(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 January 2014 (23.01.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/012572 Al

(51) International Patent Classification:
H01L 33/48 (2010.01)

(21) International Application Number:
PCT/EP2012/063906

(22) International Filing Date:
16 July 2012 (16.07.2012)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

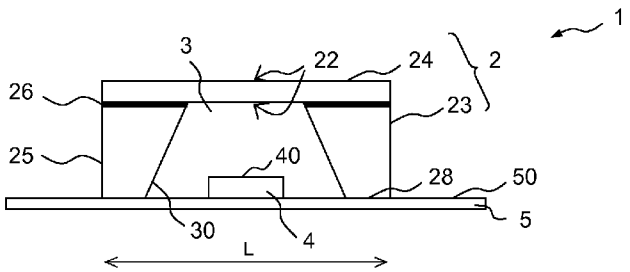
Published:

— *with international search report (Art. 21(3))*

WO 2014/012572 A1

(54) Title: OPTOELECTRONIC SEMICONDUCTOR DEVICE AND METHOD FOR PRODUCING AN OPTOELECTRONIC SEMICONDUCTOR DEVICE

FIG 1



(57) Abstract: In at least one embodiment, the optoelectronic semiconductor device (1) comprises a carrier (5) and at least one optoelectronic semiconductor chip (4) mounted onto the carrier (5). Moreover, the device (1) comprises at least one cap glass (2) comprising a cavity (3). The cap glass (2) also comprises a cover glass sheet (24) and a cavity glass sheet (23) which are connected with each other by means of an adhesive (26). The cavity glass sheet (23) is mounted in particular directly onto the carrier (5). An average lateral dimension (L) of the cap glass (2) is between 0.5 mm and 10.0 mm inclusive.

Description

Optoelectronic semiconductor device and method for producing an optoelectronic semiconductor device

An optoelectronic semiconductor device is provided. Moreover, a method for producing an optoelectronic semiconductor device is provided.

An object to be achieved is to provide an optoelectronic semiconductor device that could be manufactured efficiently.

This object is achieved in particular by an optoelectronic semiconductor device and by a method according to the independent claims. Further preferred embodiments are given in the dependent claims.

According to at least one embodiment, the optoelectronic semiconductor device comprises a carrier. The carrier is the component of the device that mechanically carries and stabilizes the device. The carrier could be of a rigid material so that the carrier does not bend in the intended use of the device. For example, the carrier is a circuit board or a printed circuit board. It is also possible for the carrier to be a metal core board or a ceramic board. Preferably, the carrier comprises tracks and contact points for an electrical connection and an electrical circuitry of the device.

According to at least one embodiment, the device comprises one or a plurality of optoelectronic semiconductor chips. Preferably, the at least one semiconductor chip is a light-emitting diode chip, LED chip for short. The semiconductor

chip is mechanically and electrically connected to the carrier. The semiconductor chip could also be thermally connected to the carrier. For example, the semiconductor chip is soldered onto the carrier. The carrier could comprise a heatsink the semiconductor chip is mounted on.

According to at least one embodiment, the optoelectronic semiconductor device comprises at least one cap glass. The cap glass comprises a cavity. For example, the cap glass is made of a borosilicate glass or of a soda lime glass. Preferably, the cap glass is transmissive for a radiation emitted by the optoelectronic semiconductor chip. The cap glass is designed to mechanically protect the semiconductor chip .

According to at least one embodiment, the cap glass comprises a cover glass sheet and a cavity glass sheet. The cover glass sheet and the cavity glass sheet are firmly connected with each other by means of an adhesive. In this case, the cavity is formed in the cavity glass sheet. Preferably, the cover glass sheet is free of a cavity. For example, the cover glass sheet could be a plane-parallel glass sheet.

According to at least one embodiment, the cavity glass sheet and thus the cap glass is mounted onto the carrier. In particular, the cavity glass sheet is directly mounted onto the carrier. This could mean that, between the carrier and the cavity glass, there is only an adhesive that provides mechanical connection between the carrier and the cavity glass sheet. The cavity glass sheet and thus the cap glass is firmly fixed to the carrier. This could mean that the cavity glass sheet does not delaminate from the carrier in the intended use of the semiconductor device. Preferably, the

cavity glass sheet is located between the carrier and the cover glass sheet. Hence, the cover glass sheet is preferably not in direct contact with the carrier.

According to at least one embodiment, an average lateral dimension of the cap glass or a minimum lateral dimension of the cap glass is at least 0.5 mm or at least 0.7 mm or at least 1.0 mm or at least 1.5 mm. In addition or as an alternative, the minimum or average lateral dimension is at most 10.0 mm or at most 7.5 mm or at most 5.0 mm. The average lateral dimension is for example an average diameter of the cap glass. Lateral could mean in a plane perpendicular to a direction of main emittance of the optoelectronic semiconductor device and/or seen in a top view.

In at least one embodiment, the optoelectronic semiconductor device comprises a carrier and at least one optoelectronic semiconductor chip mounted onto the carrier. Moreover, the device comprises at least one cap glass comprising a cavity. The cap glass comprises a cover glass sheet and a cavity glass sheet which are connected with each other by means of an adhesive. The cavity glass sheet is mounted in particular directly onto the carrier. An average lateral dimension of the cap glass is between 0.5 mm and 10.0 mm, inclusively.

In particular, by constructing the cap glass in such a way, the semiconductor device can be produced more efficiently. Moreover, a better optical quality of the cap glass can be achieved. The risk of affecting electrical connection means for the semiconductor chip, for example bonding wires, by contact with the cap glass is minimized, as such a cap glass, in particular the cavity glass sheet, can be produced very accurately .

Another way of forming a cap glass is to etch a cavity into a piece of glass. In this case, the cap glass would be fashioned in a one-piece manner. However, an etching process for such a cap glass is comparatively unstable and could cause a rough and wavy cavity surface. Also, cavity dimensions could vary. Hence, an etched cap glass might result in a not uniform light output and could result in mechanical damages of a bonding wire due to the variations in the cavity shape and in the cavity size. Furthermore, the thickness of such a cap glass would be comparatively high, as a remaining glass thickness after the etching has to be at about at least 50% of the total thickness of such a cap glass because of the unstable chemical etching process.

According to at least one embodiment, a thickness of the cover glass sheet is at least 10% or at least 20% or at least 25% of a thickness of the cavity glass sheet. In addition or as an alternative, the thickness of the cavity glass sheet is at most 60% or at most 50% or at most 40% of the thickness of the cavity glass sheet. In other words, the cover glass sheet is comparatively thin. For example, the thickness of the cover glass sheet is at least 30 µm. Furthermore, the thickness of the cover glass sheet could be at most 1.1 mm or at most 0.7 mm.

According to at least one embodiment, the cavity glass sheet surrounds the semiconductor chip only in part, seen in top view. In other words, the cavity glass sheet does not form a closed and/or ring-like structure around the semiconductor chip, seen in top view. With such a cavity glass sheet, the semiconductor chip is not hermetically sealed. This allows for an exchange, for example of air, between the cavity and a

surrounding. This could improve a cooling of the optoelectronic semiconductor device.

According to at least one embodiment, the cover glass sheet completely covers the cavity glass sheet and/or the cavity and/or the semiconductor chip. By means of the cover glass sheet, the semiconductor chip could be protected from mechanical damage. The cover glass sheet could also give protection against chemical damages.

According to at least one embodiment, the cavity in the cavity glass sheet has the form of a cross, seen in top view. In particular, this cross could have one axis of symmetry or two axes of symmetry, seen in top view. The cross comprises at least or exactly two bars in particular perpendicular to each other. The bars could divide each other in half. A width of the bars is for example between 50% and 80% or between 30% and 65% of an overall width of the cross, seen in top view. For example, a width of the bars is at least 0.3 mm and/or at most 2.5 mm.

According to at least one embodiment, the cavity completely penetrates the cavity glass sheet. Thus, a thickness of the cavity can be the same as the thickness of the cavity glass sheet.

According to at least one embodiment, the cover glass sheet is fixed to the cavity glass sheet by means of an aerobic acrylic adhesive. Preferably, the adhesive can be cured by means of ultraviolet radiation. For example, the aerobic acrylic adhesive could be OP-67-LS from DYMAX.

According to at least one embodiment, coefficients of thermal expansion of the cover glass sheet and the cavity glass sheet on the one hand and of the adhesive on the other hand differ by at most a factor of ten. Hence, the different materials of the cap glass have similar coefficients of thermal expansion.

According to at least one embodiment, sidewalls of the cavity are inclined towards the semiconductor chip at least in part or completely. This means that an angle between a top face of the carrier the semiconductor chip is mounted onto and the sidewall is an acute angle. Moreover, it is possible that the cavity narrows in a direction away from the carrier. The narrowing could be continuous or step-like.

According to at least one embodiment, the sidewalls of the cavity are inclined away from the semiconductor chip in part or completely. Hence, the top face of the carrier and the sidewalls form an obtuse angle. In this case, the cavity could broaden in a direction away from the carrier, continuously or in a step-like manner.

According to at least one embodiment, an optical coating is applied to the sidewalls of the cavity. As an alternative or in addition, the same or a different optical coating could also be applied to at least part of one or two main faces of the cover glass sheet. It is also possible that more than one optical coating is applied to the sidewalls and/or the main faces of the cover glass sheet.

According to at least one embodiment, the optical coating is at least one of an antiref lection layer, a metallic mirror, a wavelength conversion medium or a filter. By means of a wavelength conversion medium, a wavelength of a radiation

emitted by the optoelectronic semiconductor chip during use of the optoelectronic semiconductor device can be converted into another, in particular greater wavelength.

If the optical coating is or comprises a filter, it is possible that a radiation emitted by the optoelectronic semiconductor chip is not allowed to leave the optoelectronic semiconductor device. Such a filter could be used in particular in connection with a wavelength conversion medium applied within the cavity and preferably also in connection with an antireflection layer for radiation of a wavelength produced by the wavelength conversion medium.

According to at least one embodiment, the sidewalls of the cavity and/or the main faces or at least one main face of the cover glass sheet and/or of the cavity glass sheet are planar faces. In other words, said faces or surfaces could be free of a curvature.

According to at least one embodiment, the cover glass sheet and/or the cavity glass sheet is/are provided with a roughening. The roughening is preferably located, in particular exclusively located, on outer lateral faces of said components. The roughening could be obtained for example by sawing, by blasting or by polishing.

According to at least one embodiment, a bottom side of the cavity glass sheet, said bottom side facing the carrier, is provided with an additional, further roughening. By means of the additional roughening, an adhesion between the carrier and the cap glass could be improved. In this case, the cap glass is preferably designed in such a way that no or

essentially no radiation emitted by the semiconductor chip can reach the further roughening.

A method for producing an optoelectronic semiconductor chip is also provided. By means of this method, an optoelectronic semiconductor device as described in conjunction with one or several of the aforementioned embodiments could be produced. Hence, features of the method are also disclosed for the optoelectronic semiconductor device and vice versa.

In at least one embodiment, the method comprises at least or exactly the following steps:
- providing a cavity glass sheet with a plurality of cavities ,
- providing a cover glass sheet,
- mounting the cover glass sheet onto the cavity glass sheet, thus producing a cap glass sheet,
- singularizing the cap glass sheet into a plurality of cap glasses wherein each cap glass comprises at least one of the cavities,
- providing at least one optoelectronic semiconductor chip which is mounted onto a carrier, and
- mounting at least one of the cap glasses onto the carrier, wherein said semiconductor chip is located within the cavity, preferably completely within the cavity.

The order of the steps could be as given in the previous paragraph or could deviate from the given order.

By means of such a method, it is possible to produce the cover glass sheet and the cavity glass sheet independently from each other. In particular, a cavity pattern in the cavity glass sheet can be formed from a flat glass sheet by a

precise machining process. In particular, the cavities can be produced mechanically and without an etching process in which glass material is removed by etching.

According to at least one embodiment of the method, the step of singularizing the cap glass sheet is performed before the step of mounting the cap glasses onto the carrier with the semiconductor chip already being mounted onto the carrier.

Advantageous embodiments and developments of the optoelectronic semiconductor device and of the method will become apparent from the exemplary embodiments described below in association with the figures.

In the exemplary embodiments and figures, similar or similarly constituent parts are provided with the same reference symbols. The elements illustrated in the figures and their size relationships among one another should not be regarded as true to scale. Rather, individual elements may be represented with an exaggerated size for the sake of better representability and/or for the sake of better understanding.

In the figures:

Figures 1 to 4 show cross-sectional views of exemplary embodiments of optoelectronic semiconductor devices described here,

Figure 5 shows schematic top views of cover glass sheets for exemplary embodiments of the optoelectronic semiconductor device, and

Figure 6 shows an exemplary embodiment of a method for producing an exemplary embodiment of an optoelectronic semiconductor device.

Figure 1 shows an exemplary embodiment of an optoelectronic semiconductor device 1 in a cross-sectional view. The semiconductor device 1 comprises a carrier 5 with a top face 50. The carrier 5 preferably comprises electrical conductor tracks and electrical contact points, which are not shown here.

Onto the top face 50, an optoelectronic semiconductor chip 4 is mounted, for example by soldering. The optoelectronic semiconductor chip 4 comprises a radiation exit surface 40 which faces away from the top face 50 of the carrier 5.

Moreover, the device 1 comprises a cap glass 2. The cap glass 2 is composed of a cavity glass sheet 23 and of a cover glass sheet 24 and of an adhesive 26. The cavity glass sheet 23 and the cover glass sheet 24 can be made from the same material and are connected with each other by the adhesive 26. Both the cover glass sheet 24 and the cavity glass sheet 23 are made from a glass that is transparent for a radiation emitted by the optoelectronic semiconductor chip 4 during use of the semiconductor device 1. The adhesive 26 preferably is also transparent. It is possible that the adhesive 26 is located only on certain areas between the cavity glass sheet 23 and the cover glass sheet 24.

In the cavity glass sheet 23, a cavity 3 is formed. The semiconductor chip 4 is completely located within the cavity 3. The cavity 3 has sidewalls 30 that face the semiconductor chip 4. The sidewalls 30 are inclined towards the

semiconductor chip 4 so that there is an acute angle between the sidewalls 30 and the top face 50 of the carrier 5.

A thickness of the cover glass sheet 24 is smaller than the thickness of the cavity glass sheet 23, for example by at least a factor of two. An average lateral dimension L of the cap glass 2 is for example in the order of 3 mm.

The cover glass sheet 24 has two main faces 22 that are positioned parallel with regard to each other and also parallel to the top face 50 and the radiation exit surface 40, within the tolerances of manufacture. The main faces of the cavity glass sheet 23 are also positioned parallel to the top face 50.

A further exemplified embodiment of the device 1 can be seen in figure 2. According to figure 2, optical coatings in form of antireflection layers 6 are applied to the main faces 22 of the cover glass sheet 24. Unlike shown here, it is also possible that such an antireflection layer 6 is applied only to one main face 22. Moreover, it is possible, unlike shown here, that the antireflection layer 6 that faces the semiconductor chip 4 covers the whole main face 22 facing the semiconductor chip 4.

An angle between the face 50 of the carrier 5 and the sidewalls 30 of the cavity 3 is for example between 10° and 40°, inclusively. This could be the case also in all other embodiments. Unlike what is shown here, it is also possible for the sidewalls 30 to be positioned perpendicular to the top face 50 of the carrier 5.

The exemplified embodiment of the device 1 according to figure 3 comprises a plurality of cavities 3 as is also possible in all other exemplified embodiments. In each of the cavities 3, exactly one semiconductor chip 4 is mounted. Unlike shown here, there could be more than one semiconductor chip 4 in each of the cavities 3.

An angle between the top face 50 of the carrier 5 and the sidewalls 30 of the cavity 3 is an obtuse angle. The part of the cavity glass sheet 23 between the two semiconductor chips 4 is fashioned in a one-piece manner. Thus, the same piece of the cavity glass sheet 23 forms part of the cavities 3 for both semiconductor chips 4.

As in all other embodiments, it is possible that a metallic mirror 7 is applied to the sidewalls 30 of the cavities 3.

Another exemplified embodiment is shown in connection with figure 4 in a cross-sectional view. In the cavity 3, a plurality of semiconductor chips 4 is mounted.

The cover glass sheet 24 is provided with a wavelength conversion medium on the main side 22 facing the semiconductor chip 4 and with an antireflection layer 6 and a filter 9 on the other main face 22. In particular, the filter layer 9 is optional for example when a mixed radiation both from the semiconductor chips 4 and the wavelength conversion medium 8 is emitted by the device 1. Such a wavelength conversion medium 8 and/or such a filter 9 could be present also in all other embodiments.

In figure 5, top views of exemplary embodiments of the cavity glass sheet 23 with the cavities 3 are shown. For the sake of

simplicity, an inclination of the sidewalls of the cavities 3 is not shown. For the same reason, the cavity glass sheets 23 in each case have only one of the cavities 3. Of course, the cavity glass sheet 23 could also be formed with a plurality of cavities 3.

According to figure 5A, the cavity 3 is formed as a cross. This is also the case in figure 5B. According to figure 5B, the cavity 3 is completely surrounded by a material of the cavity glass sheet 23, unlike in figure 5A. In figure 5A, only two opposite ends of one bar of the cross are limited by the material of the cavity class sheet 23, while the two ends of the other bar are open ends.

According to figure 5C, the cavity 3 has the form of a rectangle or of a square. According to figure 5D, the cavity 3 has the form of a circle or of an ellipse, seen in top view.

As shown in figure 5E, the cavity 3 has the form of a T. In a head of the T, the semiconductor chip could be located. The smaller part of the T could be a cut-out for a bonding wire. Unlike shown here, it is possible that the cavity 3 or the head of the cavity 3 is located exactly in the center of the cavity glass sheet 23.

According to figure 5F, the cavity 3 has the form of a rectangle or of a square. The cavity glass sheet 23 is formed as two blocks of a rectangular shape that are located on two opposite sides of the rectangle forming the cavity 3.

A method for producing the optoelectronic semiconductor device 1 is illustrated in connection with figure 6. In

figure 6, the upper half in each case represents a schematic top view and the lower half represents a schematic cross-sectional view.

According to figure 6A, the cavity glass sheet 23 with a plurality of cavities 3 is provided. The individual cavities 3 are geometrically formed for example as disclosed in connection with figure 5A. Other forms of the cavities 3 could also be applied, compare figure 5.

According to figure 6B, the cover glass sheet 24 is provided. The cover glass sheet 24 is an unstructured, flat sheet of glass.

As shown in figure 6C, the cover glass sheet 24 is applied to the cavity glass sheet 23. Between the cavity glass sheet 23 and the cover glass sheet 24, an adhesive 26 is applied. The adhesive 26 preferably is optically transparent and can be cured by ultraviolet radiation R, indicated by an arrow. thickness of the adhesive 26 is preferably very small compared to the thicknesses of the cover glass sheet 24 and the cavity glass sheet 23.

In figure 6D, a singularization of the cavity glass sheet 23 and the cover glass sheet 24 into the cap glasses 2 is illustrated. In the lower half of figure 6D, separation lines S are shown. The singularization is performed for example by sawing. It is possible that a singularization is performed in such a way that each of the singularized cap glasses 2 comprises exactly one of the cavities 3 or a plurality of the cavities 3.

The step of mounting the cap glasses onto a carrier with semiconductor chips is not shown in figure 6.

The invention is not restricted to the exemplary embodiments by the description on the basis of said exemplary embodiments. Rather, the invention encompasses any new feature and also any combination of features, which in particular comprises any combination of features in the patent claims and any combination of features in the exemplary embodiments, even if this feature or this combination itself is not explicitly specified in the patent claims or exemplary embodiments.

Patent Claims

1. Optoelectronic semiconductor device (1) comprising:
- a carrier (5),
- at least one optoelectronic semiconductor chip (4) mounted on the carrier (5), and
- at least one cap glass (2) comprising a cavity (3),
wherein
- the cap glass (2) comprises a cover glass sheet (24) and a cavity glass sheet (23) which are connected with each other by means of an adhesive (26),
- the cavity glass sheet (23) is mounted onto the carrier (5), and
- an average lateral dimension (L) of the cap glass (2) is between 0.5 mm and 10.0 mm inclusive.

2. Optoelectronic semiconductor device (1) according to the preceding claim,
wherein a thickness of the cover glass sheet (34) is between 10% and 50% inclusive of a thickness of the cavity glass sheet (23),
wherein the cavity glass sheet (23) surrounds the semiconductor chip (4) only in part, seen in top view, and
wherein the cover glass sheet (24) completely covers the cavity glass sheet (23), the cavity (3) and the semiconductor chip (4).

3. Optoelectronic semiconductor device (1) according to any one of the preceding claims,
wherein the cavity (3) in the cavity glass sheet (23) has the form of a cross, seen in top view.

4. Optoelectronic semiconductor device (1) according to any one of the preceding claims,
wherein the cavity (3) completely penetrates the cavity glass sheet (23).

5. Optoelectronic semiconductor device (1) according to any one of the preceding claims,
wherein the cover glass sheet (24) is fixed to the cavity glass sheet (23) by means of an aerobic acrylic adhesive (26) which can be cured by means of ultraviolet radiation (R).

6. Optoelectronic semiconductor device (1) according to any one of the preceding claims,
wherein sidewalls (30) of the cavity (3) are inclined towards the semiconductor chip (4) at least in part, and
wherein the cavity (3) narrows in a direction away from the carrier (5).

7. Optoelectronic semiconductor device (1) according to any one of the preceding claims,
wherein the sidewalls (30) of the cavity (3) are inclined away from the semiconductor chip (4) at least in part.

8. Optoelectronic semiconductor device (1) according to any one of the preceding claims,
wherein the sidewalls (30) of the cavity (3) and/or at least one main face (22) of the cover glass sheet (24) are provided with an optical coating (6, 7),
the optical coating (6, 7) being at least one of an antireflection layer (6), a metallic mirror (7), a wavelength conversion medium (8) and a filter (9).

9. Optoelectronic semiconductor device (1) according to any one of the preceding claims, wherein the sidewalls of the cavity (3) and the main face (22) of the cover glass sheet (24) that faces the semiconductor chip (4) are planar faces.

10. Optoelectronic semiconductor device (1) according to any one of the preceding claims, wherein the cover glass sheet (24) and the cavity glass sheet (23) are provided with a roughening on outer lateral faces (25).

11. Optoelectronic semiconductor device (1) according to any one of the preceding claims, wherein the cover glass sheet (24) is flush with the cavity glass sheet (23) in a lateral direction.

12. Optoelectronic semiconductor device (1) according to any one of the preceding claims, wherein a bottom side of the cavity glass sheet (23) that faces the carrier (5) is provided with a roughening (28) to improve adhesion with the carrier (5).

13. Method for producing optoelectronic semiconductor devices (1) comprising the steps of:
- providing a cavity glass sheet (23) with a plurality of cavities (3),
- providing a cover glass sheet (24),
- mounting the cover glass sheet (24) onto the cavity glass sheet (23), thus producing a cap glass sheet (20),
- singularizing the cap glass sheet (20) into a plurality of cap glasses (2), each cap glass (2)

comprising at least one of the cavities (3),
- providing at least one optoelectronic semiconductor chip (4) which is mounted onto a carrier (5), and
- mounting at least one of the cap glasses (2) onto the carrier (5) such that the semiconductor chip (4) is located in the cavity (3).

14. Method according to the preceding claim,
wherein the step of singularizing the cap glass sheet (20) is performed before the step of mounting the cap glasses (2), and
wherein the cavities (3) are produced mechanically and without etching.

FIG 1

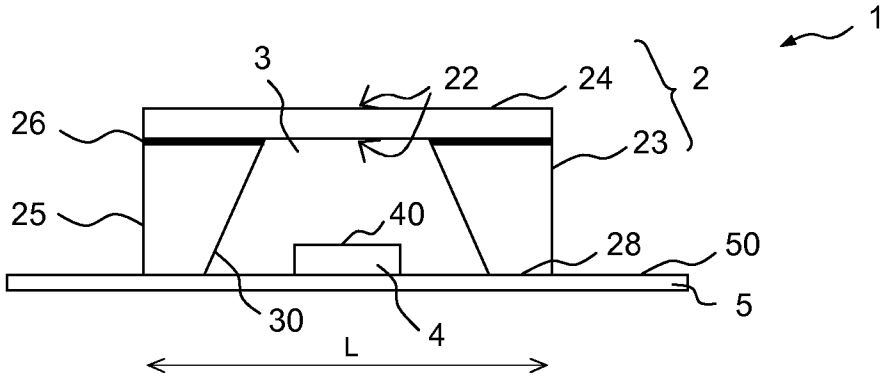


FIG 2

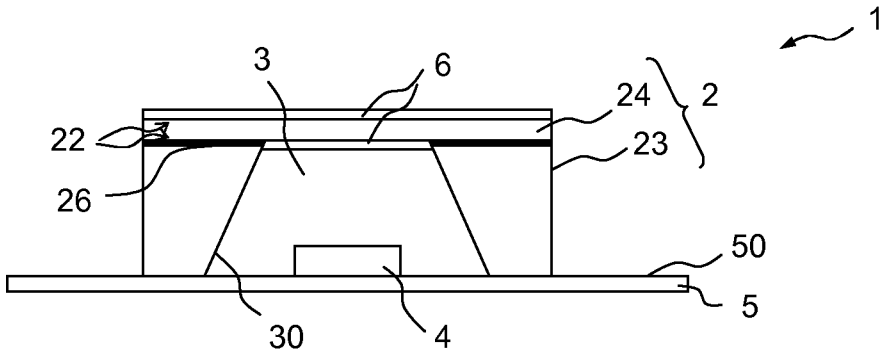


FIG 3

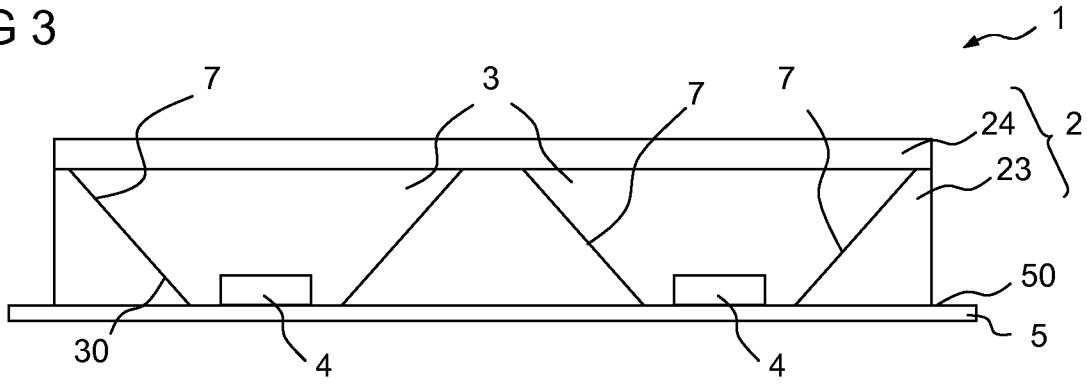


FIG 4

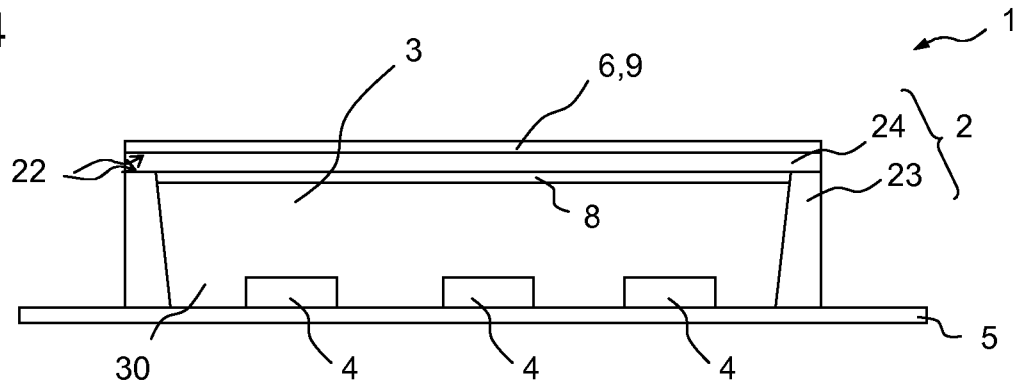


FIG 5

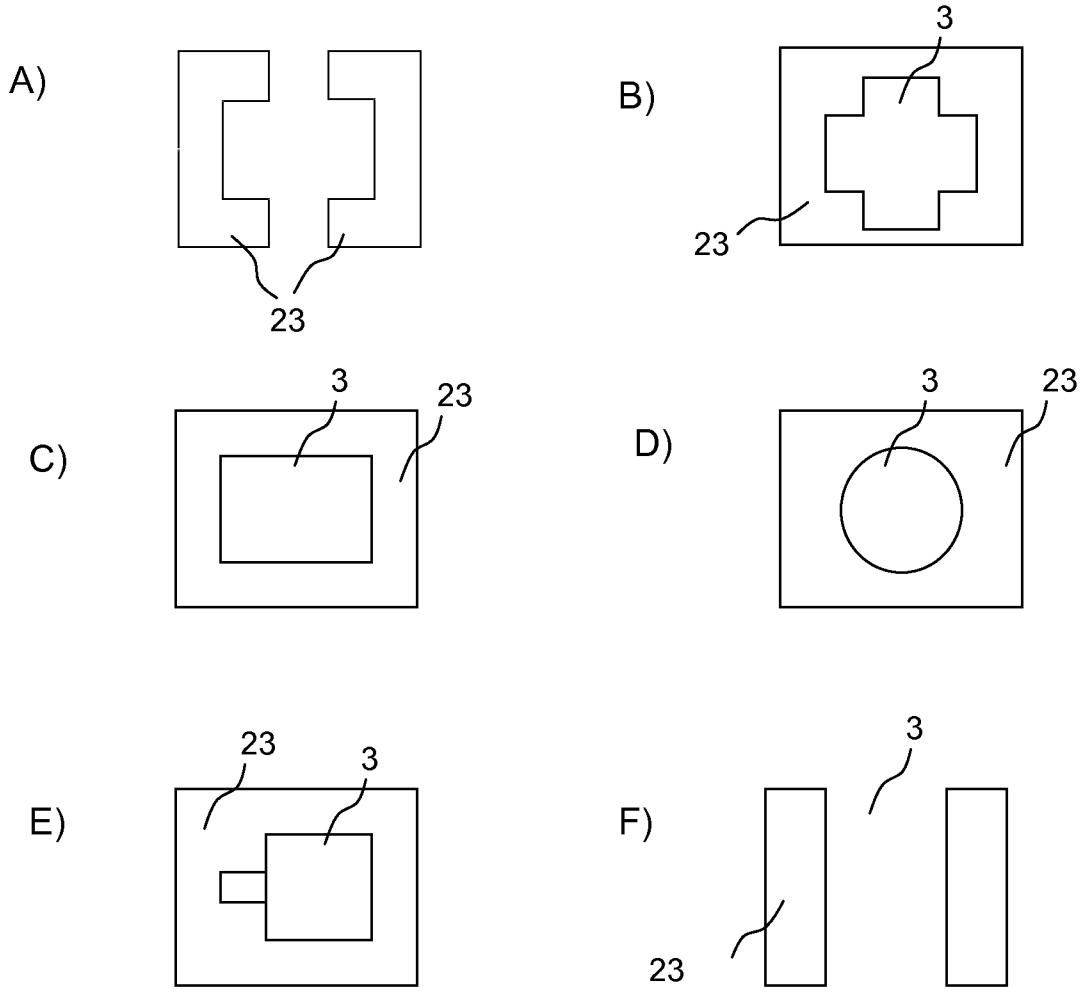
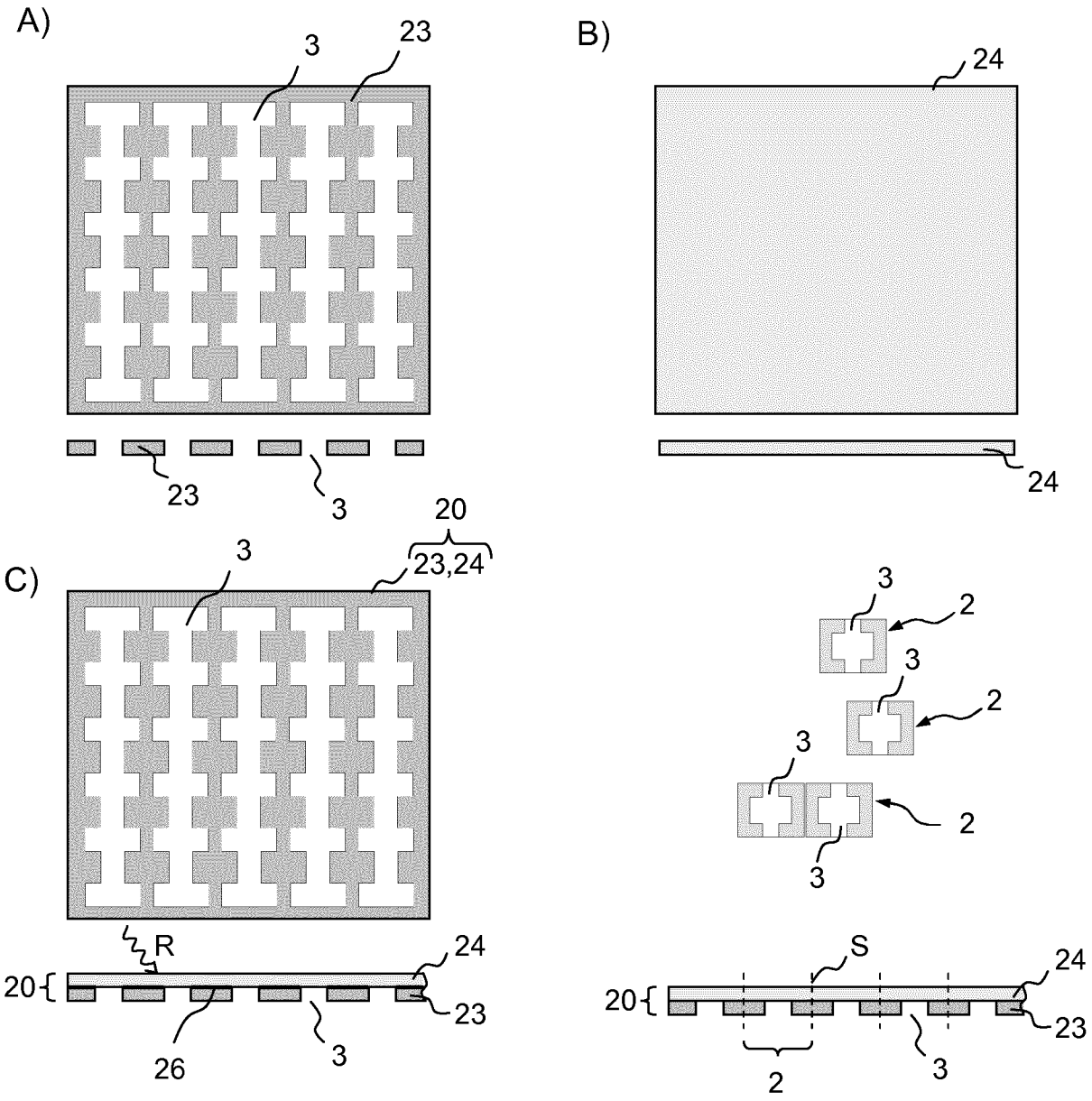


FIG 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/063906

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L33/48
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009/219728 Al (HATA SHOHEI [JP] ET AL) 3 September 2009 (2009-09-03) abstract; figures 1,2,4-10, 17 paragraphs [0011] , [0065] - [0073] , [0109] , [0111]	1-5 ,7-9 , 11 , 12
Y	US 2002/179919 Al (DEISENH0FER MANFRED [DE] ET AL) 5 December 2002 (2002-12-05) paragraphs [0039] - [0040] ; figures 1,3	1-5 ,7,8, 11 , 12
Y	US 2011/109222 Al (IN0UE TETSU0 [JP] ET AL) 12 May 2011 (2011-05-12) paragraph [0054] ; figure 1	1-5 ,7-9 , 11 , 12
Y	US 2004/000867 Al (CHEN HSING [TW]) 1 January 2004 (2004-01-01) paragraph [0010] ; figures 4,8	1-5 ,7-9 , 11 , 12

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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Date of the actual completion of the international search	Date of mailing of the international search report
18 March 2013	21/06/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Meacher, David

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/063906

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2011/092251 A2 (OSRAM OPTO SEMICONDUCTORS GMBH [DE] ; EBERHARDT ANGELA [DE] ; WIRTH-SCHO) 4 August 2011 (2011-08-04) page 9, lines 16-31 ; figures 1,2	2,3
Y	LEIB J ET AL: "New wafer-level -packaging technology using silicon-via-contacts for optical and other sensor applications" , ELECTRONIC COMPONENTS AND TECHNOLOGY, 2004. ECTC '04. PROCEEDINGS LAS VEGAS, NV, USA JUNE 1-4, 2004, PISCATAWAY, NJ , USA, IEEE, vol . 1, 1 June 2004 (2004-06-01) , pages 843-847 , XP010714585 , DOI : 10. 1109/ECTC. 2004. 1319435 ISBN : 978-0-7803-8365-4 page 844, left-hand column	5

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2012/063906

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-5, 7-9, 11, 12

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-5, 7-9, 11, 12

   optoelectronic semiconductor device having a particular form of cavity in the cavity glass sheet, seen in top view

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2. claim: 6

   device wherein sidewalls of the cavity are inclined, wherein the cavity narrows in a direction away from the carrier

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3. claim: 10

   device wherein the cover glass sheet and the cavity glass sheet are provided with a roughening on outer lateral faces

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4. claims: 13, 14

   method comprising the step of singularizing a cap glass sheet into a plurality of cap glasses before mounting at least one of the cap glasses onto the carrier

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/063906

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009219728 Al	03-09-2009	CN 101410997 A	15-04-2009
		DE 112007000843 T5	23-04-2009
		JP 4981342 B2	18-07-2012
		JP 2007281061 A	25-10-2007
		KR 20080107460 A	10-12-2008
		US 2009219728 Al	03-09-2009
		Wo 2007119671 Al	25-10-2007
US 2002179919 Al	05-12-2002	DE 10118630 Al	17-10-2002
		JP 2002344026 A	29-11-2002
		US 2002179919 Al	05-12-2002
US 2011109222 Al	12-05-2011	TW 201023404 A	16-06-2010
		US 2011109222 Al	12-05-2011
		WO 2010007781 Al	21-01-2010
US 2004000867 Al	01-01-2004	TW 558775 B	21-10-2003
		US 2004000867 Al	01-01-2004
Wo 2011092251 A2	04-08-2011	DE 102010006072 Al	18-08-2011
		WO 2011092251 A2	04-08-2011