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Datasheet for the decision of 28 February 2014

Case Number: T 1437/09 - 3.4.02

Application Number: 02257849.6

Publication Number: 1315021

IPC: G02F1/01, G02F1/225

Language of the proceedings: EN

Title of invention:
Optical modulators and a method for modulating light

Applicant:
NGK Insulators, Ltd.

Headword:

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - (yes) - after amendment

Decisions cited:
T 0967/97, T 0308/09

Catchword:

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Case Number: T 1437/09 - 3.4.02

D E C I S I O N
of Technical Board of Appeal 3.4.02
of 28 February 2014

Appellant: (Applicant)	NGK Insulators, Ltd. 2-56 Suda-cho, Mizuho-ku Nagoya-City, Aichi Pref. 467-8530 (JP)
Representative:	Paget, Hugh Charles Edward Mewburn Ellis LLP 33 Gutter Lane London EC2V 8AS (GB)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 2 February 2009 refusing European patent application No. 02257849.6 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman: D. Rogers
Members: A. Hornung
F. Maaswinkel

Summary of Facts and Submissions

I. The applicant (appellant) appealed against the decision of the examining division refusing European patent application number 02257849.6 on the basis of Article 56 EPC (main and auxiliary request).

II. The applicant requests that the decision of the examining division be set aside and that a patent be granted on the basis of the main request filed with letter dated 18 February 2014.

Present independent claims 1 and 2 of the main request are based on independent claims 1 and 4, respectively, of the auxiliary request as refused by the examining division.

III. The present decision refers to the following documents.
D1: EP0859263
D4: EP1109054

IV. Independent device claim 1 and independent method claim 2 read as follows:

"1. An optical modulator (1) for modulating light propagating in a channel optical waveguide by applying a voltage on said waveguide, said modulator comprising:

a plate (4) having a first main face (4a) and a second main face (4d),

a channel optical waveguide (5) formed in the plate (4) and having at least a pair of branched portions (5b, 5c) and a recombining portion (5f) of said branched portions (5b, 5c), the modulator having an off-mode in which light is radiated into said plate (4) from said recombining portion (5f),

a modulating electrode (7A, 7B, 7C) for applying a signal voltage and a direct current bias on said channel optical waveguide (5) to modulate light propagating in said channel optical waveguide (5),

a photo detector (13) for receiving light radiated from said plate (4) in said off-mode and providing an output, and

a controlling unit (15) for varying said direct current bias based on said output from said photo detector (13) so as to control the operational point of said modulator (1);

wherein:

the plate (4) has a thickness of not less than 3 μm and not more than 20 μm, selected so that the plate functions as a slab optical waveguide, guiding the light of the off-mode in slab mode,

the optical modulator further has a supporting substrate (2) and an adhesive layer (3) joining said supporting substrate (2) and said second main face (4d) of said plate (4) acting as a slab optical waveguide, said adhesive layer having a refractive index lower than that of said plate (4),

the material of said plate (4) acting as an optical waveguide is lithium niobate,

the material of said support substrate (2) is a ferroelectric single crystal of lithium niobate,

the channel optical waveguide (5) being a titanium-diffused lithium niobate optical waveguide formed in the lithium niobate forming said plate (4) on the side of said first main face (4a) of said plate (4), wherein the modulating electrode is formed on said first main face of said plate (4),

said channel optical waveguide (5) has an output portion (5d) having an end face (5a) at an end face of said plate (4),

and an optical fiber (21) is fitted on said end face of said plate (4) to receive said radiated light and said photodetector (13) receives the radiated light from the optical fiber (21).

2. A method for modulating light propagating in a channel optical waveguide (5) by applying a voltage on said waveguide, said method comprising the steps of:

using an optical modulator comprising a plate (4) having a first main face (4a) and a second main face (4d), a channel optical waveguide (5) being formed in the plate (4), the plate having a thickness of not less than 3 μm and not more than 20 μm selected so that the plate (4) functions as a slab optical waveguide, and said channel optical waveguide (5) including at least a pair of branched portions (5b, 5c) and a recombining portion (5f) of said branched portions (5b, 5c), a modulating electrode (7A, 7B, 7C) for applying a signal voltage and a direct current bias on said channel optical waveguide (5);

propagating light of off-mode radiated from said recombining portion (5f) in slab mode in said slab optical waveguide (4);

receiving said light of off-mode at a photodetector (13); and

varying said direct current bias based on said received light so as to control the operational point of said optical modulator (1);

wherein:

the optical modulator further has a supporting substrate (2) and an adhesive layer (3) joining said supporting substrate (2) and said second main face (4d) of said plate (4) acting as a slab optical

waveguide, said adhesive layer having a refractive index lower than that of said plate (4),

the material of said plate (4) acting as an optical waveguide is lithium niobate,

the material of said support substrate (2) is a ferroelectric single crystal of lithium niobate,

the channel optical waveguide being a titanium-diffused lithium niobate type optical waveguide formed in the lithium niobate forming said plate (4) on the side of said first main face (4a) of said plate (4), wherein the modulating electrode is formed on said first main face of said plate (4),

said channel optical waveguide (5) has an output portion (5d) having an end face (5a) at an end face of said plate (4),

and an optical fiber (21) is fitted on said end face of said plate (4) to receive said radiated light and said photodetector (13) receives the radiated light from the optical fiber (21)."

Reasons for the Decision

1. Amendments

The board is satisfied that the present amended set of claims 1-4 fulfills the requirements of Article 123(2) EPC.

No objection under Article 123(2) was raised by the examining division in its refusal against the auxiliary request then on file. Concerning the additional amendments filed during the appeal proceedings, the board accepts the basis for the amendments indicated in the marked-up copy of the claims filed by the applicant in his letter of 18 February 2014.

2. Novelty

Novelty of the claimed optical modulator was never disputed.

3. Inventive step

3.1 Closest prior art

During first instance proceedings, the examining division found that D4 constituted the closest prior art document, whereas the applicant considered D1 as being the closest prior art document.

In view of the amendments of the claimed subject-matter, filed by the applicant with letter of 18 February 2014, the board considers that both D1 and D4 constitute a suitable starting point for the consideration of inventive step. In particular, both D1 and D4 belong to the same technical field as the present invention, i.e. optical modulators, and disclose the same type of devices as the present application, i.e. a Mach-Zehnder type optical modulator for modulating light propagating in an optical waveguide by applying a voltage, the modulator comprising an input waveguide, a pair of branched waveguide portions and a recombining output portion.

If there are several different prior art documents, each of which might plausibly be taken as a starting point for the assessment of inventive step, it is established case law that inventive step be assessed relative to *all* these pieces of prior art before any decision confirming inventive step is taken (see T967/97, point 3.2; T308/09, point 1.4.1).

3.2 Starting from D4 as closest prior art

D4, with reference to figures 1a and 1b, discloses an optical modulator (1) for modulating light propagating in a channel optical waveguide by applying a voltage on said waveguide *(see D4, [0005])*, said modulator comprising:

- a plate (2),

- a channel optical waveguide (4) formed in the plate (2) and having a pair of branched portions (4b, 4c) and a recombining portion (4d) of said branched portions, the modulator having an off-mode in which light is radiated into said plate (2) from said recombining portion (4b, 4c) *(this is an inherent property of a Mach-Zehnder optical waveguide modulator; see, e.g. D1, page 2, lines 42-44, disclosing radiation light generated at the recombining portion)*,

- a modulating electrode (3A, 3B, 3C) for applying a signal voltage and a direct current bias on said channel optical waveguide to modulate light propagating in said channel optical waveguide *(see D4, e.g. [0014])*,

- wherein the plate (2) has a thickness of 10 microns (see D4, [0032]) so that the plate guides the light of the off-mode in slab mode *(see D4, e.g. [0018], [0024], [0032]; on one side, the plate (2) is surrounded by air and, on the other side, by an adhesive layer (5), wherein the refractive index of the adhesive layer is lower than that of the waveguide material, thereby implying that the plate is suitable for guiding light being radiated at the recombining portion in the OFF-mode)*,

- the optical modulator further has a supporting substrate (6) and an adhesive layer (5) joining said supporting substrate (6) and said plate (2) acting as a slab waveguide, said adhesive layer having a refractive index lower than that of said plate (2) *(see the explanations above)*,

- the material of said plate (2) acting as an optical waveguide is $LiNbO_3$ *(see D4, [0032])*,

- the channel optical waveguide being a titanium-diffused lithium niobate optical waveguide formed in the lithium niobate forming said plate (2) *(see D4, [0032])*,

- said channel optical waveguide (2) has an output portion having an end face of said plate *(see D4, figure 1b)*.

It follows that D4 discloses all features of present claim 1 except for the following features (i) to (iii) relating to the layer structure of the optical modulator and features (iv) to (vi) relating to the photodetector:

(i) the modulating electrodes (3A, 3B, 3C) and the channel optical waveguide (4) are formed on the same face of the plate (2), the so-called first main face (2a),
(ii) the adhesive layer joins the supporting substrate (6) and the other face of the plate (2), the so-called second main face (2c), the second main face being opposite to the first main face of the plate,
(iii) the material of the support substrate (6) is a ferroelectric single crystal of lithium niobate,

(iv) a photodetector for receiving light radiated from said plate in said off-mode and providing an output,
(v) a controlling unit for varying said direct current bias based on said output from said photodetector so as to control the operational point of said modulator,
(vi) wherein an optical fiber is fitted on said end face of said plate (2) to receive said radiated light and said photodetector receives the radiated light from the optical fiber.

The above features (i) and (ii) of the claimed subject-matter contribute to define a structure of an optical modulator which is fundamentally different to that of D4. Indeed, in D4, due to its specific manufacturing process (see D4, [0025] to [0028], figure 2), the electrodes and the channel waveguide are necessarily on opposite faces of the plate, instead of being formed on the same face as claimed. Moreover, the manufacturing process of D4 requires that the adhesive layer joins the support substrate and the face of the plate where the channel waveguide is formed, thereby covering the channel waveguide, whereas no such covering of the channel waveguide by an adhesive layer is claimed.

The skilled person has no obvious incentive to question the manufacturing process disclosed in D4 because it efficiently solves the problem in the prior art of reducing the thickness of the slab waveguide. Even if the skilled person would envisage forming the electrodes on the same face of the substrate as the channel waveguide, he would not only have to radically modify the manufacturing steps taught in D4, but he would lack the incentive to do so because certain technical advantages, described in D4, [0028], resulting from covering the channel waveguide with an adhesive layer, would no longer be achieved.

Furthermore, in view of the simulation results shown in annex G, filed with the applicant's letter of 21 January 2014, the board is satisfied that the above features (i) and (ii) effectively contribute to the solution of the technical problem "to allow the operational point of the optical modulator to be controlled in a more efficient and stable manner".

Even though it is generally known in the art to form a channel waveguide and electrodes on the same surface (see, for instance, the modulator of D1), the board cannot see any

compelling reason why the skilled person would apply this conventional knowledge to the specific modulator of D4, and even if he would do so, the board is of the opinion that the implied modifications of the modulator of D4 would go beyond the abilities of the person skilled in the art.

Therefore, the board comes to the conclusion that the claimed optical modulator comprises an inventive step with respect to D4 as closest prior art.

The same conclusion applies to the method for modulating light of claim 2 for corresponding reasons.

3.3 Starting from D1 as closest prior art

The claimed modulator differs from that of D1 mainly in that it comprises a plate, in which the channel optical waveguide is formed, which has a thickness of not more than 20 microns such that it functions as a slab optical waveguide, guiding the light of the off-mode in slab mode to be detected by a photodetector. Moreover, contrary to the modulator of D1, the claimed modulator comprises an adhesive layer bonding the thin plate of not more than 20 microns to a support substrate.

As disclosed in the original application, page 2, paragraphs [0004] to [0006], the objective technical problem solved by the present invention consists in providing a more efficient and more stable control of the operational point of the optical waveguide.

As admitted by the applicant in his letter of 11 June 2009, and agreed to by the board, "D1 is clearly directed at a similar (if not the same) purpose or effect as the present invention" (see point 50 of that letter), but "D1 then

describes another (alternative solution) to this problem" (point 66 of the applicant's letter).

In order to arrive at the claimed modulator, starting from the alternative solution of D1, the skilled person would have to completely redesign the layer structure of the modulator of D1. The following modifications of the modulator of D1 would become necessary:

- to suppress the light guiding region (21),

- to exchange the thick substrate (1a) of lithium niobate, on the main surface of which the channel waveguide is formed, by a slab substrate,

- to provide an additional substrate on which the slab substrate is bonded via an adhesive layer.

First of all, the board sees no incentive which would prompt the skilled person to look for an alternative solution to the apparently satisfactory solution disclosed in D1.

In addition, starting from D1 and having to abandon its main technical teaching, i.e. providing a light guiding region within a thick substrate, would constitute a serious disincentive for the skilled person to seek an alternative solution along the lines of the claimed modulator.

Furthermore, replacing the single, monolithic thick substrate including the light guiding region of D1 by two substrates to be bonded together, represents at first view a more complex manufacturing process. Therefore, without knowing the improved collection efficiency of light radiated in the off-mode, the skilled person would actually be discouraged from seeking a solution of the sort exemplified by the technical features of the claimed device.

As a consequence, the board comes to the conclusion that the claimed optical modulator comprises an inventive step also with respect to D1 as closest prior art.

The same conclusion applies to the method for modulating light of claim 2 for corresponding reasons.

3.4 In view of the above considerations, the board is satisfied that the claimed optical modulator and the corresponding method for modulating light comprise an inventive step with respect to the available prior art.

4. It follows that the main request meets the requirement of the EPC and that a patent can be granted on the basis thereof.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to grant a patent based on the following documents:

- Claims 1 to 4 of the main request as filed with letter dated 18 February 2014,

- Description pages 1 to 11 as filed with letter dated 18 February 2014,

- Drawings sheets 1/11 to 11/11 as originally filed.

The Registrar: The Chairman:

D. Meyfarth D. Rogers

Decision electronically authenticated