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Datasheet for the decision of 23 March 2012

Case Number: T 1461/08 - 3.4.02

Application Number: 04798526.2

Publication Number: 1687672

IPC: G02F1/355, G02B6/134

Language of the proceedings: EN

Title of invention:
FABRICATION OF OPTICAL WAVEGUIDES IN PERIODICALLY POLED LITHIUM NIOBATE

Applicant:
UNIVERSITY OF SOUTHAMPTON

Headword:

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step (claim 1 - yes)

Decisions cited:

Catchword:

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T1461/08 - 3.4.02

D E C I S I O N
of the Technical Board of Appeal 3.4.02
of 23 March 2012

Appellant: (Applicant)	UNIVERSITY OF SOUTHAMPTON Highfield Southampton, Hampshire SO17 1BJ (ROYAUME UNI)
Representative:	McGowan, Cathrine D Young & Co LLP 120 Holborn London EC1N 2DY (ROYAUME UNI)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted 4 March 2008 refusing European patent application No. 04798526.2 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman: A. Klein
Members: M. Rayner
B. Müller

Summary of Facts and Submissions

I. The applicant has appealed against the decision of the examining division refusing European patent application number 04 798 526.1 (=WO-A-2005/052682) concerning a method of fabricating an optical waveguide. Documents including the following have been referred to in the proceedings before the first instance:

D4 M. Fujimura, T. Suhara et al.: "Fabrication of Zn:LiNbO3 waveguides by diffusing ZnO in low pressure atmosphere, Jpn. J. Appl. Phys., vol. 39 (2000), pp. L864-L865, XP977869,

D6 M. Fujimura, T. Suhara et al.: Fabrication of $LiNbO_3$ TE/TM waveguides for 1.5µm wavelength band by Zn/Ni diffusion in low-pressure atmosphere, Jpn. J. Appl. Phys., vol. 41, part 1, no. 7B (July 2002), pp. 4825-4827, XP-001163083,

D7 M. Fujimura, T. Suhara et al.: Quasi phase matched wavelength conversion in Zn-diffused $LiNbO_3$ waveguides, Techn. Digest, CLEO/ Pacific Rim 2001 (15.07.2001), vol. 1, pp. 1-96 to 1-97.

D9 Machine Applications Corporation: "The MAC Humidity/Moisture Handbook", 1999, XP007903843.

II. In the decision under appeal, the examining division was of the view that claim 1 as before it was not allowable as its subject-matter did not involve an inventive step. In particular, document D6 discloses a method of fabricating Zn-diffused optical waveguides. Moreover, document D6 discloses that these Zn-diffused

waveguides can be applied to QPM wavelength conversion devices having a domain-inverted layer. In order to learn how the Zn-diffused waveguides according to document D6 can be applied to QPM devices with a domain-inverted grating, the skilled person would have noted that document D6 includes a reference to document D7 and it is even from the same research group as document D6. A similar non-inventiveness argument starts from the teaching of document D7, which differs from the definitions of claim 1 in that ZnO is used instead of Zn. It is known from document D7 that lower diffusion temperatures are desirable in order to protect the grating structure and it appears from document D6 that diffusion from metallic Zn could do with less than 890°C. A skilled person is always expected to look for alternative solutions that promise advantageous effects and would find document D6, which discloses diffusion from a metallic Zn layer.

Claim 1 defines, additionally, heating in dry air whereas document D6 merely discloses heating in air (see page 4825, right hand column, lines 5-8), but is silent about the precise composition of the atmosphere. However, document D6 discloses thermal diffusion in air at atmospheric pressure and in particular teaches diffusion in a low-pressure air atmosphere and implies a dry-air atmosphere, for the following reasons.

As set out in the section Saturation Pressure starting on page 4 of document D9, above the boiling point of water (which is the case in the method of the present invention) the maximum possible relative humidity is reduced (see in particular Fig. 3 and the first sentence on page 6, which states that at a temperature of 700 °F=371 °C, at atmospheric pressure the relative humidity cannot rise above 0.48%). Hence, when normal

clean room air is heated to 930 °C, the relative humidity will be far below 1 %. Moreover, document D6 teaches diffusion in air of low-pressure atmosphere (in particular, at 1.0 Torr). As set out on page 5 of document D9, the partial pressure of water vapour is equal to the atmospheric pressure above the boiling point, and the saturation pressure increases with temperature. Hence, it follows from the relation on page 5 of document D9 that in a low pressure atmosphere, the relative humidity is even lower than under atmospheric pressure, i.e. much smaller than 1%. Thus, the atmosphere used in document D6 must be considered a dry-air atmosphere. Hence, a skilled person can be expected to arrive at the subject-matter of claim 1 by adding the teaching of document D7 to that of document D6, or vice versa, and the subject-matter of the claim is not inventive.

While clean rooms are humidity controlled, with a set value in the range of about 42-45% relative humidity, relative humidity of air drops once the air is heated and/or the air pressure is reduced. The diffusion process requires the air to be heated and document D6 moreover teaches a low-pressure atmosphere. Thus, the atmosphere in document D6 can be considered as dry air. Furthermore, the present application does not define what exactly is meant with "dry", as "dry" is a relative and thus vague expression within the context. Wet atmospheres are well known in the art; however, whenever such wet atmospheres are used, they are commonly explicitly mentioned, as extra measures and devices are required (in particular, an increased pressure is necessary). However, document D6 does not disclose a wet atmosphere.

III. The appellant requested that the decision under appeal be set aside and a patent granted on the basis of the claims as refused in the decision as main request or of claims as filed as first and second auxiliary request with the statement of grounds for appeal dated 27 June 2008. Oral proceedings were requested on an auxiliary basis.

IV. In support of its case, the appellant advanced arguments including the following.

Starting from document D6 and as acknowledged by the examining division, there is not disclosed the feature of claim 1 that the sample of z-cut lithium niobate has one or more gratings of periodic domain inversion defined by electric field poling. The examining division has concluded that it would be obvious for the skilled person to take teachings from document D7 relating to grating production in lithium niobate by electrical field poling and combine them with document D6 to arrive at the claimed subject matter. The general reference to the desirability of zinc-diffused waveguides in lithium niobate for QPM in the introduction of document D6 does direct the skilled person to document D7. However, from document D7 he will learn that if it is desired to make such waveguides directly in already poled material, ZnO should be used. Beginning from document D7, claim 1 differs in using a layer of metallic zinc and does not use ZnO as taught by document D7. There are many differences between metallic zinc and ZnO which would suggest disadvantages to be weighed against any alleged advantage of lower temperatures. Therefore, the skilled person considering document D7 would not be prompted by anything in document D6 to modify the method described in document D7 in any way that would result in the

method according to claim 1.

Documents D6 and D7 are both silent on the subject of the moisture content of the air, as acknowledged in the decision. Since atmospheric pressure is a standard operational condition for any process which is not generally known to be performed at high or low pressure, it is not positively recited in the application because it would be assumed by a person skilled in the art of in-diffusion techniques in the absence of any teaching to the contrary. Only exceptions to standard conditions are given where these are necessary to enable a process to be carried out in the intended way. Hence, documents D6 and D7 clearly state the use of low pressures, because the techniques described therein deviate from standard conditions, but do not state anything about humidity, so standard cleanroom humidity is assumed. In contrast, the present invention uses dry air, so this feature is mentioned in the description (page 13, lines 2-3).

Nevertheless, the examining division has concluded that dry air can be inferred from the information given in documents D6 and D7, even in view of the explicit teaching in both documents of diffusion at low pressures together with the assumed use of standard clean room conditions (in the absence of contrary information). This is not agreed because the examining division's reasoning is erroneous. While the statements given in the decision are correct, their interpretation is wrong. Documents D6 and D7 do not teach a dry air environment, contrary to the invention according to claim 1. A key point that the division appears to have missed is that while the relative humidity (RH) changes, the percentage by volume of moisture will remain constant if a given sample of air is heated at

constant pressure. This is explained clearly in document D9 page 6, which gives an example "Let us assume the room we are in is at a temperature of 60F and the relative humidity is 50%. The % water vapour in the room under these conditions is 0.87%. If we turn on an electric heater and increase the room temperature to 72F the RH will drop to 33% even though the % moisture by volume remains at 0.87%." So, if clean room air is taken into a furnace (see document D6, "Fabrication" section) at 930 centigrade and heated, it will still contain the same amount of water vapour by volume as the original clean room air. Assuming a slightly cold clean room, the figure will be around the 0.87% previously quoted. The RH value will decrease, but the concentration of moisture will remain the same. Thus the chemical effect of the water vapour on a diffusion process may/will be considerable if clean room air is used in a furnace at high temperature. Certainly this fits with the observation in document D6 that atmospheric air results in a rough surface and poor diffusion. It is well known that moisture at high temperatures is very aggressive chemically, so for example in the production of oxide layers on silicon a steam atmosphere is often used to increase oxidation rate. Thus, in having to assume standard clean room conditions, at atmospheric pressure the fact that air is heated during diffusion does not affect moisture concentration, and a normal moisture content would be present, in contrast with the dry air recited in claim 1. The division further argues that at low pressure, as taught by documents D6 and D7, and with heating, the relative humidity is even lower than at atmospheric pressure. This again is misleading. The operation of a low pressure furnace requires a vacuum pump to control pressure, otherwise leaks will cause an increase in pressure. To maintain a stable pressure of 1.0 Torr (as

in document D6) it must be assumed that the leak rate matches the pumping rate, whether the leak is due to diffusion through the furnace material, or whether due to an artificially induced leak (such as a needle valve allows). Thus, the low pressure furnace is being fed with air that contains the same composition (and moisture per volume) as the clean room air. Hence the input air will contain the same approximately 0.87% by volume of moisture. Clearly the pressure is lower inside the furnace, and it is thus submitted that the percentage by volume of moisture would be reduced by the ratio of the pressures, i.e. reduced by around 1000 times. However, given that the clean room air would be at least 8700 ppm of water, at least 8.7ppm of moisture inside the furnace is assumed. It is submitted that this is a level that cannot be considered "dry" in chemical terms. Thus, from the information given in documents D6 and D7, it is incorrect to conclude that dry air was used. Hence, neither document D6 nor D7 teach the feature of dry air according to claim 1. There is nothing in these documents to suggest to the skilled person that dry air conditions can be employed for the diffusion of metallic zinc, and specifically not for the diffusion of metallic zinc into electric field poled lithium niobate, thus the claimed subject matter is considered to involve an inventive step.

V. Independent claim 1 according to the main request of the appellant is worded as follows.

"1.A method of fabricating an optical waveguide comprising the steps of:
(a) providing a sample of z-cut lithium niobate (10) having one or more gratings of periodic domain inversion defined therein by electric field poling;
(b) applying a layer of metallic zinc (16) to a z-face

of the sample (10), the layer having a pattern corresponding to a desired pattern of optical waveguide; and
(c) heating the sample (10) in dry air to cause the zinc (16) to diffuse into, and hence alter the refractive index of, the lithium niobate so as to form an optical waveguiding structure (18) within the lithium niobate."

It is not necessary for the present decision to give the wording of claim 1 according to the auxiliary requests in the light of section 4 of the reasons for the decision set out below.

Reasons for the Decision

1. The appeal is admissible.

2. Novelty

2.1 There is no disagreement between the examining division and the appellant that the subject matter of claim 1 is novel over either of documents D6 or D7. In the case of document D6 novelty is given by providing a sample of z-cut lithium niobate having one or more gratings of periodic domain inversion defined therein by electric field poling and in the case of document D7 because ZnO is used instead of Zn.

2.2 There is, however, a disagreement about the dry air feature. It is common ground between the examining division and the appellant that use of dry air is not explicitly disclosed in either document D6 or D7. However, in its reasoning, the examining division uses the wording in association with document D6 (or D7) "implies a dry atmosphere", leading the board to

conclude that the division considered a dry atmosphere to be implicitly disclosed in document D6 (or D7). The board is not convinced that this is correct because the division concedes that at the start clean room air is used but then relies on a calculation of relative humidity to show that the air has become dry when it is used. The problem with this is that the relative humidity calculation is just that and does not explain where the moisture in the clean room air is actually supposed to have gone, so the appellant is correct to argue that really it remains in the furnace in some form, so that the atmosphere is not dry. Therefore, the line of argument advanced by the division did not persuade the board that "heating the sample in dry air" is implicitly disclosed in the disclosure of document D6 (or D7).

2.3 The examining division also had problems understanding exactly what is meant by dry because it considered this term relative and vague. Moreover, although wet atmospheres when used are commonly explicitly mentioned, document D6 did not disclose a wet atmosphere nor measures to create such. In the board's view, one could, by the same token, also argue that wet is relative and vague and observe that document D6 does not disclose dry atmosphere measures for creating a dry atmosphere. Therefore, it is speculation either way and the division's argument is not very convincing. The discussion can, in any case, be considered moot in the light of, say, the third line of the right hand column on page L864 of document D4, deriving from the same research team as documents D6 and D7, which does refer to dry and wet in connection with a preliminary experiment. This argument of the division does not therefore persuade the board that "heating the sample

in dry air" is implicitly disclosed in the disclosure of document D6 (or D7).

2.4 Finally, it does seem that deviations from standard in relation to air, be it pressure or moisture content, are mentioned in the documents concerned when they occur, e.g. dry air in the application and pressure in document D6. The appellant is therefore correct on this point.

2.5 The board therefore reached the conclusion that "heating the sample in dry air" is not disclosed in either of documents D6 and D7 and thus, in addition to the agreed novel features, considers this subject matter of claim 1 to be novel over document D6 or D7.

3. Inventive Step

3.1 The problem addressed by the novel features of claim 1 is to provide an improved method of fabricating an optical waveguide.

3.2 There seem, especially, to be difficulties with changes to surface of material (e.g. page 4, line 21 of the application or line 6 of the right column on page 4825 of document D6). Both the application and document D6 seek to mitigate these difficulties. In the case of document D6, low pressure is seen as the way forward and in the case of the application dry air is used.

3.3 Temperature, pressure and moisture content are parameters that play an important, if not decisive, role in many chemical and fabrication methods. The skilled person can therefore be expected to consider these in relation to improving known methods. However, document D6 is the document employing Zn, so

generalisations or reference to documents using other methods are further away from the subject matter of claim 1. In the present case, the problem of the rough surface is met by using low pressure according to document D6 and, moreover, low pressure is also used in document D7. It is therefore difficult to see why the skilled person, for fear of losing this solution, would want also to use dry air, because, as the appellant argued, the chemical effect of water vapour on a diffusion process may/will be considerable. Thus, in view of the sensitivity of the fabrication method to such effects, the board cannot in all fairness consider use of dry air obvious to the skilled person. The case of the appellant as to inventive step in relation to a combination of documents D6 and D7, either way, is therefore persuasive.

3.4 The board has examined the contents of the file in relation to patentability and does not consider the available prior art otherwise to call patentability of claim 1 into question. Accordingly, the board reached the conclusion that the subject matter of claim 1 can be considered to involve an inventive step. The same conclusion can be drawn for the other claims because they depend from claim 1.

4. Auxiliary Requests

Since the board reached a positive view in relation to the main request, consideration of the auxiliary requests is not necessary in the present decision. Similarly, oral proceedings, which were requested on an auxiliary basis, are not necessary.

5. Procedure

In view of the foregoing and since the board sees no other bar to grant of a patent, the board considers it appropriate to exercise powers within the competence of the first instance and order grant of a patent.

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:

Description

Pages 1,2,5-19 as published,

Page 3 filed with the letter dated 14 December 2006,

Page 4 filed with the letter dated 01 June 2007,

Claims

1-5 filed with the letter dated 01 June 2007,

6-7 as published, and

Drawing

Sheets 1/3 to 3/3 as published.

The Registrar: The Chairman:

M. Kiehl A. Klein

Decision electronically authenticated