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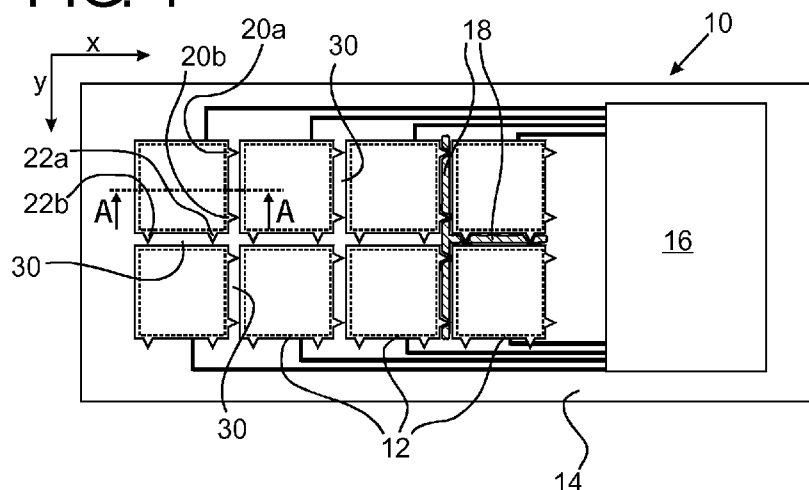
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(54) Title: **ALIGNED ARRANGEMENT OF LEDS**

FIG. 1



(57) **Abstract:** A lighting arrangement (10) includes at least a first and a second LED lighting element (12) arranged next to each other on a carrier surface (14). The spacer element (20a, 20b, 22a, 22b) has, at least in a portion thereof which is in contact with the second LED lighting element (12), a width which is less than 20% of a width of the first LED lighting element (12). The first LED lighting element (12) comprises a spacer element (20a, 20b, 22a, 22b) projecting into a direction in parallel to the carrier surface (14). The second LED lighting element (12) is arranged in contact with the spacer element (20a, 20b, 22a, 22b) such that it is arranged aligned relative to the first LED lighting element, and such that the first and second LED lighting elements (12) are arranged at a distance forming a gap between the first and second LED lighting elements (12).

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ALIGNED ARRANGEMENT OF LEDs

FIELD OF THE INVENTION

The invention relates to a lighting arrangement and a method of manufacturing a lighting arrangement. Most specifically, the invention relates to lighting arrangements and manufacturing methods for multiple LED lighting elements arranged next to each other on a carrier surface.

BACKGROUND OF THE INVENTION

Some lighting applications require multiple LEDs in a defined arrangement relative to each other. In particular, it may be desirable to arrange LEDs adjacent to each other in a line or matrix arrangement with a defined distance.

In automotive front lighting a plurality of LEDs may be arranged adjacent to each other to obtain a light source with a desired shape and a high luminous flux. Also, ADB (adaptive driving beam) function may be fulfilled by a matrix arrangement of LEDs, allowing to selectively turn portions of the emitted illumination beam on or off.

EP 2 677 232 A1 describes a light emitting module and a lighting device for a vehicle. The module is provided with semiconductor light-emitting elements mounted on a substrate and arranged in a matrix. A fluorescent substance may be provided as a plate-like member. Light shielding portions are provided to surround the perimeter of respective light-emitting surfaces of the semiconductor light-emitting elements to prevent light leakage.

WO 2009/143802 A1 discloses semiconductor components arranged alongside one another.

Each component emits an electromagnetic primary radiation during operation and comprises a wavelength conversion element with a radiation entrance area, a radiation exit area and side areas connecting the radiation entrance area and radiation exit area. A non-transparent material is arranged on the side areas.

Light emitting diodes with a reflective electrode and a side electrode are disclosed in WO 2006/138465 A2. The light emitting diodes include a first doped semiconductor layer, an active region, and a second doped semiconductor layer. A reflective electrode is connected to the edge

surfaces of the first doped semiconductor layer. A second reflective electrode includes an optically transparent layer and is connected to the second doped semiconductor layer.

EP 1 930 947 A1 describes a backlight assembly including a plurality of blocks each including a plurality of light emitting diodes. Sides of adjacent blocks are fitted to each other.

JP 2009176899 describes a light source. A body with a light emitting surface has an almost quadrangular-plate shape. Protruding parts and recessed parts in side faces are provided with input and output terminals to electrically connect the light-emitting body elements. The recessed part and protruding parts are fittable to each other.

SUMMARY OF THE INVENTION

It may be considered an object to provide a lighting arrangement, a vehicle headlight, and a manufacturing method allowing to easily achieve a desired relative arrangement of multiple LEDs.

This is addressed by the lighting arrangement according to claim 1, the vehicle headlight according to claim 14 and the method according to claim 15. Dependent claims refer to preferred embodiments of the invention.

According to the invention, at least a first and a second LED lighting element are arranged next to each other on a carrier surface. As the skilled person will understand, arrangement of only two LED lighting elements is used here to demonstrate the general concept of the invention, while in practice it is preferred to arrange more than two LED lighting elements, such as e.g. three, four or more on the carrier surface. As will be further explained below, different arrangements of two or more LED lighting elements may be formed, e.g. as a line in an x or y direction or as a matrix in both x and y directions.

The term "LED lighting element" here relates to any solid-state lighting element or element comprised of more than one such solid-state lighting elements. While this comprises LED lighting elements such as laser diodes and OLEDs, the presently preferred type of LED lighting element are light-emitting diodes comprising one or more doped semiconductor elements. An especially preferred type of LED lighting element including a luminescent color converter will be discussed in connection with preferred embodiments of the invention.

The carrier surface, on which the LED lighting elements are arranged, may be e.g. a circuit board for an electrical circuit. While the surface may be a plane surface, this is not a requirement.

According to the invention, at least the first LED lighting element comprises at least one spacer element. As will be further discussed below, both LED lighting elements may preferably have the same shape. Further, it is preferred to provide more than one spacer element on each LED lighting element. At least a portion of the spacer element projects into a side direction, i.e. at least substantially in parallel to the carrier surface. Thus, for the first and second LED lighting elements arranged next to each other on the carrier surface, the spacer element of the first LED lighting element extends towards the second LED lighting element.

The second LED lighting element is arranged in contact with the spacer element, such that it is aligned relative to the first LED lighting element, i.e. in a defined relative position thereto, such that the first and second LED lighting elements are arranged at a distance from each other, and that a gap is formed between the first and second LED lighting elements.

The spacer element is arranged to extend over the gap formed. It may be attached to the first LED lighting element. Thus, the spacer element mechanically connects the first and second LED lighting element over the gap, thus ensuring a defined arrangement and gap width. The spacer element may be made of any suitable material with at least some stability to keep the LED lighting elements at a distance at least during manufacturing of the lighting arrangement. Possible materials of the spacer element may include plastic, silicone, glass, or ceramic materials. The spacer element may be of opaque material to avoid optical cross talk. In some embodiments, the spacer element may be a separate body attached to the first LED lighting element, and may consist of a material different from the materials of the LED lighting element. In other embodiments, the spacer may be integrally formed with at least a part of the first LED lighting element. In particular, an optically active part of the first LED lighting element, i.e. a part which emits light, may comprise one or more spacer elements formed integrally therewith.

Providing an LED lighting element with a spacer element greatly facilitates the arrangement of the LED lighting elements in close proximity. While an exact relative arrangement and alignment of the LED lighting elements may also be achieved by very exact individual placing of the components, provision of at least one spacer element significantly facilitates to obtain high accuracy.

The distance, i.e. the width of the gap between the LED lighting elements obtained by the spacer element may be e.g. 1 mm or less, preferably less than 500 μm , particularly preferred 200 μm or less. A larger distance allows a better optical separation of adjacent LED lighting elements. The distance leads to a gap being formed between the LED lighting elements. A further improved separation may be achieved by arranging a separator material in between the LED lighting elements to reduce optical cross talk. The separator material may be opaque, e.g. optically absorbing or preferably have reflecting properties. The separator material may e.g. comprise a polymer, for example silicone, and further particles with desired optical properties.

In preferred embodiments, the first and second LED lighting elements may have at least one straight edge, particularly preferred is a rectangular shape. The LED lighting elements may e.g. have a size (measured in parallel to the carrier surface) of 200 μm to 3 mm, preferably 500 - 1500 μm , e.g. as edge length. The aligned arrangement of the first and second LED lighting elements may preferably refer to an arrangement in parallel, in particular with adjacent edges arranged at a small distance (gap width). Especially preferred are rectangular or square LED lighting elements arranged next to each other with parallel straight edges.

It is generally preferred to provide a relatively small spacer element. Contact between the spacer element and the second LED lighting element may lead to a certain amount of optical cross-talk, i.e. if the first LED lighting element is switched on and the second LED lighting element is switched off, there may still be a certain amount of light emitted from the area of the second LED lighting element due to optical coupling. In order to reduce optical cross-talk, the width of the portion of the spacer element which is in contact with the second LED lighting element is less than 20% of the width of the first LED lighting element. Further preferred is a width of the contacting portion of the spacer element of less than 10% of the width of the first LED lighting element, particularly preferred less than 5%. The width of the spacer element and of the first LED lighting element is preferably measured in parallel directions, e.g. in parallel to the edge of the first LED lighting element which is closest to the second LED lighting element.

Also in order to reduce optical cross-talk, the spacer element may have a tapered shape, i.e. such that its width decreases from e.g. a wider portion closer to an edge of the first LED lighting element to a narrow portion in contact with the second LED lighting element. Several different shapes are possible, such as e.g. (hemi-) spherical shape, pyramid shape, etc. For flat LED lighting elements with preferably parallel upper and lower surfaces,

the shape of the spacer element is preferably also flat, e.g. with parallel upper and lower surfaces, and with e.g. a triangular, partly circular or trapezoid contour.

In preferred embodiments, the first and second LED elements may be electrically connected to an electrical circuit such that they can be independently operated. In particular, it is preferred that both the first and the second LED lighting element, as well as preferably further LED lighting elements, may be turned off or on independently of each of the other LED lighting elements. This is particularly preferred for matrix lighting applications, in particular for a vehicle headlamp using matrix lighting for ADB function.

In preferred embodiments, more than one spacer element is provided at the first LED lighting element (and preferably at further LED lighting elements). For example, two spacer elements may be provided projecting in at least substantially parallel direction, arranged at a distance from each other, e.g. projecting from the same edge. The second LED lighting element may be arranged in contact with both spacer elements, such that a parallel alignment may be easily achieved.

In particular for two-dimensional arrangement of LED lighting elements, such as for matrix arrangements, the first LED lighting element may be provided with spacer elements extending into different directions. In one embodiment, the LED lighting element may comprise at least a first and a second straight edge which are arranged at an angle, e.g. substantially at right angles to each other. A first spacer element may project from the first straight edge and a second spacer element may project from the second straight edge. Particularly preferably, at least two spacer elements extend from each of the two straight edges, thus facilitating a parallel aligned matrix configuration.

In one preferred embodiment, the lighting arrangement includes at least three LED lighting elements, i.e. a third LED lighting element besides the first and second LED lighting elements. The first LED lighting element comprises at least a first spacer element projecting into a first direction and a second spacer element projecting into a second direction, at least substantially at right angles to the first direction. The second LED lighting element is arranged spaced from the first element in the first direction and the third LED lighting element is arranged spaced from the first LED lighting element in the second direction. Both the second and third LED lighting elements are in contact with the respective spacer elements, such that an aligned position in both directions may be easily obtained.

According to a particularly preferred embodiment, the first LED lighting element, and preferably also the second LED lighting element as well as further LED lighting elements, may comprise a light emitting LED element and a luminescent color converter

plate. The light emitting LED element may be e.g. a semiconductor die disposed to emit light of a predetermined wavelength range. The color converter plate converts the light to a different wavelength range. Preferably, the color converter plate may comprise a phosphor. Particularly preferred are converter plates made out of a ceramic material. In LED lighting elements with a color converter plate, the spacer elements may advantageously be formed integrally with the color converter plate.

A color converter plate may be arranged on top of a light emitting LED element. It is preferred to provide a color converter plate with a larger extension than the light emitting LED element at least in one direction parallel to the carrier surface. The converter plate may be arranged to form an overlap at least at one side of the LED lighting element.

In the vehicle headlight according to the invention, a lighting arrangement as described above is used in a headlight for a motor vehicle. In particular, a plurality of LED lighting elements may be arranged in matrix configuration for ADB functions.

In the manufacturing method according to the invention, the LED lighting elements are arranged on a carrier surface and aligned relative to each other by the at least one spacer element. In particular, the LED lighting elements may be soldered to the portions of the carrier surface, in particular to contacts on a circuit board. Alignment of the LED lighting elements may be achieved e.g. by reflow soldering, which in connection with one or more spacer elements may automatically provide alignment of the LED lighting elements.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a partly schematical top view of a lighting arrangement which may be used as a vehicle headlight;

Fig. 2 shows a perspective view of a portion of the lighting arrangement of Fig. 1;

Fig. 3 shows a sectional view along A..A of an LED lighting element of the lighting arrangement of Fig. 1, Fig. 2;

Fig. 4a-4c show top and side views of portions of different embodiments of spacers arranged at LED lighting elements.

DETAILED DESCRIPTION OF EMBODIMENTS

Fig. 1 shows in a top view, partly schematically, a lighting arrangement 10 with, in the example shown, eight LEDs 12 arranged on a circuit board 14.

As visible from Fig. 1, Fig. 2, each LED 12 is of flat, plate-like shape with, in top view, a generally square contour.

The LEDs 12 are soldered to contact pads (not shown) on the circuit board 14. As schematically indicated in Fig. 1, the contact pads are connected by conductor tracks to a control circuit 16. The control circuit 16 supplies electrical operating power selectively to each of the eight LEDs 12 so that they are operated to emit light selectively and independently of one another.

As shown in Fig. 1, the LEDs 12 are arranged in a matrix configuration, which in the example shown comprises two rows and four columns. In a preferred use, the lighting arrangement 10 is used as a vehicle headlight for matrix lighting, which enables ADB (adapted driving beam) function by separately supplying operating power to individual LEDs 12, thereby selectively turning portions of the resulting emitted beam on or off.

In the matrix arrangement of Fig. 1, the LEDs 12 are arranged next to each other and aligned relative to each other. Formed between the LEDs 12 are narrow gaps 30.

In the example shown, the LEDs 12 may e.g. have a size of $700\text{ }\mu\text{m} \times 700\text{ }\mu\text{m}$ or $1\text{ mm} \times 1\text{ mm}$. The edges of adjacent LEDs 12 are arranged in parallel at a short distance of e.g. $150\text{--}200\text{ }\mu\text{m}$, i.e. the width of the gaps 30 may be e.g. $150\text{--}200\text{ }\mu\text{m}$. In alternative embodiments, the LEDs 12 may have different sizes of e.g. $500\text{ }\mu\text{m} \times 500\text{ }\mu\text{m}$, or of $400\text{ }\mu\text{m} \times 600\text{ }\mu\text{m}$.

Relative arrangement of the LEDs 12 is achieved by spacers 20a, 20b, 22a, 22b extending across the gaps 30. Each LED 12 has a first set of spacers 20a, 20b extending in an x-direction and a second set of spacers 22a, 22b extending in an y-direction perpendicular thereto. The spacers 20a, 20b; 22a, 22b each extend from a straight edge of the square LED 12. The two spacers of each set are arranged distant from each other, spaced e.g. by 50-80% of an edge length.

Adjacent LEDs 12 are arranged such that their straight, adjacent edges contact the spacers 20a, 20b; 22a, 22b. Thus, the width of the gaps 30 and the parallel aligned orientation of the LEDs is ensured both in x-direction and in y-direction, leading to a well-defined matrix arrangement.

The gaps 30 formed between the LEDs 12 are filled with a separator filling 18 of a reflective material. In order to show the structure more clearly, the filling 18 is only

shown for some of the LEDs in Fig. 1 and is not shown in Fig. 2 and 3. However, as the skilled person will understand, the filling 18 is preferably provided in each gap 30 between the LEDs 12 to reduce optical cross-talk.

In the example of Fig. 1, Fig. 2, the spacers 20a, 20b, 22a, 22b each have a flat shape with a triangular contour as viewed from above. Due to the triangular contour, each spacer 20a, 20b, 22a, 22b has a wide portion adjacent to the edge of its LED 12, whereas the tip, which is contact with an adjacent LED 12, is narrow in comparison. Thus, the contact area between the spacers 20a, 20b, 22a, 22b and the adjacent LEDs 12 is very small.

For example, for an edge length of the LED 12 of 1 mm, the width of the wide portions of the triangular spacers may be e.g. 100 μm . Depending on how small the tip can be formed, the width thereof will only be a few μm . Due to the reduced contact area, an amount of optical cross-talk, i.e. light emitted from a first LED 12 and coupled into a second LED 12, is minimized.

Different shapes for spacers 20 are possible, as shown in Fig. 4a-4e. For production purposes, flat shapes with tapering contour but constant thickness are preferred, such as shown in fig. 4a for triangular contour, 4c for trapezoid contour and 4d for rounded (semicircular) contour. Alternative shapes such as pyramid shapes (fig. 4b) or hemispherical shape (fig. 4e) are also possible.

In the preferred example, the LEDs 12 have a structure as shown in Fig. 3. A square, flat LED die plate 22 is covered by a ceramic color converter plate 24. The color converter plate 24 is larger than the LED die 22, thus forming an overlap of e.g. 30 μm along each edge. In alternative embodiments, the color converter plate 24 may be of the same size as the LED die 22, so that no overlap is formed. Depending on the choice of the relative dimensions of the LED die 22 and the color converter plate 24, an overlap of e.g. 0 μm to 50 μm may be formed.

The LED die 22 is mechanically and electrically connected to contact portions (not shown) of the circuit board 14 by solder pads 26. In operation, the LED die 12 emits light, e.g. of primarily blue color. The emitted light stimulates luminescence in the phosphor components of the color converter plate 24, such that white light is emitted.

The spacers 20a, 20b, 22a, 22b are integrally formed with the ceramic color converter plate 24. The lighting arrangement 10 may be manufactured by providing the circuit board 14 with contact portions for the LEDs 12. Solder material is applied to the contact portions, and the LEDs 12 are placed thereon. Through reflow soldering, the LEDs 12 are soldered to the contact portions, thereby automatically aligning through the spacers

20a, 20b, 22a, 22b. Following the solder process, the separator material 18 may be applied in the gaps between the LEDs 12. In the presently preferred embodiment, silicone with dispersed TiO₂ particles may be used to obtain a reflective barrier.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the claims.

The references to LED sizes with edge lengths of 400 μm to 700 μm are directed to examples only of LEDs available today. The concept of the invention applies to any size of LEDs. Also, the spacing of the LEDs may be chosen according to the desired application and may significantly differ from the values give in the examples.

While the above examples show spacers 20 formed integrally with a part of the LED, they may alternatively be provided as separate bodies e.g. of black or white plastic, silicone, glass, or ceramic, glued or otherwise fixed to the color converter plate or other parts of the LED.

While eight LEDs in a 2 x 4 matrix configuration are shown in the embodiment, the skilled person will understand that the concept of spacers applies to any number or arrangement of two or more LEDs, e.g. in a line, matrix or other configuration. While in the example shown, the spacers are provided integrally with a color converter plate, the concept of spacers may equally be applied with other types of LEDs, which may not include a color converter plate. Also, the shape and dimension of the LEDs 12 as well as the shape and dimensions of the spacers 20a, 20b, 22a, 22b may differ.

In the claims, any reference signs shall not be construed as limiting the claims. The word "comprising" does not exclude the presence of elements or steps other than those listed in the claims. The indefinite article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. Lighting arrangement, including

- at least a first and a second LED lighting element (12) arranged next to each other on a carrier surface (14), said first and second LED lighting elements (12) being arranged at a distance forming a gap (30) between said first and second LED lighting

5 elements (12),

- wherein at least said first LED lighting element (12) comprises at least one spacer element (20a, 20b, 22a, 22b) projecting into a direction at least substantially in parallel to said carrier surface (14),

- said second LED lighting element (12) being arranged in contact with
10 said spacer element (20a, 20b, 22a, 22b) such that said second LED lighting element (12) is arranged aligned relative to said first LED lighting element (12), said spacer element (20a, 20b, 22a, 22b) having, at least in a portion thereof being in contact with said second LED lighting element (12), a width which is less than 20% of a width of said first LED lighting element (12).

15 2. Lighting arrangement according to claim 1, wherein

- said spacer element (20a, 20b, 22a, 22b) is formed integrally with an optically active part (24) of said first LED lighting element (12), said optically active part (24) emitting light during operation of said first LED lighting element (12).

20 3. Lighting arrangement according to one of the above claims, wherein

- said spacer element (20a, 20b, 22a, 22b) has a tapered shape such that a width thereof decreases up to a portion thereof being in contact with said second LED lighting element (12).

25 4. Lighting arrangement according to one of the above claims, wherein

- said first and second LED lighting elements (12) are electrically connected to an electrical circuit (16) such that they can be independently operated.

5. Lighting arrangement according to one of the above claims, wherein

- said first LED lighting element (12) comprises at least two spacer elements (20a, 20b; 22a, 22b) projecting into at least substantially parallel directions, said two spacer elements (20a, 20b; 22a, 22b) being arranged at a distance from each other,

5 - and said second LED lighting element (12) is arranged in contact with said two spacer elements (20a, 20b; 22a, 22b).

6. Lighting arrangement according to one of the above claims, wherein

10 - at least said first LED lighting element (12) comprises at least one straight edge,

- said spacer element (20a, 20b, 22a, 22b) projecting at least substantially perpendicularly from said edge.

7. Lighting arrangement according to claim 6, wherein

15 - said first LED lighting element (12) comprises at least a first and a second straight edge, said first and said second straight edges being arranged at least substantially at right angles to each other,

20 - wherein at least a first spacer element (20a, 20b) projects from said first straight edge, and at least one second spacer element (22a, 22b) projects from said second straight edge.

8. Lighting arrangement according to one of the above claims, wherein

25 - said first LED lighting element (12) comprises at least a first spacer element (20a, 20b) projecting into a first direction at least substantially in parallel to said carrier surface (14), and a second spacer element (22a, 22b) projecting into a second direction at least substantially in parallel to said carrier surface (14), said first and said second direction being arranged at least substantially at right angles to each other,

30 - wherein said second LED lighting element (12) is arranged spaced from said first LED lighting element (12) in said first direction and in contact with said first spacer element (20a, 20b),

- and wherein a third LED lighting element (12) is arranged spaced from said first LED lighting element (12) in said second direction and in contact with said second spacer element (22a, 22b).

9. Lighting arrangement according to one of the above claims, wherein
- a plurality of LED lighting elements (12) of identical shape
comprising at least said first and said second LED lighting elements (12) are arranged next to
5 each other on said carrier surface (14).

10. Lighting arrangement according to one of the above claims, wherein
- said first LED lighting element (12) comprises a light emitting LED
element (22) and a luminescent color converter plate (24).

10 11. Lighting arrangement according to claim 10, wherein
- said spacer element (20a, 20b, 22a, 22b) is formed integrally with
said color converter plate (24).

15 12. Lighting arrangement according to one of claims 10, 11, wherein
- said color converter plate (24) is arranged on top of said light emitting
LED element (22),
- wherein said color converter plate (24) has a larger extension in at
least one direction at least substantially parallel to said carrier surface (14),
20 - said color converter plate (24) being arranged to form an overlap over
said LED lighting element (22).

13. Lighting arrangement according to one of the above claims, wherein
- a reflective or opaque material (18) is provided between the first and
25 second LED lighting elements (12).

14. Vehicle headlight, including a lighting arrangement (10) according to one of
the above claims.

15. Method of manufacturing a lighting arrangement, comprising the steps of

- arranging a first LED lighting element (12) on a carrier surface (14),

said first LED lighting element (12) comprising at least one spacer element (20a, 20b, 22a,

5 22b) projecting into a direction at least substantially in parallel to said carrier surface (14),

said spacer element (20a, 20b, 22a, 22b) having, at least in a portion thereof being in contact

with said second LED lighting element (12), a width which is less than 20% of a width of

said first LED lighting element (12),

- arranging at least a second LED lighting element (12) on said carrier

10 surface (14) next to said first LED lighting element (12) to be in contact with said spacer

element (20a, 20b, 22a, 22b), such that said second LED lighting element (12) is arranged

aligned relative to said first LED lighting element (12) , and such that said first and second

LED lighting elements (12) are arranged at a distance forming a gap between said first and

second LED lighting elements (12)..

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FIG. 1

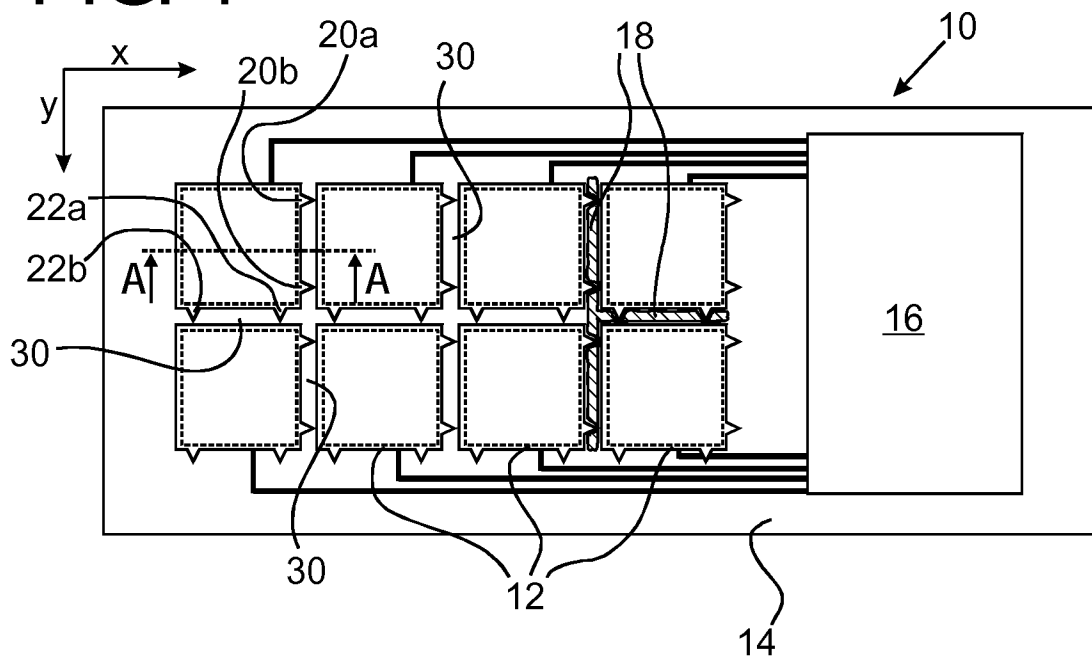


FIG. 2

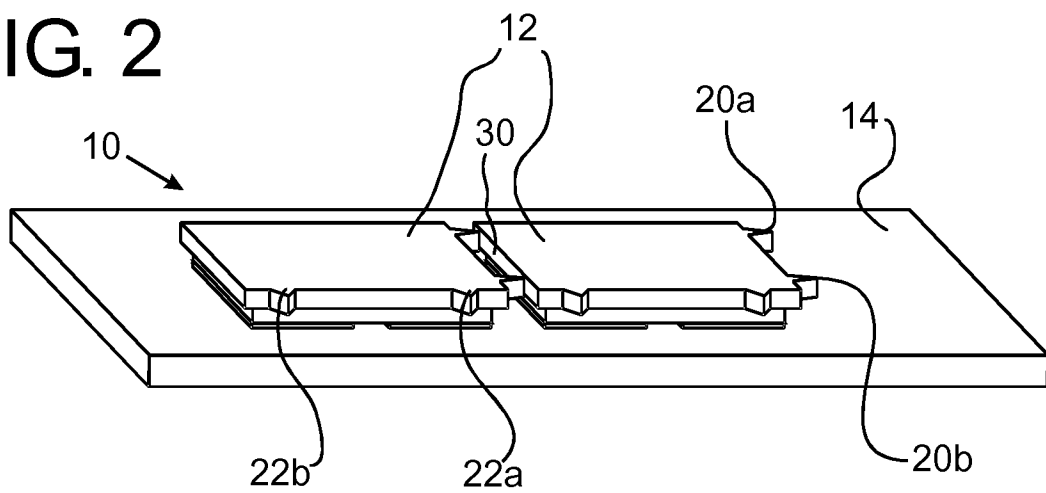
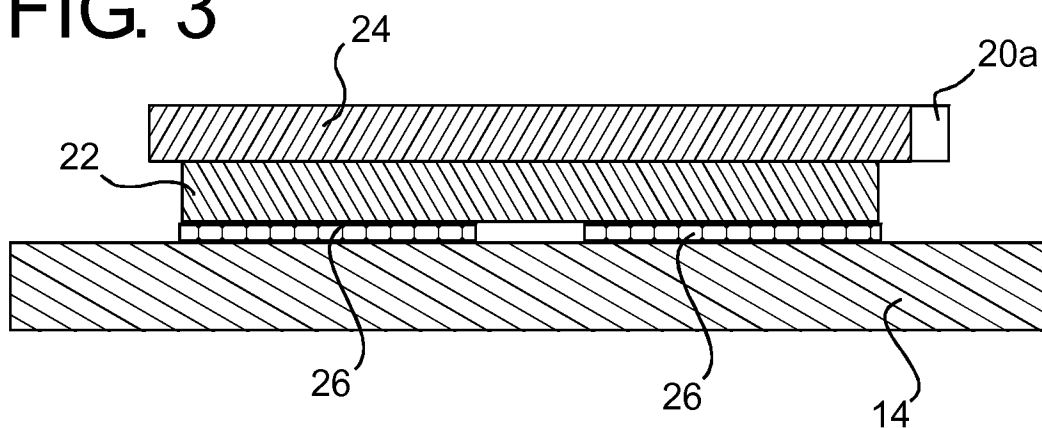


FIG. 3



2/2

FIG. 4a

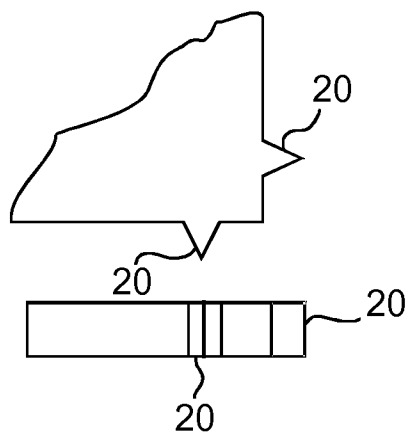


FIG. 4b

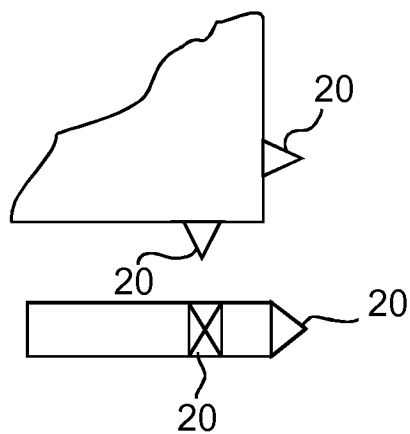


FIG. 4c

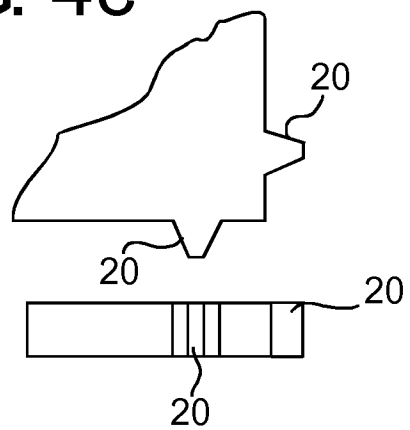


FIG. 4d

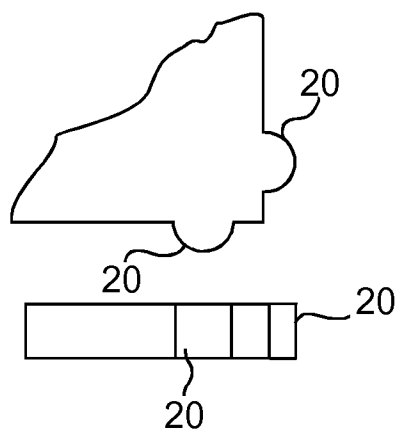
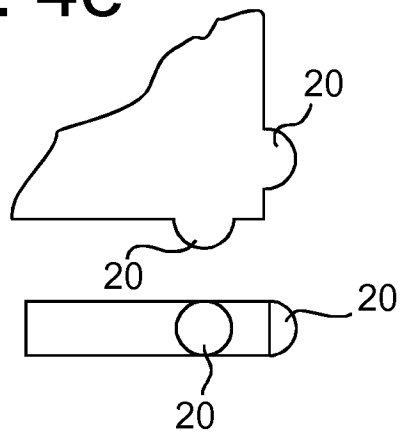


FIG. 4e



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/082381

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01L25/075

ADD. H01L33/50 B60Q1/00

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 2009/237936 A1 (KU C-L) 24 September 2009 (2009-09-24) paragraphs [0035] - [0048] -----	1,3-10, 12-15
A	US 2012/074446 A1 (CHOI H) 29 March 2012 (2012-03-29) paragraphs [0049] - [0055] -----	1,14,15
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	- / - -	



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

7 February 2018

Date of mailing of the international search report

14/02/2018

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Authorized officer

van der Linden, J

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/082381

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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