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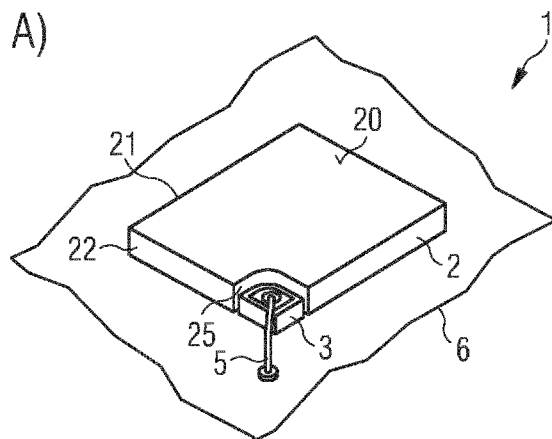
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FIG 1



(57) Abstract: In at least one embodiment, the luminescence conversion element (2) is designed for an optoelectronic semiconductor chip (3) in order to adjust the luminescence conversion element (2) to said optoelectronic semiconductor chip (3). The luminescence conversion element (2) comprises a cover (21) and a ledge (22). At least the cover (21) contains a phosphor. The ledge (22) protrudes from an edge of the cover (21) in a direction away from a light exit side (20) of the cover (21) on sufficient lateral sides of the cover (21) so that a displacement of the luminescence conversion element (2) in the direction left/right and also bottom/top is avoided.



Description

LUMINESCENCE CONVERSION ELEMENT, OPTOELECTRONIC SEMICONDUCTOR
DEVICE AND METHOD FOR PRODUCING AN OPTOELECTRONIC
5 SEMICONDUCTOR DEVICE

A luminescence conversion element is provided. An
optoelectronic semiconductor device with such a luminescence
conversion element is also provided. Further, a method for
10 producing such an optoelectronic semiconductor device is
provided.

An object to be achieved is to provide a luminescence
conversion element that can accurately be applied to an
15 optoelectronic semiconductor chip in an optoelectronic
semiconductor device.

This object is achieved *inter alia* by a luminescence
conversion element, by an optoelectronic semiconductor device
20 and by a method having the features of the independent
claims. Preferred further developments constitute the
subject-matter of the dependent claims.

In particular, the invention relates to a luminescence
25 conversion element that has a cover and a ledge. The cover
can be a platelet and the ledge surrounds the cover. By means
of the ledge, the luminescence conversion element can be
applied to an LED chip in a well-defined manner. In
particular, due to the ledge the luminescence conversion
30 element is prevented from rotating or shifting against the
semiconductor chip during application of the conversion
element due to swimming on a liquid adhesive. Thus, a high
accuracy and a high process yield can be achieved by means of

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the luminescence conversion element having the ledge at edges of the cover.

According to at least one embodiment, the luminescence
5 conversion element is designed for an optoelectronic semiconductor chip. In particular, the optoelectronic semiconductor chip is a light-emitting diode chip, LED chip for short, or also a laser diode chip, LD chip for short. Hence, the luminescence conversion element is designed for
10 comparably high optical powers at a light entrance face. Further, a operational temperature range the luminescence conversion element is designed for is, for example, from room temperature to at least 70 °C or 80 °C or 110 °C. Such comparably high temperatures occur because of the nearby
15 semiconductor chip.

The semiconductor chip preferably comprises a semiconductor layer sequence which is based on a III-V compound semiconductor material. The semiconductor material is for
20 example a nitride compound semiconductor material such as $\text{Al}_n\text{In}_{1-n-m}\text{Ga}_m\text{N}$ or a phosphide compound semiconductor material such as $\text{Al}_n\text{In}_{1-n-m}\text{Ga}_m\text{P}$ or also an arsenide compound semiconductor material such as $\text{Al}_n\text{In}_{1-n-m}\text{Ga}_m\text{As}$, wherein in each case $0 \leq n \leq 1$, $0 \leq m \leq 1$ and $n + m \leq 1$ applies. The
25 semiconductor layer sequence may comprise dopants and additional constituents. For simplicity's sake, however, only the essential constituents of the crystal lattice of the semiconductor layer sequence are indicated, i.e. Al, As, Ga, In, N or P, even if these may in part be replaced and/or
30 supplemented by small quantities of further substances. The semiconductor layer sequence is particularly preferably based on the AlInGaN material system.

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According to at least one embodiment, the luminescence conversion element comprises a cover. The cover contains a phosphor. The cover could be designed as a plane-parallel platelet. Preferably, the cover has a constant thickness. A phosphor content in the cover can also be constant.

The phosphor is preferably a luminescent material or a luminescent material mixture comprising at least one of the following luminescent materials: Eu^{2+} -doped nitrides such as

(Ca,Sr)AlSiN₃:Eu²⁺, Sr(Ca,Sr)Si₂Al₂N₆:Eu²⁺,

(Sr,Ca)AlSiN₃*Si₂N₂O:Eu²⁺, (Ca,Ba,Sr)₂Si₅N₈:Eu²⁺,

(Sr,Ca)[LiAl₃N₄]:Eu²⁺; garnets from the general system

(Gd,Lu,Tb,Y)₃(Al,Ga,D)₅(O,X)₁₂:RE with X = halide, N or divalent element, D = tri- or tetravalent element and RE =

rare earth metals such as Lu₃(Al_{1-x}Ga_x)₅O₁₂:Ce³⁺, Y₃(Al₁₋

_xGa_x)₅O₁₂:Ce³⁺; Eu^{2+} -doped sulfides such as (Ca,Sr,Ba)S:Eu²⁺;

Eu^{2+} -doped SiONs such as (Ba,Sr,Ca)Si₂O₂N₂:Eu²⁺; SiAlONs for

instance from the system Li_xM_yLn_zSi_{12-(m+n)}Al_(m+n)O_nN_{16-n}; beta-

SiAlONs from the system Si_{6-x}Al_zO_yN_{8-y}:RE_z; nitrido-

orthosilicates such as AE_{2-x-a}RE_xEu_aSiO_{4-x}N_x, AE_{2-x-a}RE_xEu_aSi_{1-y}O_{4-x-}
_{2y}N_x with RE = rare earth metal and AE = alkaline earth metal;

orthosilicates such as (Ba,Sr,Ca,Mg)₂SiO₄:Eu²⁺;

chlorosilicates such as Ca₈Mg(SiO₄)₄Cl₂:Eu²⁺; chlorophosphates

such as (Sr,Ba,Ca,Mg)₁₀(PO₄)₆Cl₂:Eu²⁺; BAM luminescent

materials from the BaO-MgO-Al₂O₃ system such as

BaMgAl₁₀O₁₇:Eu²⁺; halophosphates such as

M₅(PO₄)₃(Cl,F):(Eu²⁺,Sb³⁺,Mn²⁺); SCAP luminescent materials such

as (Sr,Ba,Ca)₅(PO₄)₃Cl:Eu²⁺. The luminescent materials stated

in document EP 2 549 330 A1 may also be used as a phosphor.

With regard to the phosphor used, the disclosure content of

this document is included by reference. "Quantum dots" may

moreover also be introduced as converter material. Quantum

dots in the form of nanocrystalline materials which contain a

group II-VI compound and/or a group III-V compound and/or a group IV-VI compound and/or metal nanocrystals, are preferred in this case.

- 5 According to at least one embodiment, the luminescence conversion element comprises a ledge. The ledge may also be referred to as cornice or protrusion. The ledge may also contain the phosphor or may be free of the phosphor. It is possible that the ledge contains the phosphor but in a
10 reduced concentration compared with the cover.

According to at least one embodiment, the ledge protrudes from an edge of the cover in a direction away from a light exit side. The light exit side is preferably a side of the
15 cover facing away from the ledge. The light converted by the luminescence conversion element is intentionally emitted at the light exit side.

According to at least one embodiment, the ledge protrudes on
20 at least on three lateral sides or, preferably, on all lateral sides or of the cover from the latter. If the cover may have a non-rectangular geometry when seen in top view, it might be sufficient to fix a position of the luminescence conversion element on the optoelectronic semiconductor chip
25 by having the ledge at at least three lateral sides of the cover. However, the ledge is arranged on sufficient lateral sides so that a displacement in the direction left/right and also bottom/top is avoided.

30 According to at least one embodiment, the ledge is configured to adjust the luminescence conversion element onto the optoelectronic semiconductor chip for which it is designed. Hence, because of the ledge an accurate adjustment can be

realized. For this reason, a space surrounded by the ledge preferably corresponds or approximately corresponds to a size of the optoelectronic semiconductor chip when seen in top view.

5

In at least one embodiment, the luminescence conversion element is designed for an optoelectronic semiconductor chip in order to adjust the luminescence conversion element to said semiconductor chip. The luminescence conversion element comprises a cover and a ledge. At least the cover contains a phosphor. The ledge protrudes from an edge of the cover in a direction away from a light exit side on sufficient lateral sides of the cover so that a displacement in the direction left/right and also bottom/top is avoided.

15

Luminescence conversion layers such as chip level conversion layers, ceramic platelets or phosphor-in-glass-layers have a tendency to swim or rotate from the original placement position after a layer attachment process. This effect is observed regardless of the placement accuracy of the conversion layer attachment process and results from the fact that the uncured glue acts as a viscous liquid which allows a movement of the conversion layer from external forces.

Because of the displacement of the conversion layer, blue piping can occur. That is, a part of the surface of the optoelectronic semiconductor chip is exposed after layer adhesion or motion. Moreover, an inhomogeneous radiation pattern can occur. When the conversion layer swims on the glue, it could cover the optoelectronic chip unevenly which can affect the symmetry of the emitted radiation pattern. Further, when the conversion layer swims onto the glue, it may overhang or lie on a bond ball, both of which may act as

a stress concentrator increasing the risk of layer cracks. Moreover, that the conversion layer may swim and/or rotate on the glue may not cause any technical problems, but may still lead to a rejection of the device by the customer just for
5 cosmetic reasons.

Other possibilities to solve these problems include to increase the viscosity of a glue by adding aerosol or the like. However, this may increase a minimum thickness of the
10 silicone glue or may increase production costs. Further, a luminescence conversion layer may be directly manufactured on a semiconductor chip, for example by means of spray coating. However, some phosphors are different to handle with a techniques such as spray coating.

15 In the present invention, the luminescence conversion element design is changed in such a way that an interlock based on the "Lego" concept is realized. The design of the optoelectronic semiconductor chip may be adapted accordingly.
20 That is, the luminescence conversion elements dimensional size is increased. This is to provide space for the extra ledges, in particular on all four sides. The design of the luminescence conversion element can enable a wire bonding process on both a bar and a notch bond pad.

25 Hence, the ledge acts as a boundary which interlocks with the optoelectronic semiconductor chip during conversion layer attachment. Hence, a reduced color shift in an LED device by reducing blue piping can be realized. Improved tolerances of
30 optical properties by reducing a variance due to layer swimming can be achieved. Moreover, yield losses in the production of LED devices from layer cracks and blue piping

units can be reduced. Further, a better cosmetic appearance can be realized.

According to at least one embodiment, the cover and the ledge
5 are made as one piece. Thus, both the cover and the ledge may have the same material composition. In this case, preferably there is no seam between the cover and the ledge.

According to at least one embodiment, the cover and the ledge
10 are made of different pieces that have to be attached to one another or one of said pieces has been manufactured on the other one. That is, a seam or a boundary can lie between the cover and the ledge. For example, the cover and the ledge are attached to one another by means of an adhesive or the ledge
15 is manufactured onto the cover by means of molding or welding.

When the cover and the ledge are not made of one piece it is possible that the cover and the ledge may have different
20 material compositions. In particular, in this case the ledge can be free of the phosphor. The ledge can have different optical properties to the cover. For example, the ledge can be opaque to visible light.

25 According to at least one embodiment, a width of the ledge amounts to at most 25% or 15% or 5% of a width of the cover when seen in top view. That is, because of the ledge the lateral size of the luminescence conversion element is not significantly increased. However, a width of the ledge is
30 preferably large enough to ensure sufficient mechanical stability of the ledge in order to fix the luminescence conversion element onto the optoelectronic semiconductor chip.

According to at least one embodiment, a thickness of the luminescence conversion element at the ledge is at least 20 μm or 35 μm and/or at most 200 μm or 100 μm or 70 μm . That
5 is, the luminescence conversion element still has a comparably low overall thickness.

According to at least one embodiment, the thickness of the luminescence conversion element at the ledge exceeds a
10 thickness of the cover by a factor of at least 1.1 or 1.2 or 1.5. As an alternative or in addition, this factor is at most 2.5 or 1.8 or 1.5.

According to at least one embodiment, the luminescence
15 conversion element comprises at least one of a ceramic, a silicone and a glass. The ceramic, the silicone or the glass may be a matrix material for the phosphor or for at least part of the phosphor. In the case of a ceramic, it is also possible that the phosphor itself is sintered to the ceramic
20 so that the ceramic and the phosphor may be identical; a matrix material can then be omitted. If a matrix material is present for the phosphor, the phosphor is preferably present in the form of particles that can be homogeneously or also inhomogeneously distributed in the matrix material.

25

According to at least one embodiment, the cover comprises a base layer and a phosphor layer. The phosphor layer is applied to the base layer preferably completely over a main face of the base layer. If there is a plurality of phosphors,
30 there may also be a plurality of phosphor layers stacked one above the other. It is possible that the phosphor layer constitutes the light exit side of the luminescence conversion element. Thus, the phosphor of the luminescence

conversion element can be limited to the at least one phosphor layer.

Further, an optoelectronic semiconductor device is provided.

5 The optoelectronic semiconductor device comprises one or more luminescence conversion elements as indicated in connection with at least one of the above-mentioned embodiments. Features of the luminescence conversion element are therefore also disclosed for the optoelectronic semiconductor device
10 and vice versa.

In at least one embodiment, the optoelectronic semiconductor device comprises one or a plurality of optoelectronic semiconductor chips like LED chips. The at least one
15 optoelectronic semiconductor chip has a main emission side and side faces. The luminescence conversion element is located on the main emission side. An adhesive fixes the luminescence conversion element to the optoelectronic semiconductor chip. The ledge at least partly covers all side
20 faces of the optoelectronic semiconductor chip. An average distance between the side faces and the ledge is preferably at most 10% or 5% or 3% of a main length of the side faces when seen in top view.

25 Because of the low distance between the side faces and the ledge, only a small rotational or lateral displacement can occur between the semiconductor chip and the conversion element.

30 According to at least one embodiment, an electrical connection of the optoelectronic semiconductor chip comprises one or more bond wires. The at least one bond wire is arranged on the main emission side. As an alternative, the

optoelectronic semiconductor chip can be designed as a flip-chip that has its electrical contact faces on a side facing away from the cover. Thus, optoelectronic semiconductor chips can be used that are surface-mountable devices, SMD for short.

According to at least one embodiment, the cover, and as an option also the ledge, has a cut-out for the bond wire. If there is a plurality of bond wires, there can be one cut-out for all bond wires together or there can be a separate cut-out for each of the bond wires.

According to at least one embodiment, the cut-out is located at an edge of the cover when seen in top view. That is, the cut-out is then not a hole in the cover that is surrounded on all sides by a material of the cover.

According to at least one embodiment, the ledge surrounds the cover and the optoelectronic semiconductor chip all around on the side faces except at the cut-out. That is, the cut-out in the cover can be continued to the ledge. Preferably, the ledge is removed only in the area of the cut-out and is otherwise present all around the cover and, thus, the optoelectronic semiconductor chip.

According to at least one embodiment, the cut-out is located at a corner of the cover when seen in top view. As an alternative, the cut-out is located in the middle of an edge of the cover when seen in top view. If there is more than one bond wire, there can be cut-outs at different, in particular at opposite, corners or edges of the cover.

According to at least one embodiment, the cover has a reduced thickness at the cut-out so that the cut-out is completely covered by the cover with a reduced thickness, compared with other regions of the main emission side. Hence, the main emission side of the semiconductor chip can be completely covered by the luminescence conversion element and, thus, by the cover.

According to at least one embodiment, the cover is a plane-parallel platelet that is preferably oriented parallel with the main emission side. Hence, the adhesive can have a constant thickness, too. A distance between the main emission side and the cover and, thus, the thickness of the adhesive, is preferably at least 0.5 μm or 1 μm or 2 μm and/or at most 20 μm or 10 μm or 6 μm .

According to at least one embodiment, the ledge has a constant width. As an alternative, a width of the ledge can be varied around the cover when seen in top view.

According to at least one embodiment, the optoelectronic semiconductor device further comprises a support. The optoelectronic semiconductor chip is mounted on the support. For example, the support is a circuit board like a printed circuit board or a ceramic carrier or a metal core board comprising electrical contact areas to apply the optoelectronic semiconductor chip and, as an option, the bond wire to.

According to at least one embodiment, a height of the ledge is equal to a height of the optoelectronic semiconductor chip together with the adhesive. This applies in particular with a tolerance of at most 10 μm or 5 μm or 2 μm . As an

alternative, the height of the ledge can be smaller than a height of the optoelectronic semiconductor chip together with the adhesive. Hence, the luminescence conversion element can either form a cap that runs down to the support or can be a cap that just covers a top part of the optoelectronic semiconductor chip.

According to at least one embodiment, the optoelectronic semiconductor device comprises a plurality of the optoelectronic semiconductor chips. The semiconductor chips can be of identical design or there can be semiconductor chips of different designs, for example emitting different colors.

According to at least one embodiment, all the optoelectronic semiconductor chips are commonly covered by the luminescence conversion element. Preferably, the ledge surrounds all said optoelectronic semiconductor chips at least in part on all lateral sides of an array of said optoelectronic semiconductor chips. It is possible that additional ledges are arranged between adjacent semiconductor chips. However, preferably the ledge only runs at the edges of the cover.

According to at least one embodiment, the adhesive partly or completely covers the side faces of the optoelectronic semiconductor chip. It is possible for the adhesive to run until a bottom face of the ledge. The bottom face is opposite the light exit side. The bottom face can partly or completely be covered by the adhesive. If there is a support, it is possible that by means of the adhesive the bottom face is connected to the support.

Furthermore, a method for producing an optoelectronic semiconductor device is provided. By means of the method, an optoelectronic semiconductor device as indicated in connection with at least one of the above-mentioned
5 embodiments is produced. Thus, features of the luminescence conversion element and of the optoelectronic semiconductor device are also disclosed for the method and vice versa.

In at least one embodiment, the method comprises the
10 following steps, in particular in the stated order:

- preparing the luminescence conversion element,
- providing the optoelectronic semiconductor chip,
- providing the adhesive to the main emission side wherein the adhesive is a liquid,
- 15 - attaching the luminescence conversion element to the optoelectronic semiconductor chip so that the cover covers the main emission side and swims on the adhesive wherein the luminescence conversion element is adjusted to the optoelectronic semiconductor chip by means of the ledge when
20 seen in top view, and
- curing the adhesive to permanently fix the luminescence conversion element to the optoelectronic semiconductor chip.

According to at least one embodiment, preparation of the
25 luminescence conversion element includes the following steps, preferably in the stated order:

- providing a patterned substrate, the substrate comprises elevations that correspond to negatives of the spaces surrounded by the ledges,
- 30 - spreading a material composition for the luminescence conversion elements onto the patterned substrate,
- hardening the material composition, and
- singulating to the luminescence conversion elements.

A luminescence conversion element, an optoelectronic semiconductor device and a method described herein are explained in greater detail below by way of exemplary
5 embodiments with reference to the drawings. Elements which are the same in the individual figures are indicated with the same reference signs. The relationships between the elements are not shown to scale, however, but rather individual elements may be shown exaggeratedly large to assist in
10 understanding.

In the figures:

Figure 1A shows a perspective view of an exemplary embodiment
15 of an optoelectronic semiconductor device as described here;

Figure 1B show a bottom view of a luminescence conversion element described here;

20 Figure 1C illustrates a sectional view of an exemplary embodiment of an optoelectronic semiconductor device described here;

Figure 2A shows a perspective view of an optoelectronic
25 semiconductor device;

Figure 2B shows a bottom view of a luminescence conversion element;

30 Figure 3A shows a perspective view of an optoelectronic semiconductor device;

Figure 3B shows a top view of a luminescence conversion element;

5 Figure 3C shows a bottom view of a luminescence conversion element,

Figure 3D shows a sectional view of a luminescence conversion element;

10 Figures 4 to 7 show cross-sectional view of luminescence conversion elements;

Figures 8 to 10 show bottom views of luminescence conversion elements;

15

Figures 11 to 14 show method steps for producing luminescence conversion elements in perspective views;

Figure 15 shows a sectional view of a method step to produce
20 luminescence conversion elements;

Figures 16A and 16B show top views of modifications of optoelectronic semiconductor devices;

25 Figure 16C shows a cross-section of a modification of an optoelectronic semiconductor device; and

Figure 17 shows a top view of an exemplary embodiment of an optoelectronic semiconductor device as described here.

30

Figure 1 shows an exemplary embodiment of an optoelectronic semiconductor device 1. The semiconductor device 1 comprises an optoelectronic semiconductor 3, in particular an LED chip

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that emits blue light when in operation. A main emission side 30 of the optoelectronic semiconductor chip 3 is covered by a luminescence conversion element 2. The luminescence conversion element 2 is attached to the optoelectronic semiconductor chip 3 by means of an adhesive 4. The adhesive 4 is, for example, a silicone glue.

The luminescence conversion element 2 contains a phosphor or a phosphor mixture. Thus, light generated by the optoelectronic semiconductor 3 is in part or completely converted to radiation with another wavelength. For example, together with blue light from the optoelectronic semiconductor chip 3, overall white light can be produced by means of the luminescence conversion element 2.

The luminescence conversion element comprises a cover 21 that is formed as a plane-parallel platelet. The luminescence conversion element 2 also comprises a ledge 22. The ledge 22 surrounds the cover 21 along edges of the cover 21 all around but at a cut-out 25. The cut-out 25 is located in a corner of the cover 21, when seen in top view. The ledge 22 extends in a direction away from the light exit side 20. The cover 21 and the ledge 22 are made of one piece.

As an option, the optoelectronic semiconductor device 1 includes a support 6. The support 6 is, for example, a printed circuit board. An electrical connection from the support 6 to the optoelectronic semiconductor chip 3 is made, for example, by means of a bond wire 5. The bond wire 5 runs to the main emission side 30. Thus, the bond wire 5 is located at the cut-out 25.

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As in all other exemplary embodiments it is possible that the adhesive 4 runs down to the optional support 6. Otherwise, the adhesive 4 can be limited to the main emission side 30 and may cover side faces 31 of the optoelectronic semiconductor chip 3 only in part or not at all.

In the exemplary embodiment of Figure 2, the cut-out 25 is located at one edge of the luminescence conversion element 2. Thus, the cut-out 25 has the form of a stretched slit along the edge. In this case, too, the ledge 22 surrounds the cover 21 all around except at the cut-out 25.

Otherwise, the exemplary embodiment of Figure 2 corresponds to the exemplary embodiment of Figure 1.

15

According to the exemplary embodiment of Figure 3, the cover 21 completely extends as a continuous layer over the light exit side 20 of the luminescence conversion element 2. In particular, the cut-out 21 for the bond wire 5 is also completely covered by the cover 21. In the area of the cut-out 25, however, the cover 21 has a reduced thickness.

As an option, as possible in all other exemplary embodiments, in Figure 3D it is illustrated that the luminescence conversion element 2 touches or nearly touches the support 6 with the ledge 22. There can be a gap between the side faces 31 and the ledge 22 which is not filled with the adhesive 4. Thus, a height of the ledge 22 equals a height of the optoelectronic semiconductor chip 3 together with the adhesive 4.

According to Figure 4, the cover 21 of the luminescence conversion element 2 is composed of a continuous base layer

23 and of a phosphor layer 24. The phosphor of the luminescence conversion element 2 is limited to the phosphor layer 24. The ledge 22 and the base layer 23 can be made of one piece that is coated with the phosphor layer 24.

5

In Figure 5 it is illustrated that the cover 21 can be composed of the base layer 23 and of the phosphor layer 24. In addition, the ledge 22, which can be formed as a frame, is a component distinct from the cover 21. Thus, the cover 21,
10 in particular the base layer 23, and the ledge 22 can be made of different materials.

It is possible that the ledge 22 is formed onto the cover 21 without the use of an additional adhesive. For example, the
15 ledge 22 can be formed by molding or casting or printing directly on the base layer 23.

In the exemplary embodiment of the luminescence conversion element 2 of Figure 6 it is shown that there could be an
20 additional adhesive 27 between the ledge 22 and the cover 21. The same can apply to all other exemplary embodiments.

In Figure 7 it is illustrated that the ledge 22 can have a step at the cover 21. Thus, the cover 21 can form fit into
25 the step of the ledge 22.

Other than shown in Figure 7, it is also possible that the cover 21 and the ledge 22 terminate flush with each other at the light exit side 20.

30

According to Figure 8, the luminescence conversion element 2 has the shape of a regular hexagon when seen in bottom view. As an option, the ledge 22 can be limited to three sides of

the hexagon in an alternating manner. Other than shown, the ledge 22 can also extend to four or five or six sides of the hexagon. When every second side of the hexagon is provided with the ledge 22, it is assured that that the luminescence conversion element 2 does not move unintentionally in the left/right or bottom/up direction. Hence, in a geometry which is not rectangular, the ledge 22 need not extend on all sides of the cover 21 when seen in top view.

10 According to Figure 9, the ledge 22 is of L-shape and is limited to the four corners of the cover 21 when seen in bottom view.

Contrary to that, in the exemplary embodiment of Figure 10
15 the corners of the cover 21 are free of the ledge 22 which is limited to a central portion of the edges thereof.

The arrangements of Figures 9 and 10 which are exemplified for rectangular covers 21 can also be used when the cover 21
20 has a different geometric shape when seen in bottom view or in top view.

In Figures 11 to 15, methods to produce the luminescence conversion elements 2 are illustrated. In these exemplary
25 methods, the luminescence conversion element 2 is made of one piece in each case. However, the configurations of Figures 4 to 7 could be produced analogously. Moreover, the methods of Figures 11 to 15 are shown for square or rectangular optoelectronic semiconductor chips 3. With optoelectronic
30 semiconductor chips 3 shaped in another way, the method can be used analogously, too.

According to Figure 11, there is a substrate 7. The substrate 7 comprises a plurality of elevations 71. The elevations 71 have the shape of a space that is surrounded by the ledges 22 in the finished luminescence conversion elements 2. For the sake of simplicity, the cut-out 25 as indicated in Figures 1 to 3 are not illustrated at the elevations 71 of Figure 11. However, such negatives of the respective cut-outs 25 could be added to the elevations 71.

The elevations 71 and, thus, the substrate 7 are covered with a material composition 72 for the luminescence conversion element 2. Hence, a shape of the elevations 71 is transferred to the material composition 72 and, thus, to the luminescence conversion elements 2.

According to Figure 12, the material composition 72 is provided via a storing tank 74. The plane light exit sides 20 are established by a doctor blade 73. The substrate 7 with the elevations, not shown, may move around the doctor blade 73.

Then, the material composition 72 which is in particular a phosphor mixture in a ceramic matrix or a ceramic material, is stacked and cut to sheets with, for example, lateral dimensions of 10 cm x 10 cm.

Afterwards, with a punch tool 75 the green sheets are singulated to the later luminescence conversion elements. Then, sintering is done in a furnace 76, for example at a temperature of around 1500 °C.

In the method of Figure 13, a stencil 77 is provided which has a plurality of cavities for the luminescence conversion

elements. The material composition 72 is applied to these recesses in the stencil by means of the doctor blade 73, for example. The material composition 72 can be a silicone with phosphor particles admixed. Again, the substrate 7 can be
5 formed as described in connection with Figure 11.

Then, the material composition 72 is cured and the stencil 77 is removed.

10 According to Figure 14, the material composition 72 can be a glass with a phosphor admixture. The glass can be applied similar to the ceramic material of Figure 12. Then, sintering is done in the furnace 76. Afterwards, for example by means of a laser 78, the glass sheets are singulated to the
15 luminescence conversion elements 2.

According to Figure 15, a mold 79 is used to simultaneously form the ledges 22 and to do the singulation. The mold 79 can have oblique side faces at singulation areas. Further, as an
20 option, in the central portion for the luminescence conversion elements the mold 79 can be of truncated pyramidal shape in order to allow the material composition 72 flow out of the central portion and to ensure luminescence conversion elements without any voids therein.

25

In Figure 16, semiconductor devices with common conversion elements are shown, said conversion elements do not have a ledge. According to Figure 16A, due to swimming of the conversion element 9 onto the adhesive, not shown, a lateral
30 displacement 81 occurs. Thus, on a side edge the semiconductor chip 3 is not covered by the conversion element 9 so that blue piping could occur.

According to Figure 16B, a conversion element 9 is rotated with a rotational displacement 82 against the semiconductor chip 3. Hence, in different directions light of different colors could be emitted.

5

Finally, in Figure 16C it is shown that during a film-assisted molding for a mold body that surrounds the semiconductor chip 3 and the conversion element 9 in a lateral direction, not shown, a crack 83 occurs in the conversion element 9 as the conversion element 9 is not exactly placed above the semiconductor chip 3.

10

Because of the ledge 22 as illustrated in connection with Figures 1 to 15, lateral displacements, rotational displacements and formation of cracks as indicated in Figure 16 can be avoided or the risk thereof can be significantly reduced.

15

In the exemplary embodiment of Figure 17, the semiconductor device 3 comprises a plurality of the semiconductor chips 3. All the semiconductor chips 3 are covered by the luminescence conversion element 2. The ledge 22 surrounds all semiconductor chips 3. The optional cut-outs are not shown. Preferably, no cut-outs are needed because the semiconductor chips 3 are flip-chips. As a further option, not shown, the ledge 22 could extend between adjacent semiconductor chips 3.

20

25

The components shown in the figures follow, unless indicated otherwise, preferably in the specified sequence directly one on top of the other. Layers which are not in contact in the figures are preferably spaced apart from one another. If lines are drawn parallel to one another, the corresponding surfaces are preferably oriented parallel to one another.

30

Likewise, unless indicated otherwise, the positions of the drawn components relative to one another are correctly reproduced in the figures.

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

List of Reference Signs

	1	optoelectronic semiconductor device
	2	luminescence conversion element
5	20	light exit side
	21	cover
	22	ledge
	23	base layer
	24	phosphor layer
10	25	cut-out
	26	bottom face
	27	adhesive
	3	optoelectronic semiconductor chip
	30	main emission side
15	31	side face
	4	adhesive
	5	bond wire
	6	support
	7	substrate
20	71	elevation
	72	material composition for the conversion element
	73	doctor blade
	74	storing tank
	75	punch tool
25	76	furnace
	77	stencil
	78	laser
	79	mold
	81	lateral displacement
30	82	rotational displacement
	83	crack
	9	conversion element without ledge

Patent Claims

1. A luminescence conversion element (2) for an optoelectronic semiconductor chip (3) comprising a cover (21) and a ledge (22), wherein
- at least the cover (21) contains a phosphor,
 - the ledge (22) protrudes from an edge of the cover (21) in a direction away from a light exit side (20) on all lateral sides of the cover (21), and
 - the ledge (22) is configured to adjust the luminescence conversion element (2) onto the optoelectronic semiconductor chip (3) for which it is designed.
2. The luminescence conversion element (2) according to the preceding claim,
- wherein the cover (21) and the ledge (22) are made as one piece and both have the same material composition (72) so that the phosphor is also present in the ledge (22).
3. The luminescence conversion element (2) according to claim 1,
- wherein the cover (21) and the ledge (22) are made of different material compositions (72) so that the ledge (22) is free of the phosphor, and
- wherein a seam lies between the cover (21) and the ledge (22).
4. The luminescence conversion element (2) of one of the preceding claims,
- wherein a width of the ledge (22) amounts to at most 15% of a width of the cover (21) when seen in top view,
- wherein a thickness of the luminescence conversion element (2) at the ledge (22) is between 20 μm and 200 μm inclusive, and

wherein the thickness at the ledge (22) exceeds a thickness of the cover (21) by a factor of at least 1.1 and of at most 1.8.

5 5. The luminescence conversion element (2) of one of the preceding claims,
comprising at least one ceramic, at least one silicone and/or at least one glass which is a matrix material for at least part of the phosphor.

10 6. The luminescence conversion element (2) of one of the preceding claims,
wherein the cover (21) comprises a base layer (23) and a phosphor layer (24) which is applied to the base layer (23), wherein the phosphor layer (24) constitutes the light exit side (20) and comprises at least part of the phosphor.

15 7. An optoelectronic semiconductor device (1) comprising:
- an optoelectronic semiconductor chip (3) with a main emission side (30) and with side faces (31),
- the luminescence conversion element (2) of one of the preceding claims which is located on the main emission side
20 (30), and
- an adhesive (4) which fixes the luminescence conversion element (2) to the optoelectronic semiconductor chip (3),
wherein
- the ledge (22) at least partly covers all side faces (31),
25 and
- an average distance between the side faces (31) and the ledge (22) is at most 5% of a mean length of the side faces (31) when seen in top view.

30 8. The optoelectronic semiconductor device (1) according to the preceding claim,

- 27 -

wherein an electrical connection of the optoelectronic semiconductor chip (3) comprises at least one bond wire (5) which is arranged on the main emission side (30), wherein the cover (21) has a cut-out (25) for the bond wire (5).

9. The optoelectronic semiconductor device (1) according to the preceding claim, wherein the cut-out (25) is located at an edge of the cover (21) when seen in top view, and

wherein the ledge (22) surrounds the cover (21) and the optoelectronic semiconductor chip (3) all around despite at the cut-out (25).

10. The optoelectronic semiconductor device (1) according to one of the two preceding claims,

wherein the cut-out (25) is located at a corner of the cover (21), or is located in the middle of an edge of the cover (21).

11. The optoelectronic semiconductor device (1) according to one of claims 8 to 10,

wherein the cover (21) has a reduced thickness at the cut-out (25) so that the cut-out (25) is completely covered by the cover (21) with a reduced thickness, compared with other regions of the main emission side (30).

12. The optoelectronic semiconductor device (1) according to one of claims 7 to 11,

wherein the cover (21) is a plane-parallel platelet that is oriented parallel with the main emission side (30),

wherein a distance between the main emission side (30) and the cover (21) is between 1 μm and 20 μm inclusive, and

wherein the ledge (22) has a constant width.

13. The optoelectronic semiconductor device (1) according to one of claims 7 to 12,
further comprising a support (6) on which the optoelectronic semiconductor chip (3) is mounted,

5 wherein a height of the ledge (22) is equal to a height of the optoelectronic semiconductor chip (3) together with the adhesive (4), with a tolerance of at most 5 μm .

14. The optoelectronic semiconductor device (1) according to one of claims 7 to 13,

10 comprising a plurality of the optoelectronic semiconductor chips (3),

wherein said optoelectronic semiconductor chips (3) are commonly covered by the luminescence conversion element (2), wherein the ledge (22) surrounds all said optoelectronic

15 semiconductor chips (3) at least in part on all lateral sides of an array of said optoelectronic semiconductor chips (3).

15. The optoelectronic semiconductor device (1) according to one of claims 7 to 14,

wherein the adhesive (4) at least partly covers the side
20 faces (31) and runs until a bottom face (26) of the ledge (22), the bottom face (26) lies opposite the light exit side (20).

16. A method for producing the optoelectronic semiconductor device (1) of one of claims to comprising the steps:

25 - preparing the luminescence conversion element (2),
- providing the optoelectronic semiconductor chip (3),
- providing the adhesive (4) to the main emission side (30) wherein the adhesive (4) is a liquid,
- attaching the luminescence conversion element (2) to the
30 optoelectronic semiconductor chip (3) so that the cover (21) covers the main emission side (30) and swims on the adhesive

- 29 -

(4) wherein the luminescence conversion element (2) is adjusted to the optoelectronic semiconductor chip (3) by means of the ledge (22) when seen in top view, and
- curing the adhesive (4) to permanently fix the luminescence
5 conversion element (2) to the optoelectronic semiconductor chip (3).

17. The method according to the preceding claim,
wherein preparing the luminescence conversion element (2)
includes:

- 10 - providing a patterned substrate (7), the substrate (7) comprises elevations (71) that correspond to negatives of spaces surrounded by the ledges (22),
- spreading a material composition (72) for the luminescence conversion elements (2) onto the patterned substrate (7),
15 - hardening the material composition (72), and
- singulating to the luminescence conversion elements (2).

FIG 1

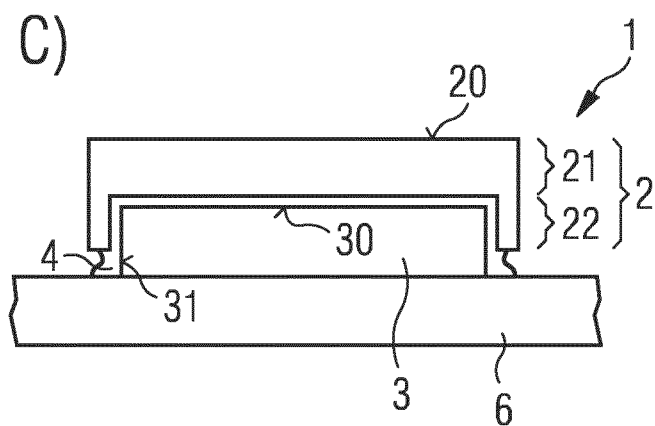
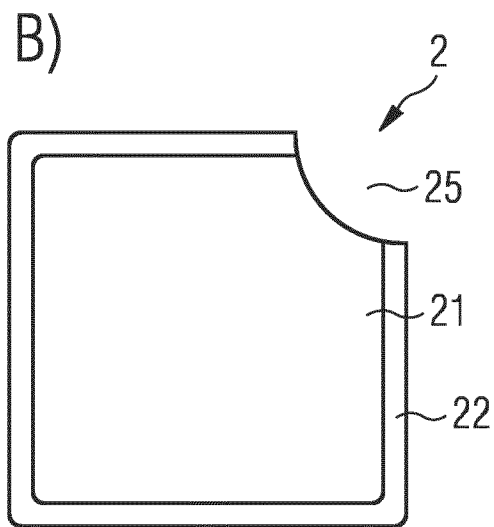
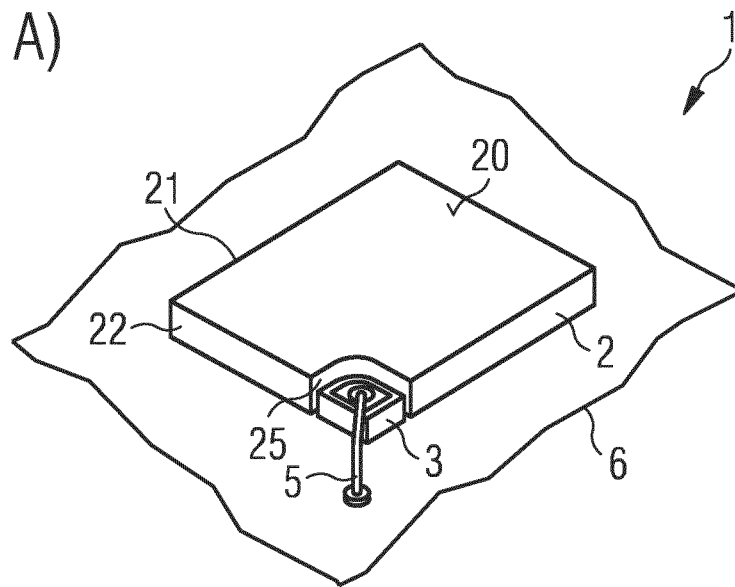
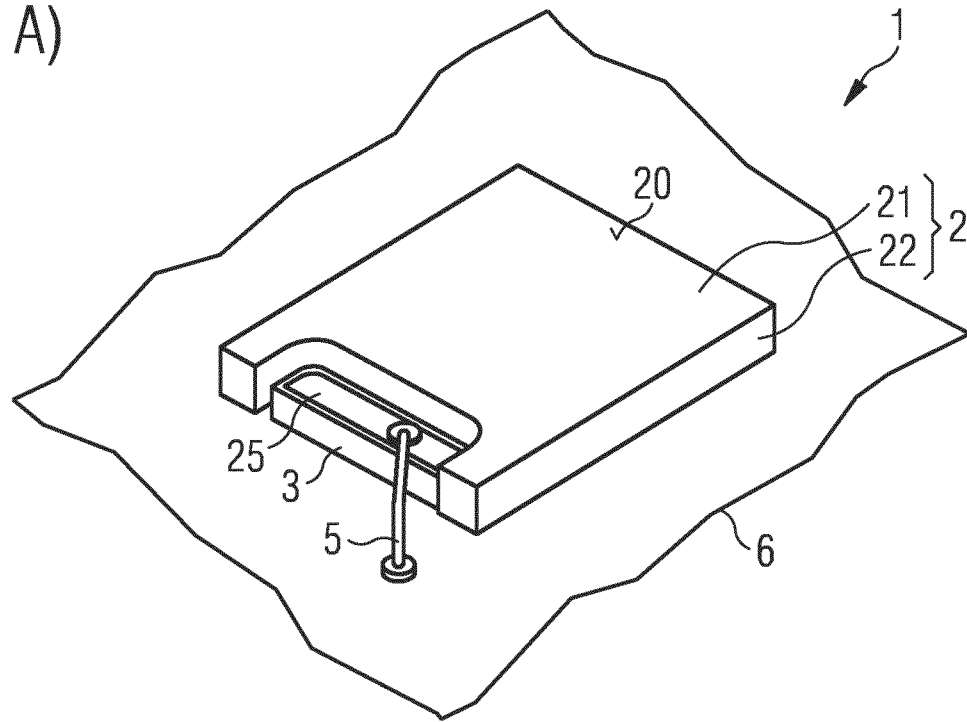


FIG 2

A)



B)

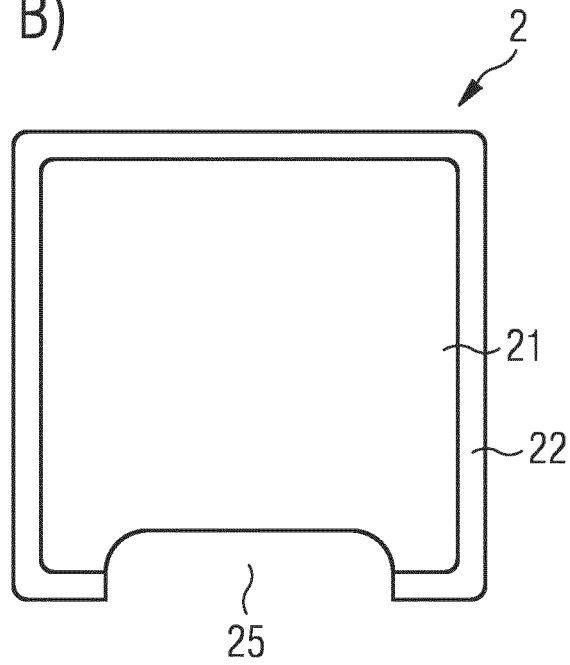


FIG 3

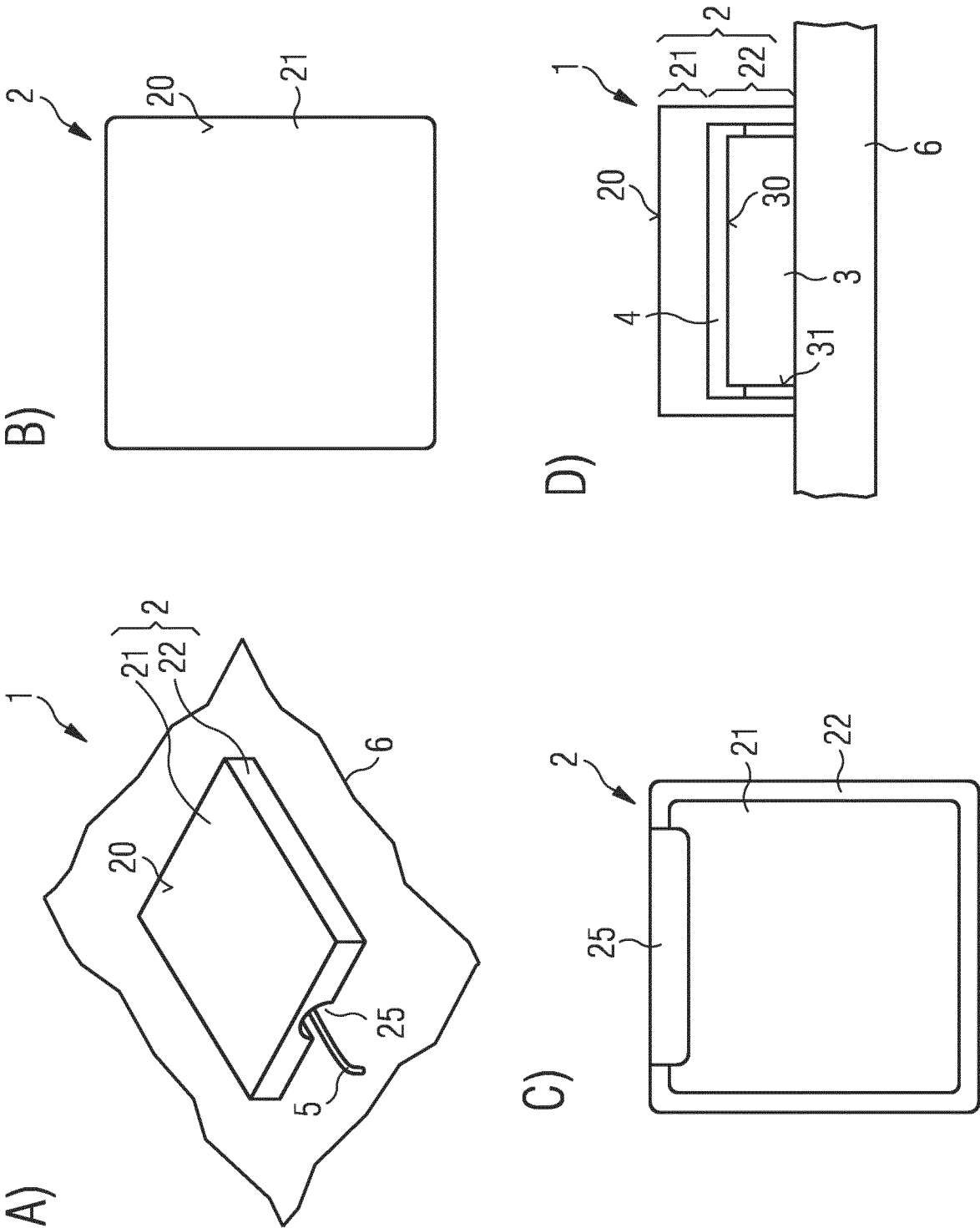


FIG 4

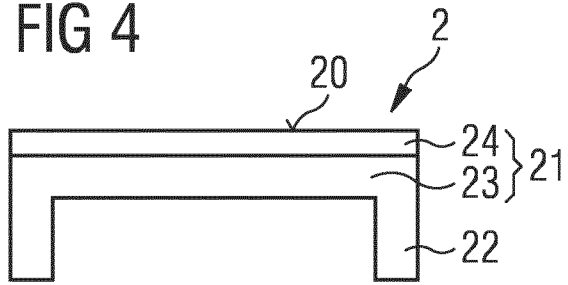


FIG 5

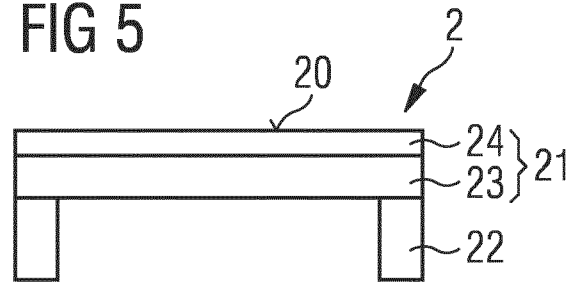


FIG 6

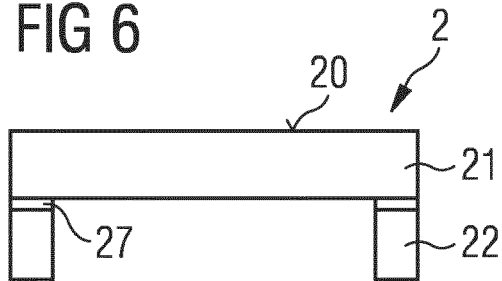


FIG 7

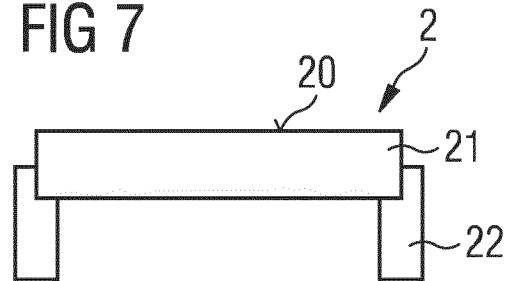


FIG 8

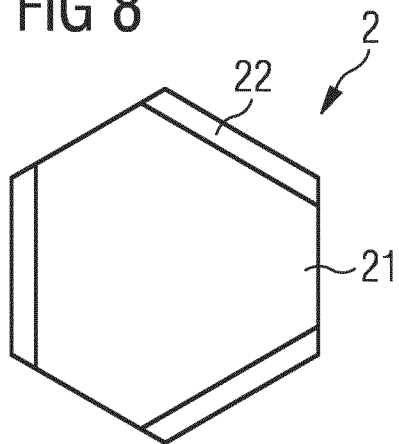


FIG 9

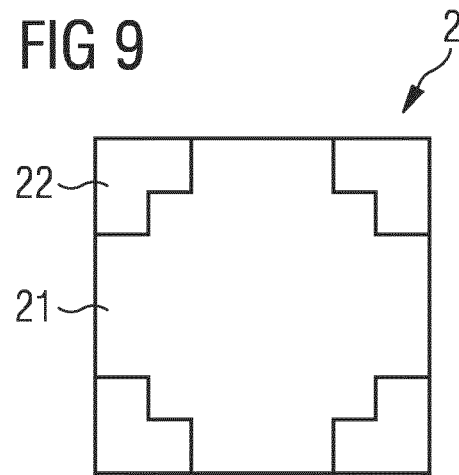


FIG 10

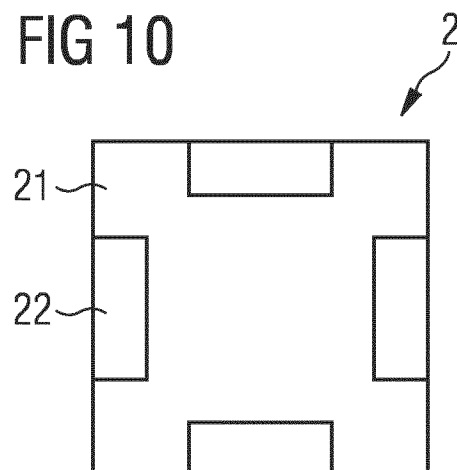


FIG 11

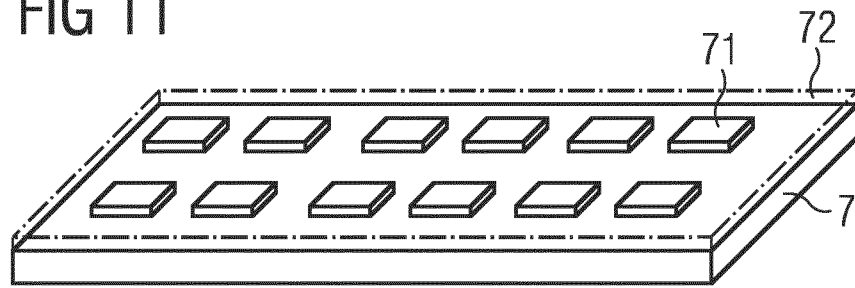


FIG 12

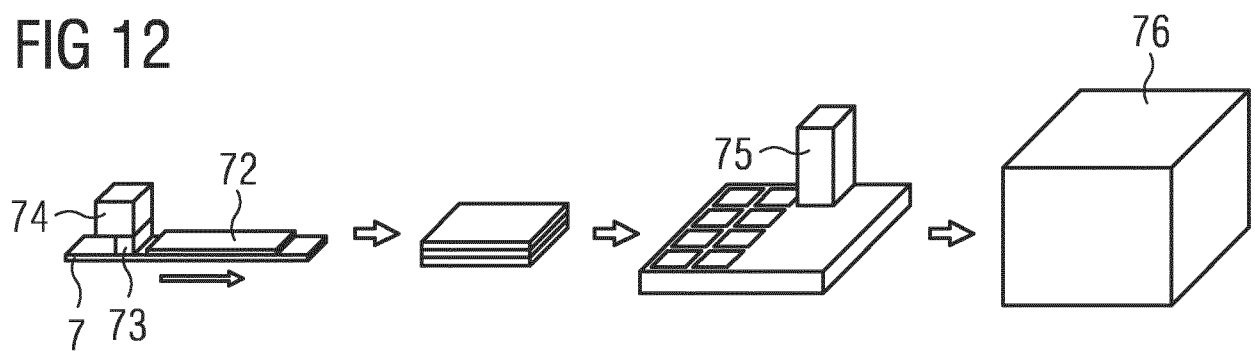


FIG 13

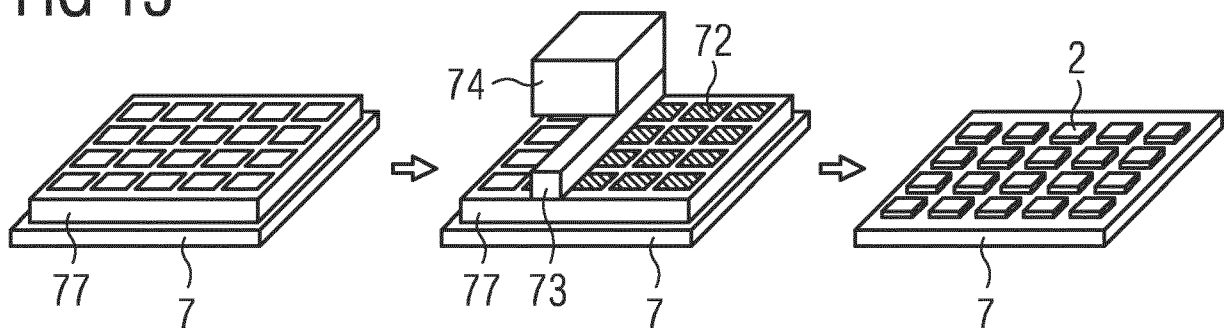


FIG 14

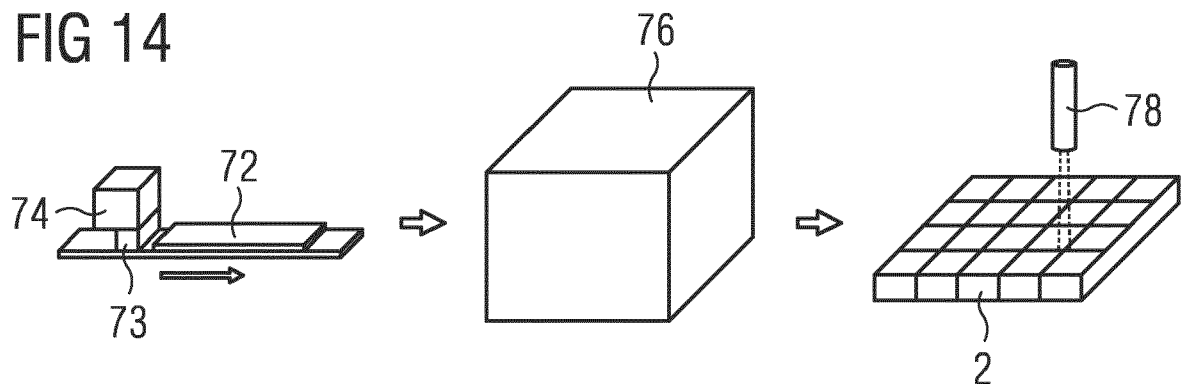


FIG 15

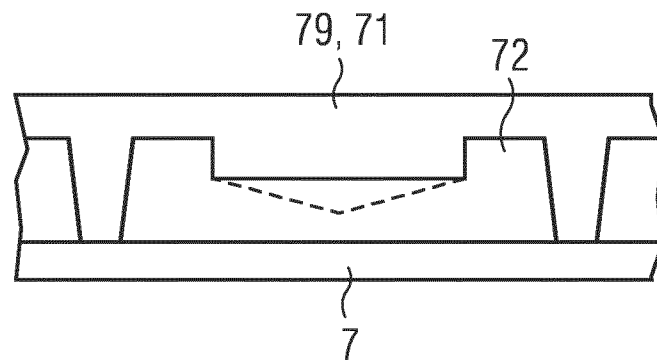
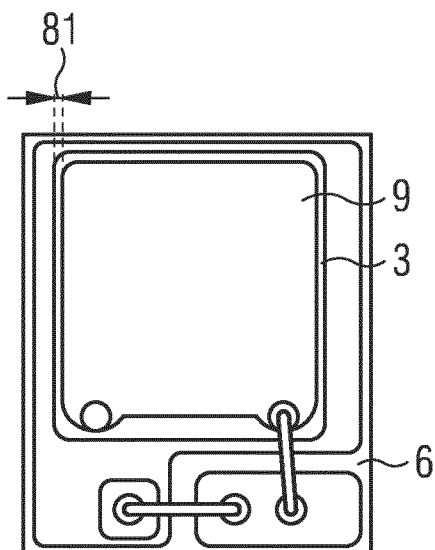
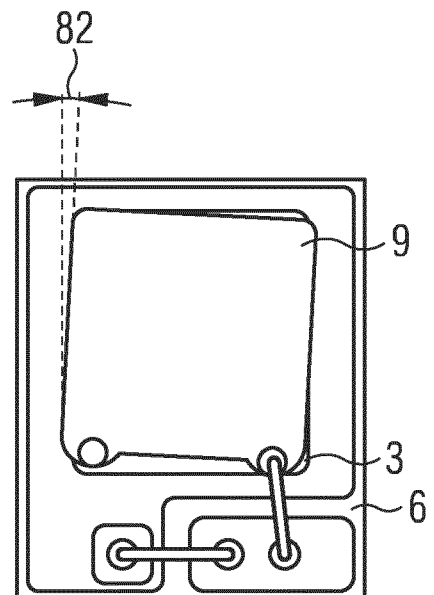


FIG 16

A)



B)



C)

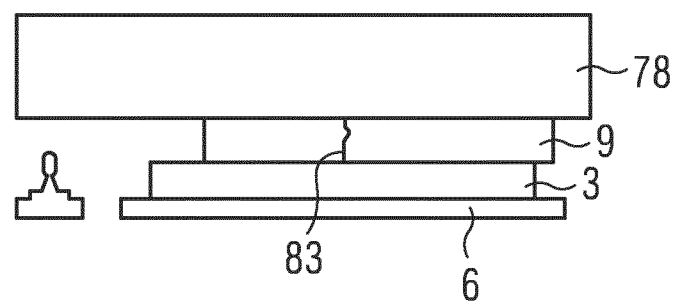
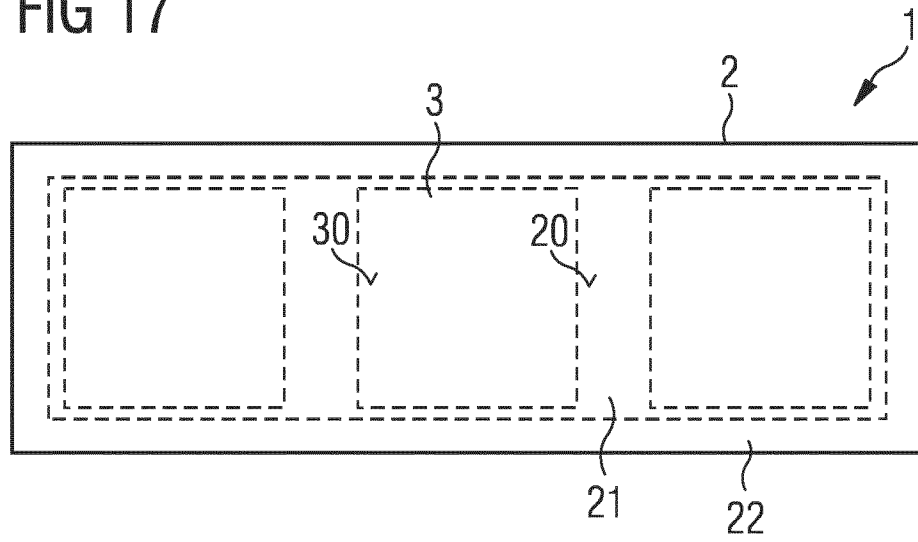


FIG 17



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/068137

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01L33/00 H01L33/50 H01L33/56
ADD. H01L25/075 H01L33/62

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/121911 A1 (ANDREWS PETER S [US] ET AL) 29 May 2008 (2008-05-29)	1,2,4-16
Y	abstract	3
A	figures 2-9,12-14	17
	paragraph [0001]	
	paragraph [0006] - paragraph [0018]	
	paragraph [0049] - paragraph [0075]	
	paragraph [0078] - paragraph [0091]	

Y	US 2012/074446 A1 (CHOI HYUCK JUNG [KR]) 29 March 2012 (2012-03-29)	3
A	abstract	1,2,5,8,
	figures 1-6	10,16
	paragraph [0009] - paragraph [0015]	
	paragraph [0023] - paragraph [0064]	

	-/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

6 March 2019

Date of mailing of the international search report

19/03/2019

Name and mailing address of the ISA/

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Authorized officer

De Kroon, Arnoud

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/068137

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2017/263829 A1 (RACZ DAVID [DE] ET AL) 14 September 2017 (2017-09-14) abstract figures 8,9,11-14 paragraph [0008] - paragraph [0073] paragraph [0116] - paragraph [0124] paragraph [0168] - paragraph [0174] -----	1,5,6,8, 10,11,16
A	US 2016/118559 A1 (MIN JAE SIK [KR] ET AL) 28 April 2016 (2016-04-28) the whole document -----	1-17

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2018/068137

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008121911 A1	29-05-2008	DE 102007055170 A1 JP 2008166740 A JP 2011188001 A US 2008121911 A1	12-06-2008 17-07-2008 22-09-2011 29-05-2008
US 2012074446 A1	29-03-2012	KR 20120032780 A US 2012074446 A1 US 2014346549 A1 US 2016111607 A1	06-04-2012 29-03-2012 27-11-2014 21-04-2016
US 2017263829 A1	14-09-2017	CN 106688096 A DE 102014112973 A1 DE 112015004123 A5 KR 20170055961 A US 2017263829 A1 WO 2016038009 A1	17-05-2017 10-03-2016 01-06-2017 22-05-2017 14-09-2017 17-03-2016
US 2016118559 A1	28-04-2016	KR 20160050341 A US 2016118559 A1	11-05-2016 28-04-2016