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(71) **Applicant: OSRAM OPTO SEMICONDUCTORS GMBH** [DE/DE]; Leibnizstr. 4, 93055 Regensburg (DE).

(72) **Inventors: LIM, Choon Kim**; 1A-6-2, One Sky, Tingkat Mahsuri 2, Bayan Baru, Penang, 11950 (MY). **LIM, Choo Kean**; E-Park, 2C-24-07, Jalan Batu Uban, Penang, 11700 (MY). **TEOH, Hui Chiang**; 26, Taman Suria 5, Jitra, Kedah, 06000 (MY).

(74) **Agent: ZACCO PATENT- UND RECHTSANWALTSGESELLSCHAFT MBH**; Bayerstrasse 83, 80335 München (DE).

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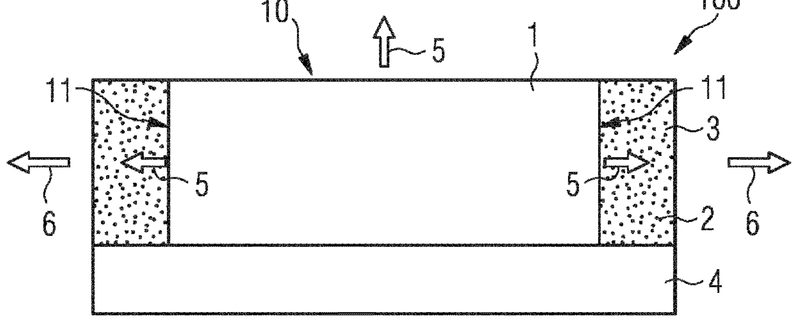
(54) **Title:** LIGHT-EMITTING DEVICE AND METHOD FOR PRODUCING A LIGHT-EMITTING DEVICE

FIG 2



(57) **Abstract:** The invention refers to a light emitting device (100) comprising a semiconductor chip (1) having a main radiation surface (10), which emits UV light (5) in operation,a phosphor (2), which is arranged in the radiation beam of the UV light (5), absorbs partially the UV light (5), wherein the phosphor (2) converts the UV light (5) into visible light (6), so that the device emits mixed light comprising the UV light (5) as well as visible light (6).

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Description

LIGHT-EMITTING DEVICE AND METHOD FOR PRODUCING A LIGHT-EMITTING DEVICE

A light-emitting device is specified. Furthermore a method for producing a light-emitting device is specified.

One object to be achieved is to specify a light-emitting device which has good properties for use in medical applications or as an indicator showing the operational capability.

Furthermore, another object to be achieved is to produce a light-emitting device which has good properties for use in medical applications or as an indicator showing the operational capability.

This object is or these objects are achieved, inter alia, by means of a light-emitting device and by means of a method for producing a light-emitting device comprising the features of the independent patent claims 1 and 17. Preferred developments and advantageous embodiments are provided in the dependent claims.

According to at least one embodiment, the light-emitting device comprises a semiconductor chip. The semiconductor chip has a main radiation surface. The main radiation surface emits UV light or at least UV light in operation. The light-emitting device comprises a phosphor. The phosphor is arranged in the radiation beam of the UV light. The phosphor absorbs in operation at least partially the UV light and converts the UV light, in particular the absorbed UV light, into visible light. Therefore, the device emits mixed light comprising the UV light as well as the visible light.

According to one aspect of the invention, the light-emitting device is a light-emitting diode, in particular an inorganic light-emitting diode (LED).

The inventors have found that the described light-emitting device has advantageous properties for use in medical applications.

In particular the light emitting device, in particular the light-emitting diode, comprises a semiconductor chip and at least one phosphor. This arrangement can also be called a phosphor integrated LED, which is able to emit visible light, for example white light, around the semiconductor chip. The semiconductor chip can be embodied as a UV LED. Therefore, this light-emitting device alerts the user when the UV LED is turned on with visible light around the UV LED, since UV light is invisible to the user.

In accordance with at least one embodiment, the light-emitting device comprises one or a plurality of semiconductor chips. The semiconductor chip(s) comprise(s) at least one semiconductor layer sequence. The semiconductor layer sequence is preferably based on a III-V compound semiconductor material. The semiconductor material is, for example, a nitride compound semiconductor material such as $Al_nIn_{1-n-m}Ga_mN$ or a phosphide compound semiconductor material such as $Al_nIn_{1-n-m}Ga_mP$ or an arsenide compound semiconductor material such as $Al_nIn_{1-n-m}Ga_mAs$, wherein in each case $0 \leq n \leq 1$, $0 \leq m \leq 1$ and $n + m \leq 1$. In this case, the semiconductor layer sequence can comprise dopants and additional constituents. For the sake of simplicity, however, only the essential constituents of the crystal lattice of the semiconductor layer sequences, that is to say Al, As, Ga, In, N or P, are indicated, even if these can be replaced and/or supplemented in part by small amounts of further substances.

The semiconductor layer sequence comprises one or a plurality of active layers. The at least one active layer is designed for generating an electromagnetic radiation, also called light.

By way of example the active layer includes at least one pn-junction or at least one quantum well structure. In particular, the ultraviolet, visible and/or near infrared radiation is/are generated in the active layer during operation of the semiconductor chip. The radiation generated in the active layer has a peak wavelength. The peak wavelength is that wavelength at which the highest radiation intensity is generated during operation as intended.

According to at least one embodiment the semiconductor chip has a main radiation surface. The main radiation surface is arranged perpendicular to the growth direction of the semiconductor layer sequence of the semiconductor chip. The semiconductor chip emits UV light via the main radiation surface in operation.

According to at least one embodiment the wavelength or the peak wavelength of the UV light lies in the range of between 280 nm and 380 nm, in particular between 315 nm and 380 nm, for example 360 nm.

According to at least one embodiment the light-emitting device comprises at least one phosphor or a mixture of at least two phosphors. The phosphor is arranged in the radiation beam of the UV light. In particular the semiconductor chip also comprises, beside the main radiation surface, side surfaces which are arranged perpendicular to the main radiation surface. The UV light is emitted in particular via the main radiation surface and the side surfaces. The phosphor is in particular arranged at the side surfaces. The phosphor partially absorbs the UV light and converts the UV light or the absorbed UV light into visible light.

The light-emitting device emits mixed light, which comprises UV light as well as the visible light. In other words, the mixed light is the sum of the emitted UV light and the emitted visible light.

According to at least one embodiment the semiconductor chip has side surfaces, which are arranged perpendicular to the main radiation surface, wherein the phosphor is arranged at the side surfaces, wherein a maximum of 40 percent of the UV light is absorbed and a maximum of 5 percent of the absorbed UV light is converted into visible light by the phosphor.

According to at least one embodiment the semiconductor chip has side surfaces, in particular four side surfaces if the semiconductor chip is embodied as a cube or cuboid. The side surfaces are arranged perpendicular to the main radiation surface. In particular, the phosphor is arranged at the side surfaces. In particular the phosphor is embodied as a layer. The phosphor layer has in particular a thickness of 10 µm, 20 µm, 30 µm, 40 µm, 50 µm, 60 µm, 70 µm, 80 µm, 90 µm or 100 µm as the lower limit to 0,2 mm, 0,5 mm, 1 mm or 2 mm as the upper limit.

A maximum of 40 % or 30 % or 20 % or 10 % of the UV light is absorbed by the phosphor. Additionally a maximum of 1 %, 2 %, 3 %, 4 %, 5 %, 10 %, 15 %, 20 %, 25 % or 30 % or 35 % of the absorbed UV light is converted into visible light by the at least one phosphor.

According to one embodiment the light-emitting device comprises two phosphors. In particular, the phosphors emit light with different peak wavelengths. For example, the first phosphor emits blue or green light and the second phosphor emits red or orange light.

According to at least one embodiment the semiconductor chip is arranged on a substrate. The substrate is in particular a growth substrate of the semiconductor layer sequence. A possible material for the substrate can be gallium arsenide, germanium or sapphire.

According to at least one embodiment a maximum of 30 % of the UV light is absorbed by the phosphor. In particular a maximum of 20 % or 10 % or 5 % or 1 % of the UV light is absorbed by the phosphor.

According to at least one embodiment a maximum of 1 %, 2 % or 3 % of the absorbed UV light is converted into visible light by the phosphor.

According to at least one embodiment the device emits UV light as well as visible light at the same time in operation.

According to at least one embodiment the device emits in operation the UV light over the main radiation surface, wherein the semiconductor chip comprises side surfaces which are embedded by the phosphor, wherein the device emits in operation the visible light via the side surfaces.

According to at least one embodiment the visible light is white light. White light can be produced by mixing red, blue and green light and/or by varying the intensities of the individual red, blue and green emitted semiconductor materials or phosphors.

According to at least one embodiment the visible light is red, green or blue light.

According to at least one embodiment the phosphor or the at least one phosphor forms a frame around the side surface of the semiconductor chip. The frame can have a thickness of 10 µm, 20 µm, 30 µm, 40 µm, 50 µm, 60 µm, 70 µm, 80 µm, 90 µm or 100 µm as the lower limit to 0,2 mm, 0,5 mm, 1 mm or 2 mm as the upper limit.

According to at least one embodiment the phosphor partially converts the absorbed UV light (partial conversion). In contrast to partial conversion, full conversion can mean that in operation the device solely emits light which is converted by the phosphor.

According to at least one embodiment the phosphor directly borders the side surfaces of the device. In this context "directly borders" means that no further layers or elements are arranged between the phosphor or the phosphor layer and the side surfaces of the device.

According to at least one embodiment the phosphors, or the at least one phosphor, are embedded in an organic matrix material. An organic matrix material can be, for example, silicone or epoxy resin. The phosphor can be embedded homogenously in the organic matrix material. Alternatively, the phosphor can have the concentration gradient in the organic matrix material. The phosphor can be embodied as a layer or an element like a frame. In particular, the phosphor forms a frame around the side surfaces of the semiconductor chip. The layer can have a homogenous layer thickness of 10 µm, 20 µm, 30 µm, 40 µm, 50 µm, 60 µm, 70 µm, 80 µm, 90 µm or 100 µm as the lower limit to 0,2 mm, 0,5 mm, 1 mm or 2 mm as the upper limit.

According to at least one embodiment the phosphor is selected from the group consisting of Eu^{2+}-doped nitrides such as $(Ca,Sr)AlSiN_3:Eu^{2+}$, $Sr(Ca,Sr)Si_2Al_2N_6:Eu^{2+}$, $(Sr,Ca)AlSiN_3{*}Si_2N_2O:Eu^{2+}$, $(Ca,Ba,Sr)_2Si_5N_8:Eu^{2+}$, $(Sr,Ca)[LiAl_3N_4]:Eu^{2+}$; 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 $Lu_3(Al_{1-x}Ga_x)_5O_{12}:Ce^{3+}$, $Y_3(Al_{1-x}Ga_x)_5O_{12}:Ce^{3+}$; Eu^{2+}-doped sulfides such as $(Ca,Sr,Ba)S:Eu^{2+}$; Eu^{2+}-doped SiONs such as $(Ba,Sr,Ca)Si_2O_2N_2:Eu^{2+}$; 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 $(Ba,Sr,Ca,Mg)_2SiO_4:Eu^{2+}$; chlorosilicates such as $Ca_8Mg(SiO_4)_4Cl_2:Eu^{2+}$; chlorophosphates such as $(Sr,Ba,Ca,Mg)_{10}(PO_4)_6Cl_2:Eu^{2+}$; BAM luminescent materials from the BaO-MgO-Al_2O_3 system such as

$BaMgAl_{10}O_{17}:Eu^{2+}$; halophosphates such as $M_5(PO_4)_3(Cl,F):(Eu^{2+},Sb^{3+},Mn^{2+})$; SCAP luminescent materials such as $(Sr,Ba,Ca)_5(PO_4)_3Cl:Eu^{2+}$. The phosphors or luminescent materials stated in document EP 2 549 330 A1 may also be used. With regard to the luminescent materials used, the disclosure content of this document is included by reference. "Quantum dots" may moreover also be introduced as phosphors. 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.

In principle the invention is not specific to the above mentioned type of phosphors. Any phopshors that absorb UV light and emit visible light is suitable for this concept. This includes all traditional phosphors used in fluorescent lamps and any white LED exited from UV LED

According to at least one embodiment, the UV light has a different main emission direction compared to the main emission direction of the visible light.

According to at least one embodiment, the light emitting device comprises a filter material. The filter material absorbs the UV light which is not converted into visible light and is emitted via the side surface. The filter material can be any UV absorbing filter material.

According to at least one embodiment the visible light serves as an indicator showing the operational capability of the device for the user.

According to at least one embodiment the device is used in medical applications. Ultra-violet light has a huge number of useful applications in modern medicine, such as disinfection, decontamination of surfaces, drug detection, forensic analysis, light therapy in medicine, and curing polymers. Since UV light is usually invisible and may cause danger to humans, especially during unintentional exposure, there are always safety concerns with modern UV medical applications.

Furthermore a method for producing a light-emitting device is specified. Preferably a light-emitting device as specified in conjunction with one or more of the embodiments mentioned above is produced by the method. Therefore, features of the method are also disclosed for the light-emitting device and vice versa.

In at least one embodiment the method comprises at least or exclusively the following steps:

A) Applying at least two semiconductor chips on a substrate, each of the two semiconductor chips having a main radiation surface and side surfaces,
B) Applying a UV tape on the main radiation surfaces,
C) Filling a phosphor between neighboured semiconductor chips so that the phosphor forms a frame around the side surfaces of each semiconductor chip,
D) Removing the UV tape, and
E) Singulating the assembly mentioned in step D) or C).

According to at least one embodiment the phosphor is embedded in an organic matrix material and the organic matrix material with the phosphor is cured after step C).

According to at least one embodiment a thermal tape is arranged between the semiconductor chips and the substrate.

According to at least one embodiment the phosphor partially converts the UV light into visible light.

Furthermore, a light-emitting device is specified. Furthermore, features of the above-mentioned method and the above-mentioned light-emitting device are also disclosed for the following light-emitting device and vice versa.

In at least one embodiment the light-emitting device comprises a semiconductor chip having a main radiation surface which emits UV light in operation. The light-emitting device comprises a second semiconductor chip which emits visible light in operation. The light-emitting device emits mixed light comprising the light of the first semiconductor chip (the UV light) as well as the light of the second semiconductor chip (the visible light). In particular the first and second semiconductor chips are embodied as a light-emitting diode. The inventor has also found out that instead of using one phosphor integrated in a semiconductor chip which emits UV light (UV LED), two semiconductor chips, in particular two light-emitting diodes (one UV LED and one visible LED) can solve UV safety concerns.
According to at least one embodiment, the second semiconductor chip comprises a semiconductor layer sequence, which is designed to generate visible light. When in proper use, the semiconductor layer sequence generates colored or white light. The semiconductor layer sequence may optionally additionally generate a fraction of the radiation in the ultraviolet and/or in the near infrared region of the spectrum. The visible region of the spectrum is in the

present case considered in particular to be the wavelength range between 400 nm and 720 nm inclusive. The semiconductor layer sequence preferably comprises a light-emitting diode layer sequence.

In accordance with at least one embodiment, the first and/or second semiconductor chip comprises at least one semiconductor layer sequence. The semiconductor layer sequence is preferably based on a III-V compound semiconductor material. The semiconductor material is, for example, a nitride compound semiconductor material such as $Al_nIn_{1-n-m}Ga_mN$ or a phosphide compound semiconductor material such as $Al_nIn_{1-n-m}Ga_mP$ or an arsenide compound semiconductor material such as $Al_nIn_{1-n-m}Ga_mAs$, wherein in each case $0 \leq n \leq 1$, $0 \leq m \leq 1$ and $n + m \leq 1$. In this case, the semiconductor layer sequence can comprise dopants and additional constituents. For the sake of simplicity, however, only the essential constituents of the crystal lattice of the semiconductor layer sequences, that is to say Al, As, Ga, In, N or P, are indicated, even if these can be replaced and/or supplemented in part by small amounts of further substances.

The initial of the invention is UV light generated from UV LED is dangerous as it is not visible to human eyes. According to one aspect of the invention, phopshors are added so that partial of the lights are converted to visible lights as indicators. According to another aspect or an embodiment of the invention, single UV chips or plurality can be used. There could be more than 1 chips in module for higher power UV systems.

A light-emitting device and a method for producing a light-emitting device described herein are explained in greater detail below on the basis of exemplary embodiments with reference to the drawings. In this case identical reference signs indicate identical elements in the individual figures. Relations to scale are not illustrated in this case. Rather individual elements may be illustrated with an exaggerated size to enable a better understanding.

Figures 1 and 2 show a side view of a schematic illustration of a light-emitting device according to the invention; and

Figures 3A to 3F and 4A to 4F show a schematic illustration of a method for producing a light-emitting device described herein.

Figure 1 shows a light-emitting device according to one aspect of the invention. The light-emitting device 100 comprises a semiconductor chip 1 having a main radiation surface 10, which emits UV light 5 in operation.

The semiconductor chip 1 comprises side surfaces 11. The light-emitting device 100 comprises a phosphor 2 which is in direct contact with the side surfaces 11 of the semiconductor chip 1.

In particular the phosphor 2 completely coverts the side surfaces 11 of the semiconductor chip 1.

Alternatively, the phosphor 2 partially coverts the side surfaces 11 of the semiconductor chip 1 (here not shown).

The phosphor 2 is arranged in the radiation beam of the UV light 5 and absorbs at least partially the UV light 5 and converts the absorbed UV light into visible light 6.

The device emits mixed light comprising UV light 5 as well as visible light 6. In particular the light-emitting device emits UV light 5 as well as visible light 6 at the same time.

In particular the main directions of the visible light 6 and the UV light 5 are different. In particular the visible light 6 is emitted via the side surfaces 11 of the semiconductor chip 1. The UV light 6 is emitted via the main surface 10 of the semiconductor chip 1.

Therefore, the light-emitting device alerts the user when the semiconductor chip 1 is turned on because the visible light 6 around the semiconductor chip 1 emits light at the same time when the UV light 5 is emitted in operation. The UV light 5 is invisible to the user.

Optionally the light-emitting device or the semiconductor chip 1 of the light-emitting device 100 is arranged on a substrate 4, for example gallium arsenide.

Figure 2 shows a side view of a schematic illustration of a light-emitting device 100 according to the invention.

The light-emitting device 100 optionally comprises a substrate 4 on which a semiconductor chip 1 is arranged. The side surfaces 11 of the semiconductor chip 1 are completely in direct contact with the phosphor 2.

The phosphor 2 is embedded in an organic matrix material 3, for example silicone. The semiconductor chip 1 emits UV light 5 via the main radiation surface 10 and the side surfaces 11. The UV light 5 emitted via the side surfaces 11 is partially absorbed by the phosphor 2 and is converted into visible light 6 by the phosphor. Therefore the light-emitting device 100 emits UV light 5, in particular over the main radiation surface 10 as well as visible light 6 in particular over the side surfaces 11.

Therefore, if a user turns on the light-emitting device 100, the invisible UV light as well as the visible light can be seen by the user. Therefore the visible light is the indicator for the UV light. Since UV light is usually invisible and could cause danger to humans, especially during unintentional exposure, there are always safety concerns with modern UV medical applications. In particular, the eyes of the user are protected by the light-emitting device 100 according to the invention.

Figures 3A to 3F show a method for producing a light-emitting device 100 according to this invention.

Figure 3A shows a substrate 4 on which at least two semiconductor chips 1, here six semiconductor chips, are arranged. Each of the semiconductor chips 1 has a main radiation surface 10, which is facing away from the substrate 4 and side surfaces.

After applying the semiconductor chips on the substrate 4 as shown in Figure 3A, a UV tape 7 is applied on the main radiation surface of each of the semiconductor chips (Figure 3B). In particular one UV tape is arranged on the main radiation surfaces of all semiconductor chips.

As shown in Figure 3C, the phosphor 2 is filled between neighbouring semiconductor chips 1 so that the phosphor forms a frame around the side surfaces 11 of each semiconductor chip.

As shown in Figure 3D, the UV tape 7 is removed. After removing the UV tape 7 the semiconductor chips 1 are singulated 9 as shown in Figure 3E.

At the end of the method a light-emitting device 100 is produced which comprises the features as mentioned at least in base claim 1. In this case the light-emitting device comprises a substrate 4, a semiconductor chip 1 having two electrical contacts 12 and a frame of phosphor 2, which is arranged directly on the side surfaces 11 of the semiconductor chip 1.

Figures 4A to 4F show a method for producing a device according to the invention.

According to Figure 4A a thermal tape 8 is arranged on the substrate 4. Semiconductor chips 1 are arranged on the thermal tape 8.

As shown in Figure 4B, a UV tape 7 is applied on the main radiation surfaces 10 of the semiconductor chips 1.

As shown in Figure 4C the phosphor 2 is filled between neighbouring semiconductor chips 1 so that the phosphor forms a frame around the side surfaces 11 of each semiconductor chip 1.

As shown in Figure 4D the UV tape is removed and the assembly as produced in Figure 4D is singulated 9.

In particular the thermal tape 8 and the substrate 4 are not singulated.

As shown in Figure 4F the method produces a light-emitting device 100 which comprises a semiconductor chip 1 and a phosphor 2 and electrical contacts 12. In contrast to the device of Figure 3F, the light-emitting device 100 of Figure 4F does not comprise a substrate 4. In other words, the light-emitting device 100 of Figure 4F is free of a substrate 4.

The inventor has found that only one semiconductor chip is needed to emit UV light and visible light. A small package footprint is possible. The emission of visible light around the UV LED can further improve the safety factor of modern medical applications.

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

Reference signs

100	light emitting device
1	semiconductor chip
2	phosphor
3	matrix material
4	substrate
5	UV light
6	visible light
7	UV tape
8	thermal tape
9	singulation
10	main surface
11	side surfaces
12	electrical contact

Patent Claims

1. Light emitting device (100) comprising
  - a semiconductor chip (1) having a main radiation surface (10), which emits UV light (5) in operation,
  - a phosphor (2), which is arranged in the radiation beam of the UV light (5), absorbs partially the UV light (5), wherein the phosphor (2) converts the UV light (5) into visible light (6), so that the device emits mixed light comprising the UV light (5) as well as visible light (6).

2. Light emitting device (100) according to claim 1, wherein the semiconductor chip (1) has side surfaces (11), which are arranged perpendicular to the main radiation surface (10), wherein the phosphor (2) is arranged at the side surfaces (11), wherein a maximum of 40 percent of the UV light (5) is absorbed and a maximum of 5 percent of the absorbed UV light (5) is converted into visible light (6) by the phosphor (2).

3. Light emitting device (100) according to at least one of the preceding claims, wherein the semiconductor chip (1) is arranged on a substrate (4).

4. Light emitting device (100) according to at least one of the preceding claims, wherein a maximum of 30 percent of the UV light (5) is absorbed by the phosphor (2).

5. Light emitting device (100) according to claim 4,

wherein a maximum of 3 percent of the absorbed UV light (5) is converted into visible light (6) by the phosphor (2).

6. Light emitting device (100) according to at least one of the preceding claims, wherein the device emits UV light (5) as well as visible light (6) at the same time in operation.

7. Light emitting device (100) according to at least one of the preceding claims, which emits in operation the UV light (5) over the main radiation surface (10), wherein the semiconductor chip (1) comprises side surfaces (11), which are embedded by the phosphor (2), wherein the device emits in operation the visible light (6) via the side surfaces (11).

8. Light emitting device (100) according to at least one of the preceding claims, wherein the visible light (6) is white light.

9. Light emitting device (100) according to at least one of the preceding claims 1 to 7, wherein the visible light (6) is red, green or blue light.

10. Light emitting device (100) according to at least one of the preceding claims, wherein the wavelength of the UV light (5) lies in the range of between 280 nm and 380 nm.

11. Light emitting device (100) according to at least one of the preceding claims, wherein the phosphor (2) forms a frame around the side surfaces (11) of the semiconductor chip (1).

12. Light emitting device (100) according to at least one of the preceding claims, wherein the phosphor (2) directly borders the side surfaces (11) of the device.

13. Light emitting device (100) according to at least one of the preceding claims, wherein the phosphor (2) is selected from the group consisting of Eu^{2+}-doped nitrides, garnets, Eu^{2+}-doped sulfides, Eu^{2+}-doped SiONs, SiAlONs, beta-SiAlONs, nitrido-orthosilicates, orthosilicates, chlorosilicates, chlorophosphates, BAM luminescent materials, halophosphates, SCAP luminescent materials, Quantum dots.

14. Light emitting device (100) according to at least one of the preceding claims, wherein the phosphor (2) is embedded in an organic matrix material (3).

15. Light emitting device (100) according to at least one of the preceding claims, wherein the visible light (6) serves as an indicator showing the operational capability of the device for the user.

16. Light emitting device (100) according to at least one of the preceding claims, which is used in medical applications.

17. A method for producing a light emitting device (100) comprising the steps of:

A) Applying at least two semiconductor chips (1) on a substrate (4), each of the two semiconductor chips (1) having a main radiation surface (10) and side surfaces (11),
B) Applying a UV tape (7) on the main radiation surfaces (10),
C) Filling a phosphor (2) between neighboring semiconductor chips (1), so that the phosphor (2) forms a frame around the side surfaces (11) of each semiconductor chip (1),
D) Removing the UV tape (7), and
E) Singulating (9) the assembly.

18. Method according to claim 17,
wherein the phosphor (2) is embedded in an organic matrix material (3) and the organic matrix material (3) with the phosphor (2) is cured after step C).

19. Method according to claim 17 or 18,
wherein a thermal tape (8) is arranged between the semiconductor chips (1) and the substrate (4).

FIG 1

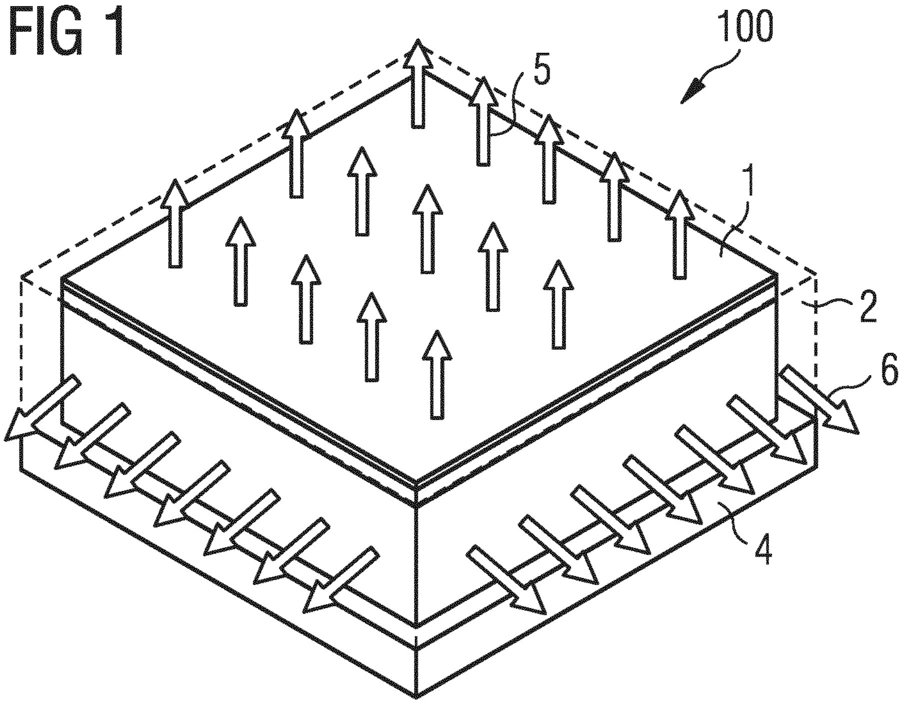


FIG 2

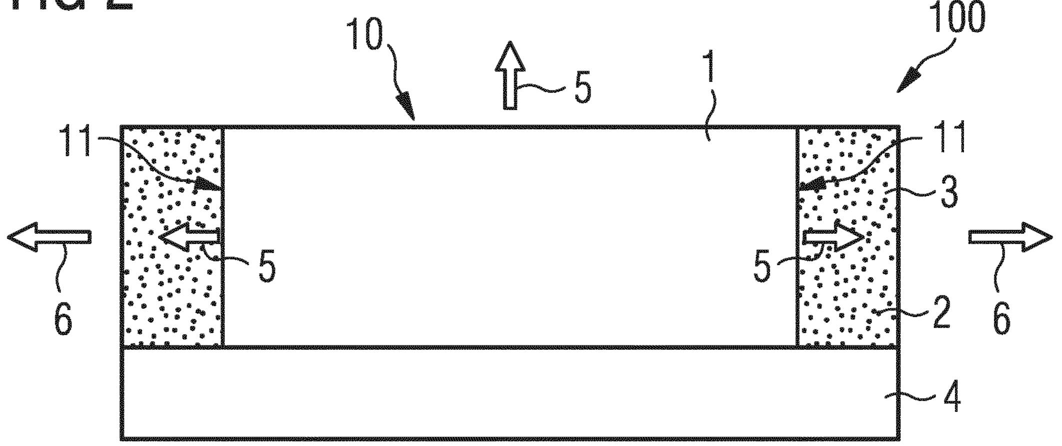


FIG 3

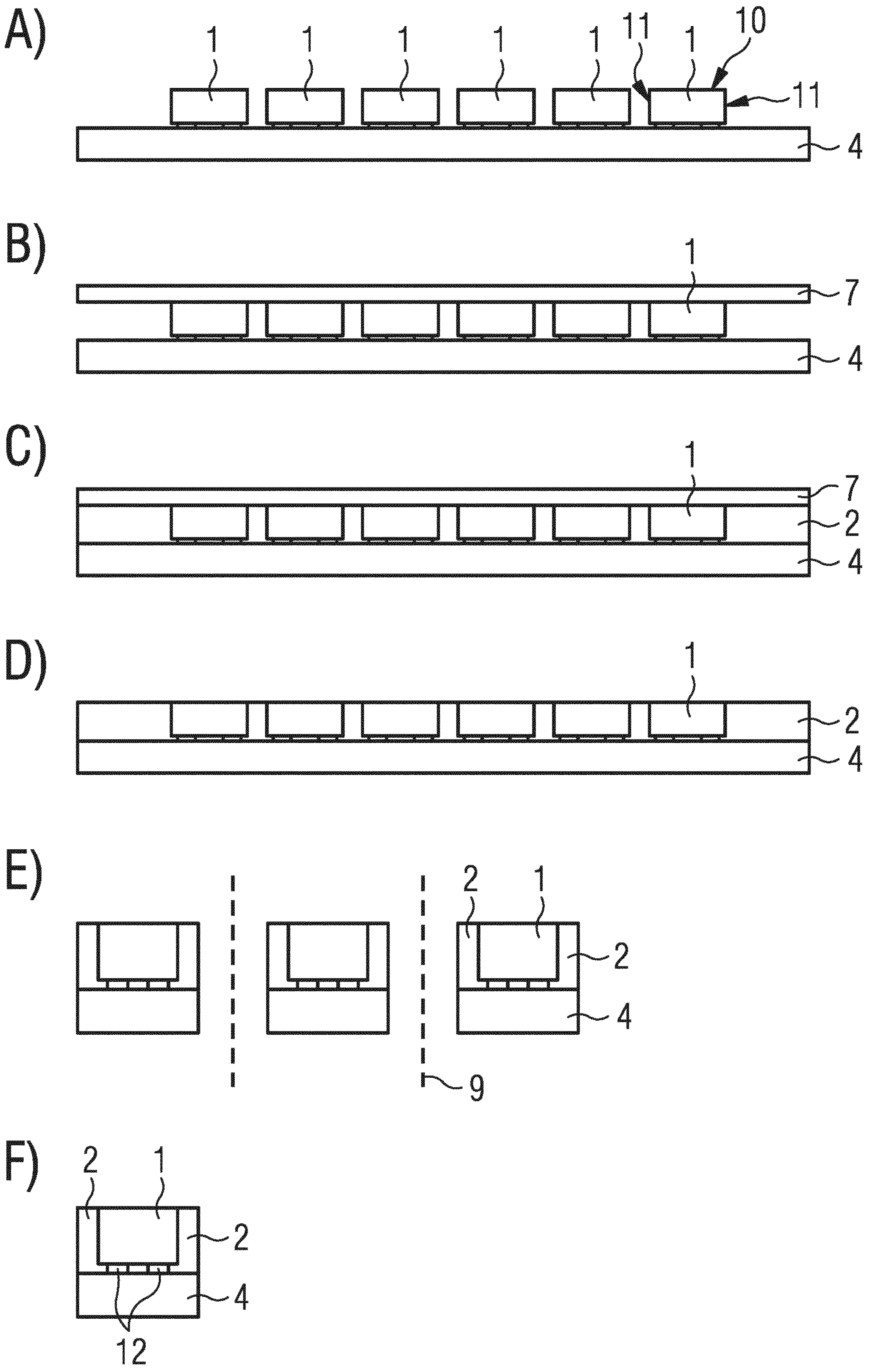
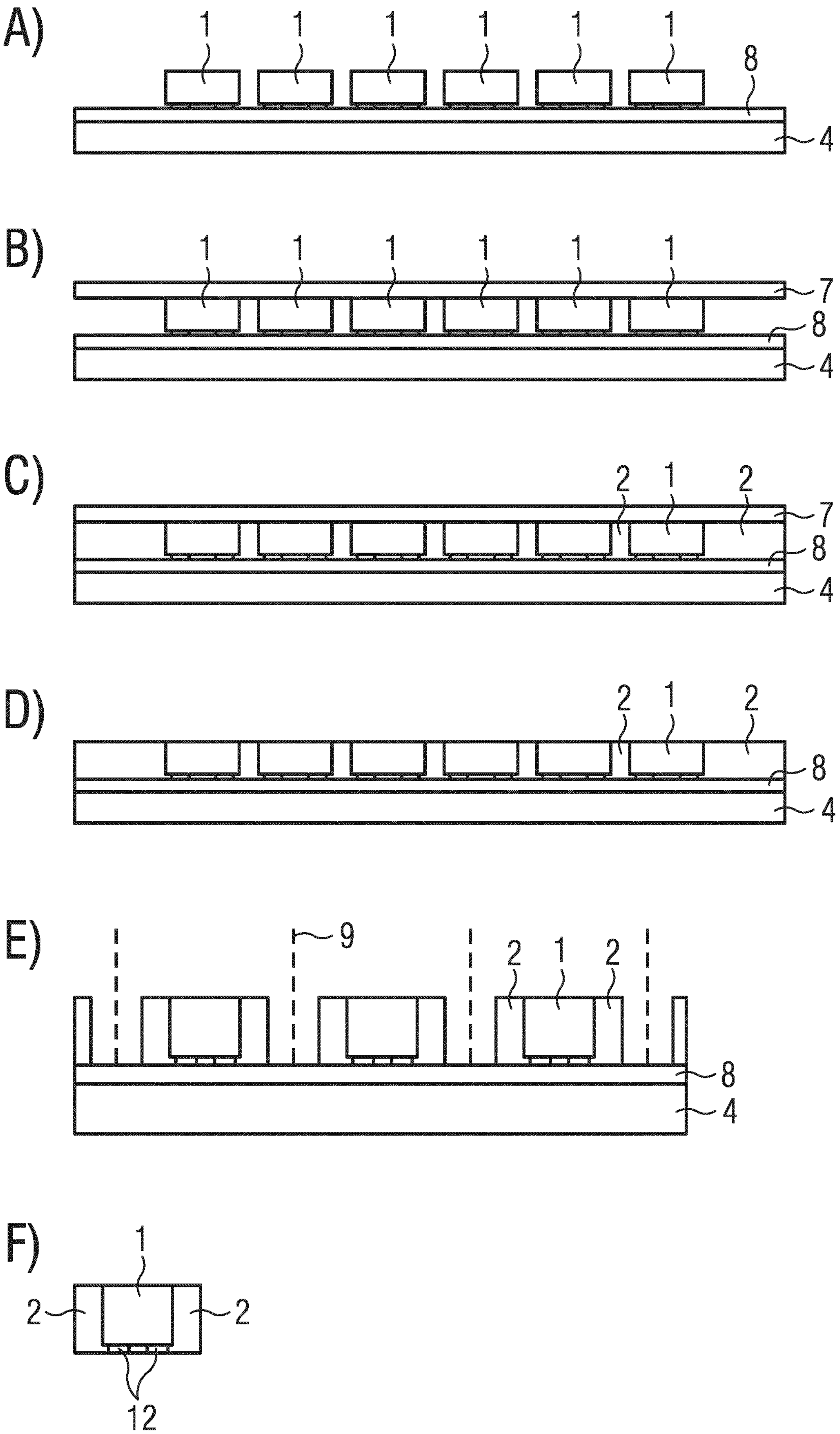


FIG 4



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/062646

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L33/50
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.
X Y	US 2013/187178 A1 (TISCHLER MICHAEL A [US]) 25 July 2013 (2013-07-25) paragraphs [0001] - [0040], [0101] - [0122], [0146] - [0151]; figure 13 -----	1-8, 10-18 19
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Y	US 2010/283062 A1 (HSIEH MIN-HSUN [TW] ET AL) 11 November 2010 (2010-11-11) paragraphs [0001] - [0005], [0066] - [0083]; figures 23, 24 -----	19

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"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	Date of mailing of the international search report
12 February 2018	19/02/2018

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	Saynova, Desislava

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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