical element being specified as at a corresponding portion of the insertion region. The problem solved by the novel features can therefore be seen in realising that the teachings of document D5 relating to alignment of waveguides exemplified as optical fibres with an optical element is applicable to an integrated waveguide structure.
- 3.2 Page 2, line 8 onwards of document D5 explain that

coupling between a fibre and an optical element can call for extremely accurate positioning with regard to alignment and distance apart (see for example page 2, lines 19-29) because coupling is subject to loss in the case of poor alignment. According to document D5, the problem of poor alignment is solved by widening optical field size by varying dopant profile along the length of the waveguide, which means that advantage is taken of the physical light guiding properties of the waveguide itself. The solution brought about by the taper according to document D5 does not depend for its physical effect upon size or use of optical fibres as waveguides, since the physical guiding property is effective in making waveguides less susceptible to losses caused by misalignment simply because they are tapered waveguides and irrespective of how they were produced or whether ferrules are used. The board is therefore convinced that no prejudice existed against applying the teaching of document D5 whenever any waveguide is aligned with an optical element and, in particular, no prejudice existed against applying the teaching in integrated optical structures. Integrated waveguide devices are in fact well known and, for example, document D8 or D9 illustrate that optical elements are provided associated with grooves in regions of such waveguide devices. Implementation of the obvious design alternative of inserting an optical element into such waveguides in the knowledge of the underlying solution known from document D5 leads to the subject-matter of present claim 1 without any inventive step.

- 3.3 Since document D10 was published after the priority date of the application and does not show a tapered

waveguide, its disclosure relating to alignment problems is not relevant to understanding of document D5 in relation to alignment of tapered waveguide structures and thus does not bear on inventive step of the subject-matter of claim 1.

3.4 In the absence of any quantification of the dimensions of the insertion region included in the dotted lines in the figures and especially of the portion of the insertion region, the remainder of the insertion region is of indeterminate size. No information relating to the dimensions is given even by the description of the application. It is therefore not possible to ascribe any physical function to parts of the insertion region other than the portion because any such function would require a function dependent length of waveguide according to the function concerned. Since no such length is defined, no physical function can be defined. Therefore, no function, for example of collimation, can be implied by use of the word "portion" in association with the insertion region. Consequently, even if the waveguide 1 is taken to be in abutment with the optical element 16 in the teaching of document D5, the wording relating to "portion" does not amount to a distinguishing technical feature upon which an inventive step of the subject-matter of claim 1 can be based.

3.5 Accordingly, the obvious combination of the teaching of document D5 with that of document D8 or D9 leads to the subject-matter of claim 1 without any inventive step.

3.6 Submissions of the appellants relating to difficulties of expense and limitation of possible components used

according to the teachings of documents D8 and D9 are premised on these documents being considered the closest prior art. The board does not accept this premise because the underlying problem is one of alignment for which document D5 is the closest prior art. Since these difficulties do not apply to the teaching of document D5, the submissions concerned cannot persuade the board as to inventive step.

First Auxiliary Request

- 4.1 The independent claims of this request contain features relating to how the mode field width change is implemented, which as such do not bear on the underlying solution of the alignment problem. Thus, the last feature of claim 3 of this request relates to the choice of the connection region decreasing refractive index difference between core and cladding. The mode field changing is therefore of the type effected according to document D5, which explains at the bottom of page 13 that refractive index profile is modified by causing dopant ions from the cladding to diffuse into the core resulting in refractive index difference decrease, which is an obvious complement to the present application, where TiO_2 from the core is diffused into the cladding. Likewise, the last feature of claim 1 relates to the choice of connection region decreasing to a core size smaller than that minimising mode field width. This obvious alternative possibility is rendered obvious by the teaching of document D6, lines 5-6 on page 3, relating to reducing the core diameter of an optical fibre to cause the spot size thereof to be enlarged when an optical element is inserted. Since the losses are minimised by the mode field width change

itself, implementation as claimed amounts in the light of the documents mentioned to no more than an obvious choice so that no inventive step can be considered involved in the subject-matter of either claim 1 or claim 3 of this request.

Second Auxiliary Request

5.1 Claim 1 of the second auxiliary request differs from that of the main request by virtue of the last feature thereof relating to core size. So far as the section of the insertion region of constant width is concerned, the absence of any quantification of the dimensions concerned with respect to the length thereof, as with claim 1 of the main request, renders impossible the ascribing of any physical function to such a section. Since no technical effect is produced thereby, no inventive step can be considered involved in the subject-matter concerned.

6. In view of the foregoing, the subject matter of the independent claims according to all the requests cannot be considered as involving an inventive step within the meaning of Article 56 EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

P. Martorana

E. Turrini