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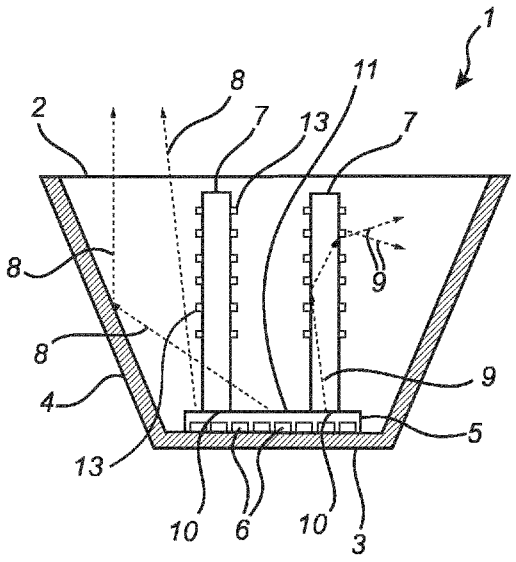


Fig. 1

(57) Abstract: The lighting device (1) uses a chip-on-board LED light source (5). One or more light guides (7) are mounted on the chip-on-board LED light source (5). The light emitted from the chip-on-board LED light source (5) is split into functional light (8) emitted directly form the chip-on board LED light source (5), and decorative light (9) received, transmitted and re-emitted from the light guides (7).

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A LIGHTING DEVICE

FIELD OF THE INVENTION

The present invention relates to downlight and spot lighting, in particular to a lighting device, comprising a chip-on-board LED light source with a light emission surface having a first surface area, and at least one light guide having a light reception surface with a second surface area and adapted to receive light and a body adapted to transmit the received light.

BACKGROUND OF THE INVENTION

Light emitting diodes (LEDs) are employed in a wide range of lighting applications such as general lighting. The transition from incandescent and fluorescent lamps to LEDs in many parts of the lighting industry is almost complete. LEDs come in many different packages depending on the lighting application and currently it can be seen that certain packages such as chip on board (CoB) are becoming a winning technology for spotlight and downlight applications. A CoB comprises a plurality of bare LED chips which are in direct contact with the substrate to produce LED arrays. The cost effectiveness and efficiency of these light sources are making them very attractive. CoB packages are inter alia successful where lamp and luminaires are being combined. An example of a combined LED and luminaire is disclosed in CN104989986. More specifically CN104989986 discloses an anti-glare luminaire for sports events were the glare that might disturb the participants such as players or athletes is prevented by providing a cylindrical light guide over an LED point source on a carrier in the bottom of a cup-shaped reflector forming luminaire. The cylindrical light guide has dimples or holes in the mantle surface from which light reflected internally is emitted towards the reflector. Thus, no direct light that might blind the participants is emitted towards them. Since the light is diffused in this way and no direct light is emitted the anti-glare luminaire disclosed in CN104989986 is unsuitable for downlight and spotlight applications.

WO13145054A1 discloses a light source for illumination that is constituted of an enclosure having a globe, a housing, and a base cap and is provided with a light emitting module disposed within the enclosure. The globe has an expanded part that expands to the outside more than the housing, and the brightness in a range of angles of -170 degrees to +170 degrees based at the center axis of the light source (1) for illumination is 1/2 or more of the center brightness at the center axis of the light source (1) for illumination.

SUMMARY OF THE INVENTION

On this background it is the object of the invention to provide a novel and decorative luminaire suitable for spotlight and downlight applications utilizing a chip-on-board LED light source. According, to the invention this object is achieved by providing a lighting device, comprising a chip-on-board LED light source with a light emission surface having a first surface area, at least one light guide having a light reception surface with a second surface area and adapted to receive light and a body adapted to transmit and emit the received light, where said second area of the light reception surface is smaller than the first area of said light emission surface, and where the second area of the light reception surface is arranged over the first light emission surface area so as to receive only a part of the light emitted from the light emission surface.

In this way a downlight or spotlight luminaire may be provided with light effects and features that are both functional and decorative, and therefore increase the acceptance among users. In particular the functional light will be provided by the light emitted directly from the surface area of the first light emission surface not covered by the second light reception surface, whereas the light captured by the second light reception surface will be dispersed by the light guide to provide the decorative lighting part. More specifically, by light in-coupling in the light guide at the light in-coupling side and light out-coupling at the light out-coupling side some light will be emitted directly from the LED as functional light for downlight and spotlight purposes, and some light be dispersed and used for decorative purposes.

According to a preferred embodiment, the body comprises an elongate body extending from the light reception surface, said elongate body having a predetermined length along which a side surface is provided, where said elongate body being adapted to emit received and transmitted light from said side surface. The elongate shape allows most, if not all, light received at the second light reception surface gets re-emitted along the side of the elongate body for the decorative purpose, such as mimicking an incandescent lamp filament.

According to a preferred embodiment, the reflector comprises a wall surrounding at least a part of said chip-on-board light source and at least a part of said light guide. This allows the directly emitted light to be properly collimated for spotlight and downlight purposes.

According to a further preferred embodiment, more than one light guide is arranged over the light emission surface and the sum of the total area of the second surface areas is smaller than the first surface area of the emission surface. Having a number of light guides increases the flexibility in design and allows for a multitude of decorative effects, such as mimicking multiple filaments. Furthermore, it allows for maintaining the elongate shape of the light guides if a larger part of the first light emission surface area is to be covered by the second light emission surface(s).

In terms of larger area of the second light emission surfaces it has been found advantageous, if the total area of the second surface area is in the range of 3 % to 30 % of the first area of the light emission surface, preferably, in the range of 4 % to 27 % of the first area of the light emission surface, and more preferred in the range of 5 % to 25 % of the first area of the light emission surface.

According to a further preferred embodiment, the elongate light guide is rod- or fiber-shaped. both rods and fibres are easy to manufacture and easy to mount on the first light emission surface while their shapes still provide the above mentioned good lateral emission.

This is in particular the case if, according yet a further preferred embodiment, the light guide has a cylindrical shape.

According to a further preferred embodiment, the shape of the body of the light guide is adapted to emit the transmitted light. This may be by the overall shape or according to a one preferred embodiment by the provision of surface elements such as surface discontinuities in an otherwise smooth surface, is a simple and effective way of disrupting the total internal reflection of the body, thereby allowing the light to exit through the surface.

According to an alternative embodiment, the elements comprise embedded particles. Embedding particles in the body of the light guide allows the light to be reflected or refracted in directions allowing it to exit from the surface, rather than being totally internally reflected.

According to another embodiment, the light reception surface of the light guide is adhered to the chip-on-board LED light source. Adhering the light reception surface

of the light guide directly onto the chip-on-board LED light source is advantageous in terms of manufacture and assembly, and with a suitable transparent adhesive allows good control of the coupling of light into the light guide.

As an alternative, the light guide is attached to the chip-on-board LED light source by over moulding, i.e. moulding a transparent resin over the surface of the chip-on-board LED, thus surrounding the base of the light guide at the light reception end and thereby securing the light guide in position on the chip.

According to yet a further preferred embodiment, the light guide comprises more than one light reception surface, this allows for advanced and aesthetically pleasing geometries, such as arcs.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be explained in greater detail based on non-limiting exemplary embodiments and with reference to the schematic drawings on which:

Fig. 1 shows a cross-section though a luminaire according to the invention,

Fig. 2 shows a top plan view of the luminaire of Fig. 1 using a first configuration of light guides on the chip-on-board LED,

Fig. 3 shows various configurations of light guides on the chip-on-board LED,

Figs. 4a and 4b show plate-shaped light guides on the chip-on-board LED,

Fig. 5 illustrates the differences in diameter between cylindrical light guides and a circular chip-on-board LED,

Figs. 6a-6e show side views of various configurations of light guides on the chip-on-board LED,

Fig. 7 shows light guides adhered to the chip-on-board LED,

Fig. 8 shows light guides mounted on the chip-on-board LED by over moulding,

Figs. 9-11 shows examples of relations between the chip-on-board LED, the light guides and the reflector of a luminaire according to the invention,

Figs. 12a and 12b show different configuration of surface elements for coupling light out of the light guides

Fig. 13 shows an embodiment where the light guide is provided with a cladding,

Fig. 14 shows an embodiment where the light guide is provided with luminescent material,

Fig. 15 shows an embodiment where the positions the light guides are not aligned respective LEDs in the LED matrix of the chip-on-board LED light source for influencing the in-coupling of light, and

Fig. 16 shows an embodiment where the light guides comprise embedded elements.

DETAILED DESCRIPTION OF EMBODIMENTS

Turning first to Fig. 1 a schematic cross-sectional view of a lighting device 1 according to the invention is illustrated. In the specific embodiment shown the lighting device is a luminaire comprising a cup-shaped reflector body 2 with a bottom 3 and a reflector 4 surrounding the bottom. In the following the terms up, down, top bottom etc. are to be understood as illustrated in fig. 1, irrespective of the fact that in normal use as a spot or downlight the luminaire 1 would typically not be mounted in illustrated orientation. In the illustrated example the reflector 4 is frusto-conical but other geometries may be envisaged. On the bottom 3 a light source, in particular a chip-on-board LED light source 5, comprising a number of LEDs 6 is mounted. Typically, the chip-on-board LED light source 5 comprises a plurality of bare LED chips which are in direct contact with the substrate of the board to produce LED arrays. The array may comprise rows and columns covering a predetermined area, but also hexagonal configurations or other patterns, and the array will typically cover the predetermined area in a generally circular or otherwise rotational symmetrical manner, so that the predetermined area is generally circular or otherwise exhibit some kind of rotational symmetry, e.g. square or rectangular. Preferably, the predetermined area covers a surface area on the chip-on-board LED light source 5 of preferably at least 1 cm^2, more preferred at least 1.5 cm^2, most preferably at least 2 cm^2. The number of LED chips is preferably at least 16, more preferably at least 25, most preferably at least 36 such as for example 49 or 64. The resulting The LEDs chips are preferably enclosed by an encapsulant e.g. a polymer such as a silicone type of material. When energized the chip-on-board LED light source 5 emits light in various directions from the top surface, as indicated with dashed lines in Fig. 1.

The LED chip light from the LEDs chips is preferably UV and/or blue. Accordingly, the encapsulant may comprise a luminescent material such as a phosphor e.g. an inorganic phosphor, an organic phosphor and/or quantum dots/rods. The luminescent material partially/fully converts the LED chip light e.g. UV light to visible light or blue light to other visible colours and combinations thereof. More specifically the chip-on-board light source 5 preferably provides white light. The white light is preferably within 15 SDCM of the

BBL. Colour temperature is preferably in the range of 2000 – 6000 K, more preferably 2200 – 5000 K, most preferably 2500 – 4000 K such as for example 2700 or 3000 K. The CRI is preferably at least 75, more preferably at least 80, most preferably at least 85 such as for example 90 or 92.

As can be seen, some of the light 8 is emitted directly from the chip-on-board LED light source 5 parts of the directly emitted light may leave the reflector 4 directly whereas other parts may be collimated by reflection of the reflector 4. However, as can also be seen some light 9 is emitted in to one or more light guides 7 from which it is later emitted, i.e. emitted indirectly. The collimated directly emitted light 8 provides the functional light from the luminaire, e.g. as a spotlight or a downlight (when mounted upside down as compared to Fig. 1). The indirectly emitted light 9 on the other hand provides visual effects of the light that may be used for decorative purposes. How this indirect light 9 is provided depends on one or more technical features, which may be embodied in or in conjunction with the light guide 7 or light guides 7 as will be explained in further detail below. In this explanation reference will be made to a single light guide 7 even though it is to be understood that often more will be used, and that in that case even different embodiment so the light guide 7 may be combined. Although it is preferred that the reflector 4 surrounds the chip-on-board LED light source 5 as described above, it should be noted that it is not excluded that the chip-on-board LED light source 5 is larger than the (open) bottom of the reflector 4, inter alia allowing for a third fraction of the light to be emitted directly and un-collimated in further directions, e.g. as decorative light.

The light guide 7 comprises a light reception surface 10. The light reception surface is mounted onto the light emission surface 11 of the chip-on-board LED source 5. As can best be seen from Fig. 5 the first area of the light emission surface of the chip-on-board LED light source 5 is larger than the second area of the light reception surface of the light guide 7. If more light guides 7 are used the combined second areas of the light guides is still smaller than the first area of the light emission surface 11. When both the light reception surface and the light emissions surface are circular as illustrated the diameter ‘d’ of the light reception are preferably less than a third of the diameter ‘D’ of the light emission surface. Normally a circular shape of the light emission surface 11 is preferred and likewise for the light reception surface of the light guide 7, but other cross-sections may be envisaged. In particular, colour mixing in the rods may improves the rods other shapes if the cross-sections are e.g. polygonal shapes having more than 3 sides.

The light guide may be made of any suitable material. Typical materials suitable for the light guide 7 are polymer materials, such as PC, PMMA, PET, PE, silicone or ceramics such as glass, quartz or the like.

The light guide 7 is adapted to transmit the light 9 received at the light reception surface, normally by total internal reflection, but since the purpose is to provide indirect light the light guide 7 is adapted to allow light 9 to be coupled out, i.e. escape and be emitted along the length of the light guide 7. In this respect, it should be noted that not all light which impinges on the light reception surface is actually coupled into the light guide. By received is meant only that part of the impinging light which is coupled into the light guide. This adaptation may be achieved in using various different techniques. As can be seen in Fig. 1 these can be surface elements 13 where the otherwise smooth surface of the light guide 7 has discontinuities, e.g. diffractive or refractive structures, ensuring that no total internal reflection is provided, the light 9 therefore being emitted through the side surface of the light guide 7. These surface elements 13 could be discontinuities such as bosses, dimples, grooves, concentric rings, or any other geometry disrupting the total internal reflection. The elements may also, as illustrated in Fig. 13, comprise a translucent or transparent cladding 12 with an index of refraction disrupting the total internal reflection. Please note that in Figs. 13 to 16 only the proximal end of the light guides 7 is shown. Another option, which is shown in Fig. 16 is elements such as particles 16 embedded in the light guide 7, e.g. in, on or at the surface thereof, and having different indices of refraction from the surrounding material of the light guide 7 or even reflective properties, so as to refract, reflect or scatter the light 9 at angles where no total internal reflection exists, in turn allowing the light 9 to exit. Such reflecting particles could inter alia comprise Al_2O_3, $BaSO_4$ and/or TiO_2. Furthermore, as illustrated in Fig. 14, luminescent particles 15 could be used, be it embedded or on the surface of the light guide 7 in order to further influence the emitted light 9, e.g. changing the colour. A further way to influence the emission and colour is to adjust the alignment of the light reception surface 10 with individual LEDs 6 of the chip-on-board LED source 5 as can be seen in Fig. 15, thereby the in-coupling of the light 9 into the light guide 7 is influenced, depending on which modes are coupled in, in turn influencing the emission as well as colour point and temperature of the emitted light 9. The various techniques described above may evidently be used in combination on a single light guide 7, and when more light guides 7 are used in a single luminaire 1 as illustrated, they may use different techniques.

Furthermore, the exterior geometry may be used for the out-coupling of the light 9. Thus, in Fig. 6a a light guide 7 which is not rod shaped is illustrated, the curvature of

the light guide 7 in this embodiment is selected so that total internal reflection is not given everywhere along the light guide. The arc-shape in Fig. 6a is merely an example and other geometries such as helixes could be envisaged. As will be obvious the arc-shape in Fig. 6a has multiple light reception surfaces 10, *in casu* two, but other more complex geometries with more light reception surfaces can also be envisaged. Also, rather than rods and other elongate bodies, in particular in the shape of elongate cylinders, which are currently preferred, plate-shaped geometries of the light guide 7 could be used, as illustrated in Figs. 4a and 4b.

As illustrated in Figs.12a and 12b the surface elements 13 for coupling the light 9 out of the lightguide need not be distributed evenly along the elongate body of the light guide 7 or even be present along the entire length thereof. So as can be seen in Fig. 12a there is a first sector s1 where the surface elements 13 are present, and a second sector s2 where fever elements 13 are present. Similarly, in Fig. 12b surface elements 13 are present in the first sector s1 only and none in the second sector s2. This uneven distribution is not restricted to the embodiments of Fig. 12 with protruding surface elements 13 but may also be employed in the other embodiments described above, i.e. an uneven distribution of particles to refract, reflect or scatter the light 9, the luminescent particles or coating of Fig. 15 or only partial cladding 12 in the embodiment of Fig. 13. This may help in mimicking well known light sources such as filaments of incandescent lamps.

In all of those illustrated embodiments where the light guide comprises 7 an elongate body with a free distal end 14, the light out-coupling means are so distributed and arranged that virtually none of the indirect light 9, and certainly no glaring light emerges from the distal end 14.

As already indicated above there may be more than a single light guide 7 placed on the light emitting surface of the chip-on-board LED light source 5. These may be arranged in desired predetermined array patterns. If the chip-on-board LED light source 5 is circular as in the illustrated embodiments or if the reflector 4 has rotational symmetry giving a nice and pleasant symmetrical appearance, patterns with rotational symmetry are preferred. In particular it is preferred that axis about which the symmetry exist coincides with the centre of the circular chip-on-board LED light source 5 and/or the symmetry axis of the reflector 4. Examples of such arrangements with second, third, fourth and sixth order symmetry for two to seven light guides 7 are shown in Fig. 3. Higher order symmetry will convey the pleasant appearance from more or less any viewing angle. Irrespective of whether a light guide structure using only a single light guide 7 is used, or as described above number of light

guides 7 are used, symmetry about an axis coincident with the centre of the circular chip-on-board LED light source 5 and/or the symmetry axis of the reflector 4 preferred. Furthermore, irrespective of whether a single light guide 7 is used or a light guide structure comprising several light guides 7, their cross wise dimensions result in a total second area of the light receiving surfaces smaller than the area of the first light emission surface 11.

As mentioned above the diameter of the light guides 7, or at least the light reception surface thereof 10, preferably less than one third of the diameter of the light emission surface 11 of the chip-on-board LED light source 5. As can also be seen from the examples of Fig 3, the total area of the light reception surfaces of the light guides 7 is also substantially smaller than the second area of the light emission surface 11 of the chip-on-board LED light source 5. More specifically it has been found that a suitable mix of functional light and decorative light is achieved if the total area of the second surface area is in the range of 2 % to 40 % of the first area of the light emission surface, preferably in the range of 3 % to 30 % of the first area of the light emission surface and most preferred range of 5 % to 25 % of the first area of the light emission surface. Examples are given below.

Example 1:

In one preferred embodiment the first surface area is circular with a diameter of 2 cm and the second surface area is also circular but has a diameter of 0.5 cm. Accordingly the ratio between total area of the second surface area and the first surface area is 0.785/12.56=6%

Example 2:

In another preferred embodiment the first surface area is likewise circular with a diameter of 2 cm and the second surface area is also circular but has a diameter of 0.8 cm. Accordingly the ratio between total area of the second surface area and the first surface area is 2 /12.56=16%.

As can further be seen from Figs. 6c to 6e the light guides 7 may be arranged at angles to the light emission surface 11 of the chip-on-board LED 5 light source, i.e. not perpendicular thereto this allows for various decorative effects as well of an enlargement of the apparent area from which the decorative light 9 is emitted. More specifically, in Fig. 6e a circle circumscribing the distal ends 14 of the light guides 7 is larger than the first area of the

light emission surface 11 of the chip-on-board LED light source 5, hence giving a larger apparent area.

As long as the light guides 7 are rod shaped as illustrated in Figs. 6b to 6e a length 'L' and a width 'W' may easily be defined, as illustrated in Figs. 6b and 6D. If a cylindrical rod-shaped light guide 7 is arranged perpendicular to the chip-on-board LED light source as illustrated in Fig. 6b, the width 'W' will thus correspond to the diameter 'd' in Fig. 5.

The length to width ratio is preferably such that 'L'/'W' is at least 10, more preferably at least 20 'W', most preferably at least 30. The more elongated the better visible the light guide will be.

For envisaged applications 'L' is preferably at least 2 cm, more preferably at least 4 cm, most preferably at least 5 cm, such as for example 8 or 10 cm.

Furthermore, the decorative effect can be influenced by the selection of the length 'L' of the light guides 7 i.e. by choosing a specific length 'L' and inclination resulting in a desired height (H) over the light emission surface 11 at the bottom 3 of the cup-shaped reflector body 2, as illustrated in Fig. 9. More specifically, the appearance may be influenced by selecting the length 'L' so that the resulting height 'H' allows parts of light guides 7 extend visible over the height of the reflector 4 of the cup-shaped reflector body 2.

The optical and mechanical mounting of the light guides 7 on the chip-on-board LED light source 5 may be achieved in different ways known *per se*. In one preferred embodiment illustrated in Fig. 7, the light receptions surfaces 10 are adhered to the light emission surface 11 of the chip-on-board LED light source 5 by means of a transparent adhesive, with suitable properties in terms of *inter alia* temperature and light stability, e.g. using a glue e.g. a silicone based glue or a silicone material. In another the light reception surfaces 10 may by in direct contact with the light emission surface 11 and held in place by an overmould that covers the light emission surface 11 and surrounds the proximal end or base of the light guides 7.

While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. For example, other geometries and materials than those illustrated could be used, in particular for the light guides but also other parts of the lighting device. Likewise, the number of light guides used could be different from those explicitly recited.

Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS:

1. A lighting device (1), comprising

a chip-on-board LED light source (5) with a light emission surface (11) having a first surface area,

at least one light guide (7) having a light reception surface (10) with a second surface area and adapted to receive light (9) and a body adapted to transmit and emit the received light (9),

where said second area of the light reception surface (10) is smaller than the first area of said light emission surface (11), and where

the second area of the light reception surface (10) is arranged over the first light emission surface area so as to receive only a part of the light emitted from the light emission surface (11), another part of the light is emitted directly from the light emission surface (11),

wherein the body comprises an elongate body extending from the light reception surface (10), said elongate body having a predetermined length (H) along which a side surface is provided, where said elongate body being adapted to emit received and transmitted light (9) from said side surface, and

wherein the lighting device (1) comprises a reflector (4), said reflector comprising a wall surrounding said at least a part of chip-on-board light source (5) and at least a part of said light guide (7), and said reflector (4) is arranged to collimate at least part of the directly emitted light.

2. A lighting device (1) according to claim 1 wherein more than one light guide (7) is arranged over the light emission (11) surface and the sum of the total area of the second surface areas is smaller than the first surface area of the emission surface (11).

3. A lighting device (1) according to any one of the preceding claims, wherein the total area of the second surface area is in the range of 2 % to 40 % of the first area of the light emission surface (11).

4. A lighting device (1) according to claim 3, wherein the total area of the second surface area is in the range of 3 % to 30 % of the first area of the light emission surface (11).

5. A lighting device (1) according to claim 4, wherein the total area of the second surface area is in the range of 5 % to 25 % of the first area of the light emission surface (11).

6. A lighting device (1) according to any one of the preceding claims, wherein the elongate light guide (7) is rod- or fiber-shaped, or the light guide (7) has a cylindrical shape.

7. A lighting device (1) according to any one of the preceding claims the shape of the body of the light guide (7) is adapted to emit the transmitted light (9).

8. A lighting device (1) according to any one of the preceding claims wherein the body of the light guide (7) comprises elements (12, 13, 15) adapted to emit the transmitted light (9).

9. A lighting device (1) according to claim 8, wherein the elements comprise surface discontinuities (13).

10. A lighting device (1) according to claim 8, wherein the elements comprise embedded particles (16).

11. A lighting device (1) according to any one of the preceding claims wherein the light reception surface (10) of the light guide is adhered to the chip-on-board LED light source (5).

12. A lighting device (1) according to any one of claims 1 to 10, wherein the light guide (7) is attached to the chip-on-board LED light source (5) by overmolding.

13. A lighting device (1) according to any one of the preceding claims wherein the light guide (7) comprises more than one light reception surface (10).

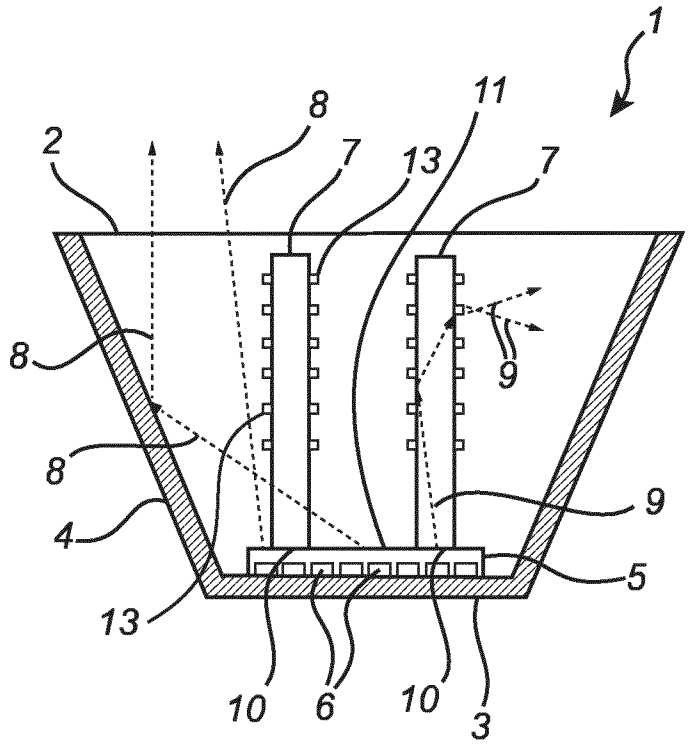


Fig. 1

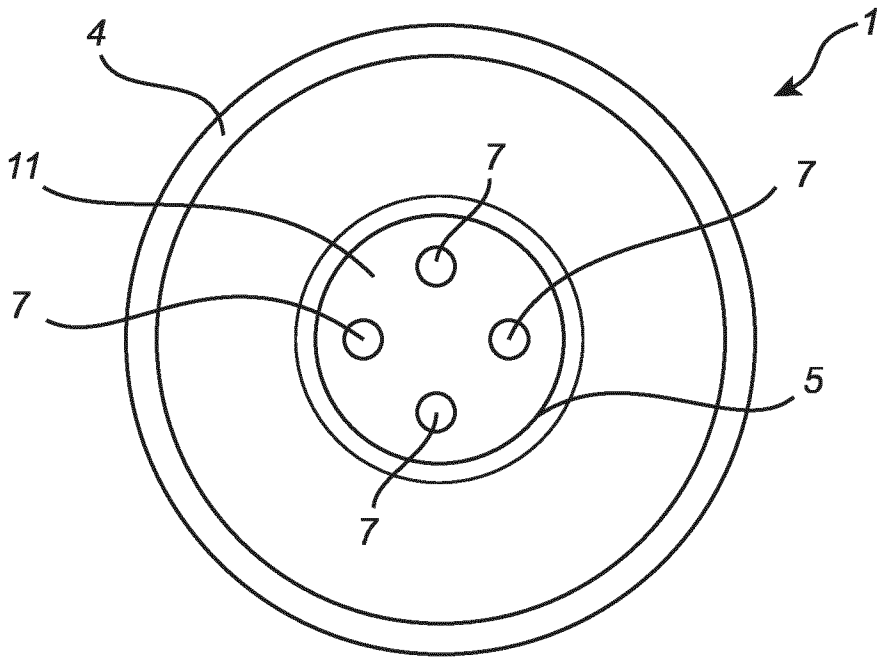


Fig. 2

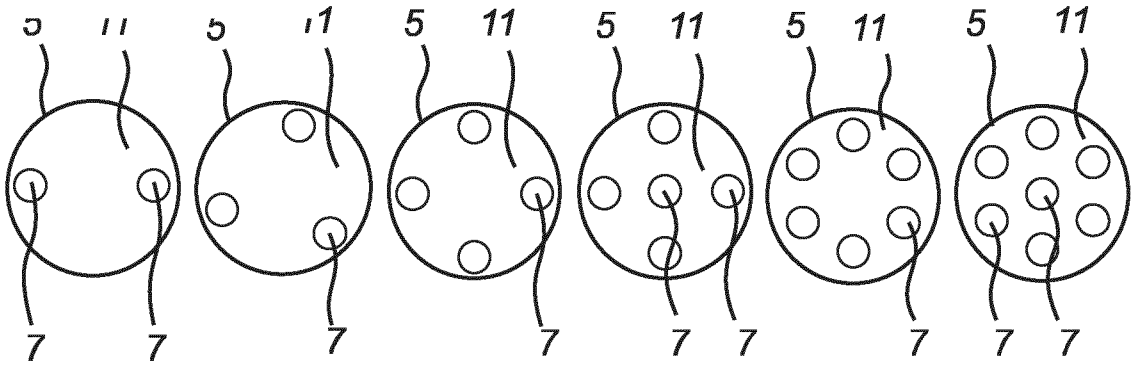


Fig. 3

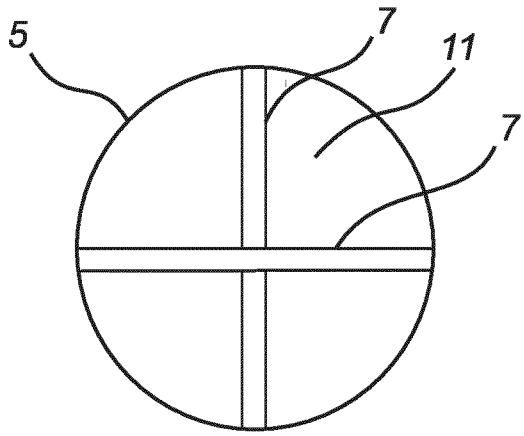


Fig. 4a

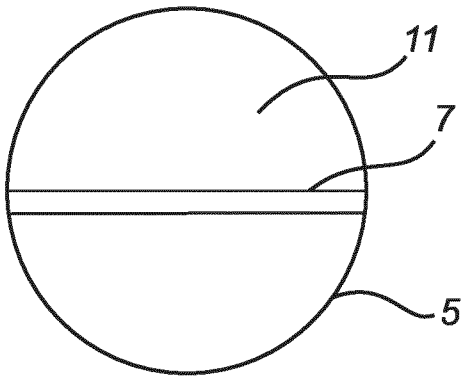


Fig. 4b

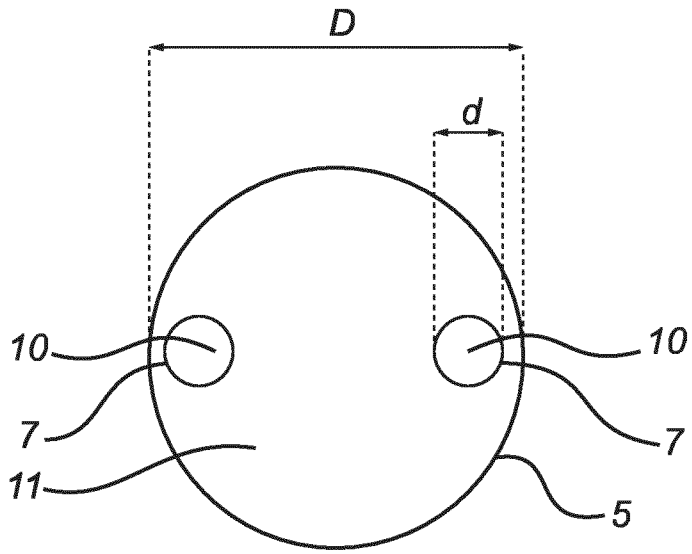


Fig. 5

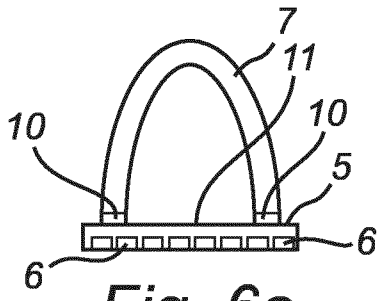


Fig. 6a

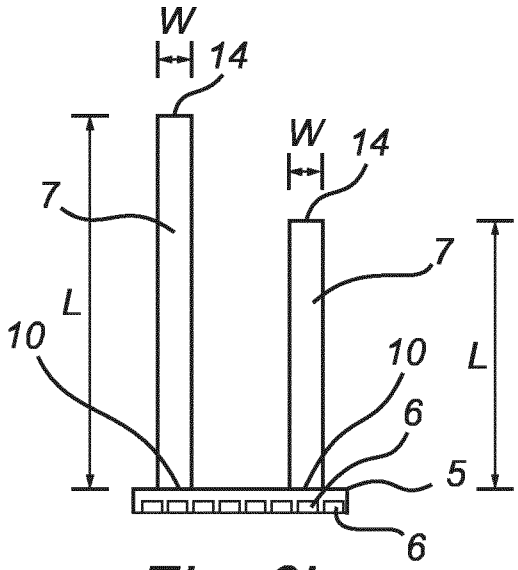


Fig. 6b

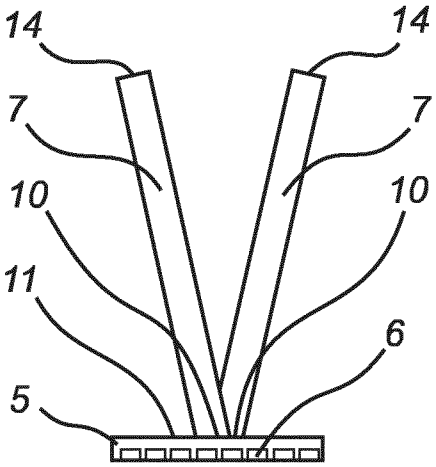


Fig. 6c

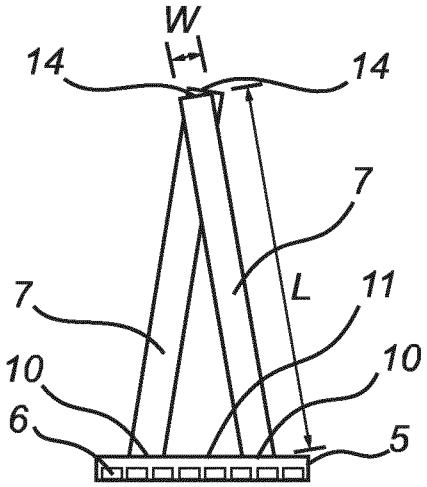


Fig. 6d

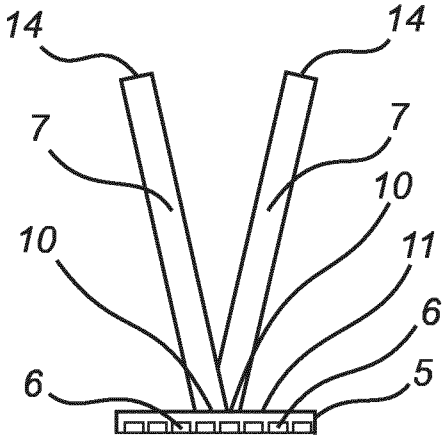


Fig. 6e

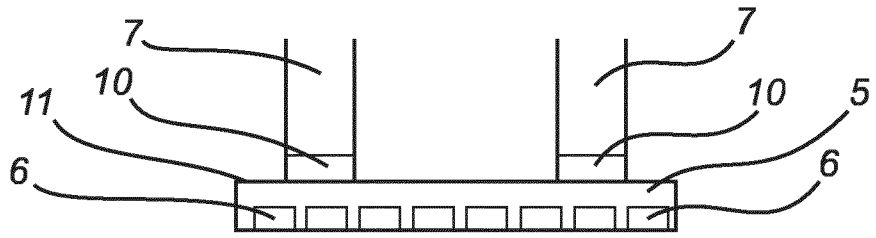


Fig. 7

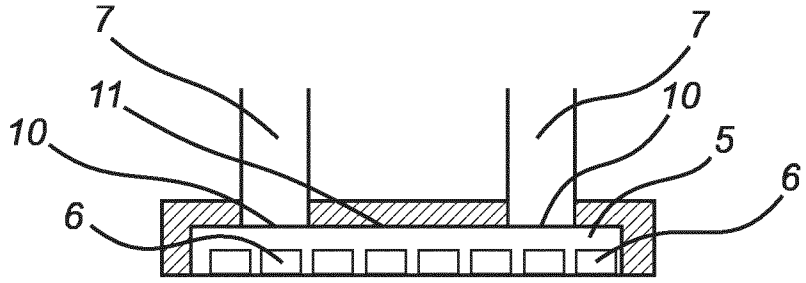


Fig. 8

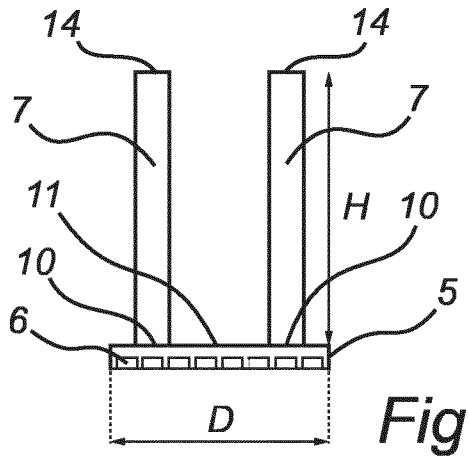


Fig. 9

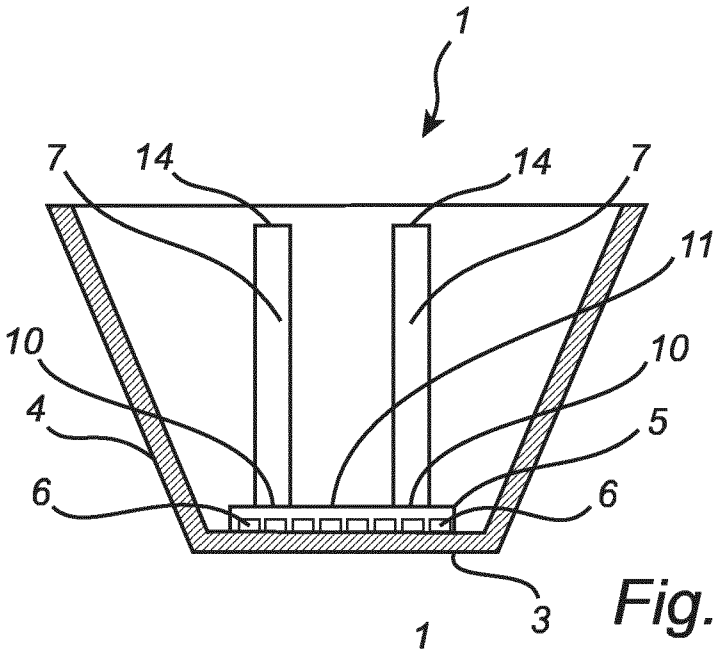


Fig. 10

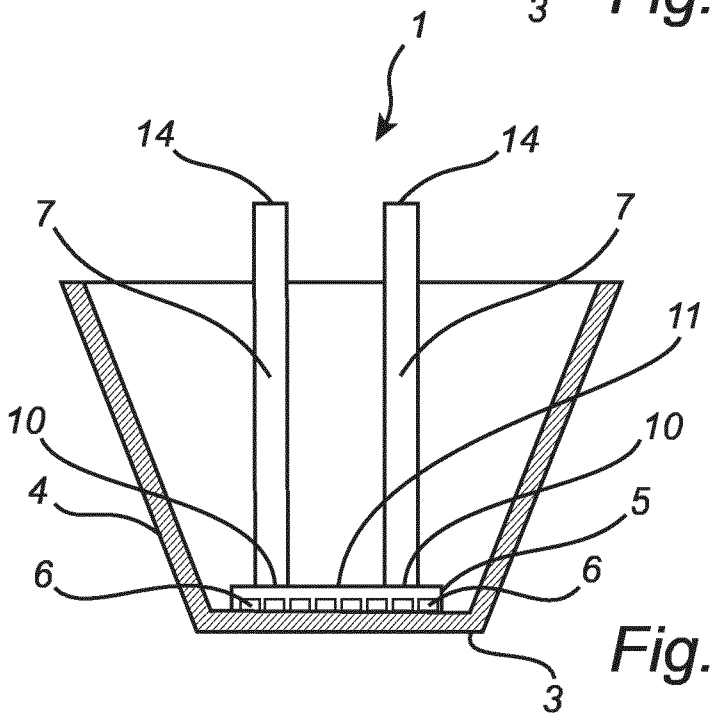


Fig. 11

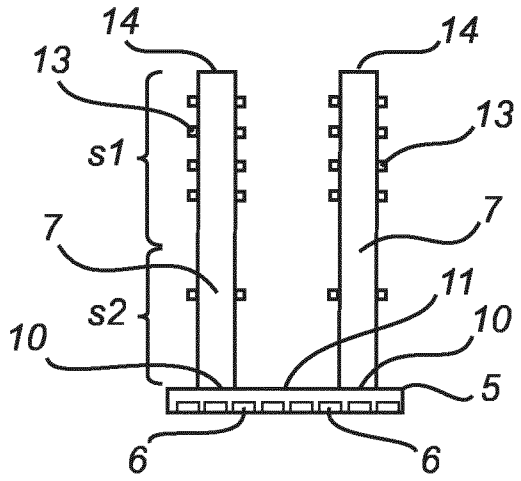


Fig. 12a

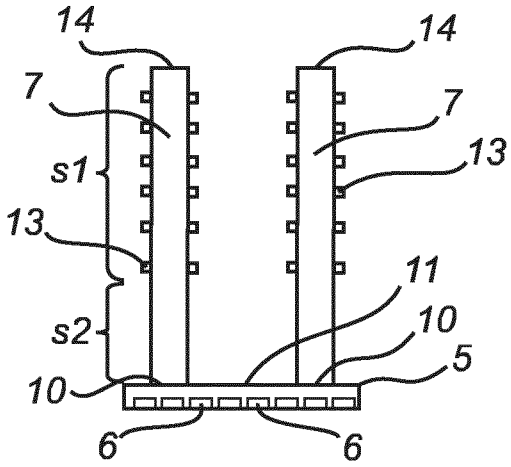


Fig. 12b

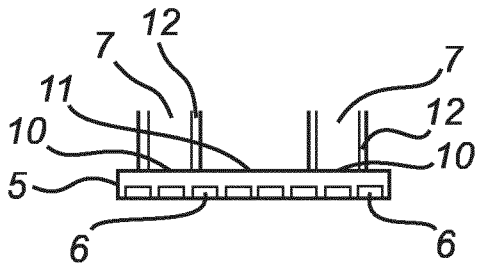


Fig. 13

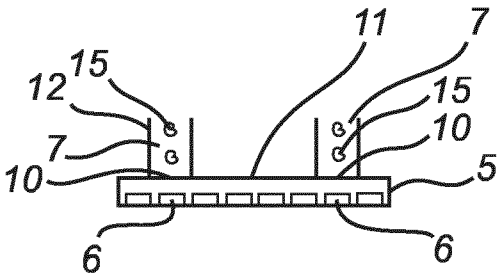


Fig. 14

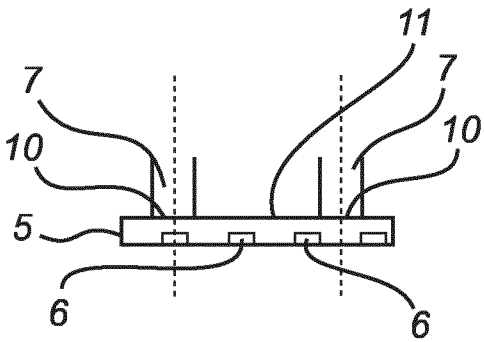


Fig. 15

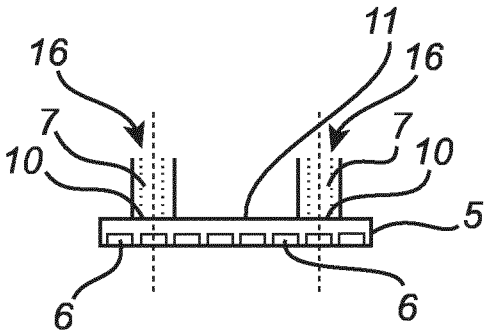


Fig. 16

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/077528

A. CLASSIFICATION OF SUBJECT MATTER
INV. F21K9/61 F21K9/62 G02B6/00
ADD. F21Y115/10 F21K9/233

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)
F21K F21Y G02B

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	US 2014/355292 A1 (KRAUSE GABRIEL [US]) 4 December 2014 (2014-12-04) paragraphs [0022], [0023], [0028], [0029], [0032], [0033] figures 1, 2A	1-13
A	US 2012/230041 A1 (MIZUTA KOHEI [JP] ET AL) 13 September 2012 (2012-09-13) paragraphs [0092], [0093] figure 21	1-13
A	WO 2013/145054 A1 (PANASONIC CORP [JP]) 3 October 2013 (2013-10-03) figures 1-5, 9, 10	1-13
A	US 2016/041324 A1 (NAVA DANTE P [US] ET AL) 11 February 2016 (2016-02-11) paragraphs [0050], [0051] figures 3, 6	1

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

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 November 2019	14/11/2019

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	Allen, Katie

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/077528

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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