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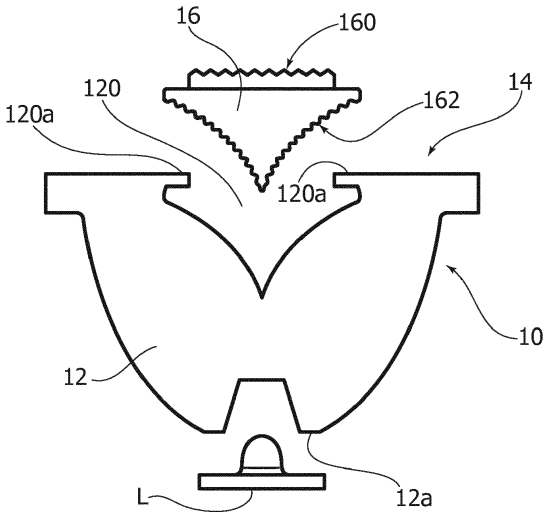
(54) A METHOD OF PRODUCING OPTICAL ELEMENTS FOR LIGHTING DEVICES AND CORRESPONDING OPTICAL ELEMENT

(57) An optical element (10), such as a lens and/or a reflector for lighting devices (L, 10), e.g. LED devices, includes:
- a body (12) of the optical element (10), the body (12) providing a light propagation path towards a light emitting surface (14), and
- an insert (16) coupled with said body (12), the insert (16) being interposed in the light propagation path, so that the optical characteristics of the light emitted from said light emitting surface (14) are a function of at least one among shape, position, material and texture of said insert (16).

FIG. 2



EP 3 263 981 A1

Description

Technical Field

[0001] The description relates to lighting devices.

[0002] One or more embodiments may refer to lighting devices employing electrically-powered light radiation sources, such as solid-state sources, e.g. LED sources.

Technological Background

[0003] In the implementation of lighting devices, such as devices employing solid-state light radiation sources such as LED sources, an optical element such as a lens or a reflector may be coupled with the light radiation source.

[0004] In this way, the optical characteristics (e.g. the arrangement in space and/or the distribution of the lighting flux, the radiation colour, etc.) are a function of the characteristics of the optical element.

[0005] Moreover, such optical elements may have accessories, i.e. separate parts, associated therewith, which determine the final operating characteristics of the optical element, and therefore of the corresponding lighting device.

[0006] This solution may lack efficiency, e.g. because in the final implementation it requires the separate management of the optical element and of the related accessories, which may have different characteristics.

[0007] Documents such as EP 2 873 910 A1, US 2014/0168975 A1, US 7 458 703 B2 or WO 2011/003713 A1 exemplify the prior art.

Object and Summary

[0008] One or more embodiments aim at overcoming the above drawbacks.

[0009] According to one or more embodiments, said drawbacks may be overcome thanks to a method having the features set forth in the claims that follow.

[0010] One or more embodiments may also concern a corresponding device.

[0011] The claims are an integral part of the technical teaching provided herein with reference to the embodiments.

[0012] One or more embodiments lead i.a. to the advantageous achievement of "integrated" optical elements, e.g. giving the possibility of obtaining lighting beams having different optical characteristics (e.g. as regards the radiation pattern, the beam opening angle, to mention a few examples) by using one basic structure of the optical element.

Brief Description of the Figures

[0013] One or more embodiments will now be described, by way of non-limiting example only, with reference to the annexed Figures, wherein:

- Figure 1 exemplifies possible embodiments,
- Figure 2 exemplifies further embodiments,
- Figure 3 shows, in a flow diagram, possible implementations of devices as exemplified in Figures 1 and 2, and
- Figures 4 to 8 exemplify further embodiments.

Detailed Description

[0014] In the following description, various specific details are given to provide a thorough understanding of various exemplary embodiments of the present specification. The embodiments may be practiced without one or several specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials or operations are not shown or described in detail to avoid obscuring various aspects of the embodiments.

[0015] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the possible appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0016] The headings provided herein are for convenience only, and therefore do not interpret the extent of protection or scope of the embodiments.

[0017] In Figures 1 and 2, reference 10 generally denotes an optical element, adapted to be coupled with an electrically-powered light radiation source L.

[0018] In one or more embodiments, light radiation source L (which may be an element distinct and separate from the embodiments) may comprise a solid-state light radiation source, e.g. a LED source.

[0019] In one or more embodiments, optical element 10 may comprise a lens and/or a reflector.

[0020] According to criteria known in themselves (and which therefore do not require a detailed description herein), in one or more embodiments optical element 10 may be adapted to perform both functions (of a lens and of a reflector), e.g. as it comprises a lens body made of a light permeable material (e.g. a transparent material) having an at least approximately parabolic external surface, so as to perform in addition (e.g. by having been treated to be reflective towards the inside) the function of a reflector.

[0021] In one or more embodiments, optical element 10 may comprise two parts:

- a body 12 of a light-permeable material (e.g. a transparent plastic material, such as polycarbonate, silicone, etc.) adapted to define a light radiation propagation path from source L towards a light emitting

surface 14, located in a position generally opposed to the end of body 12, denoted as 12a, where light radiation source L is located;

- an insert 16, adapted to be coupled with body 12 so as to be interposed in the light propagation path through optical element 10.

[0022] In this way, the optical characteristics of the light radiation emitted from optical element 10 (e.g. the emission pattern: beam opening angle, flux intensity, colour of the emitted radiation, etc.) may be a function of characteristics such as shape, position, material and/or texture of insert 16.

[0023] For example (the present list being merely exemplary and non-limiting), in one or more embodiments insert 16 may be made of a material different from the material of body 12.

[0024] For example, if body 12 is made of a transparent material, insert 16 may comprise an at least partially light diffusive material, or a material having in addition a certain opacity (because e.g. it is made of a white or light-coloured material and/or it contains, dispersed therein, light diffusive particles, e.g. alumina), being therefore optionally adapted to (back)scatter the light radiation impinging on insert 16 towards body 12, so that it can subsequently be emitted through output surface 14.

[0025] In one or more embodiments, insert 16 may have the function of masking source L if device 10 is observed frontally, performing therefore an anti-glare function.

[0026] Moreover, in one or more embodiments, insert 16 may comprise, e.g. at an "outer" side extending at light emitting surface 14, a surface sculpturing 160 adapted to perform both an aesthetic and a specific optical function (e.g. said sculpturing being implemented essentially as a Fresnel lens).

[0027] The term "texture" is used herein in its current meaning in graphics, to denote characteristics of insert 16 such as e.g. the colour or the surface finishing of the insert.

[0028] In one or more embodiments, the optical characteristics of the light radiation emitted through the emitting surface 14 may be at least partially determined by the shape and texture characteristics (e.g. thanks to a reflective treatment such as aluminization) of surface 162 of insert 16, in the position wherein the latter is coupled with body 12 of element 10.

[0029] In one or more embodiments, said coupling may be achieved e.g. via a (co)moulding process, e.g. in an injection moulding process.

[0030] Figure 2 exemplifies possible embodiments wherein insert 16 is coupled with body 12 through mechanical coupling.

[0031] In one or more embodiments, said coupling may be achieved if body 12 comprises a soft, i.e. resilient, optionally elastic material (e.g. silicone), adapted to have optical characteristics as well as mechanical characteristics of resiliency, so that insert 16 may be inserted into a corresponding cavity 120 formed in the body, while deforming body 12 locally.

[0032] Moreover, insert 16 is adapted to be "captured" by cavity 120 and to be retained therein, e.g., through lip formations 120a adapted to close, so to say, behind insert 16 once the latter is inserted in cavity 120, establishing therefore a sort of hooking coupling.

[0033] In one or more embodiments, optical elements such as optical elements 10 exemplified in Figures 1 and 2 may be obtained via a method as exemplified in an ideal flow diagram in Figure 3.

[0034] In the diagram, after an ideal START step, block 100 denotes a step wherein a set of optical bodies 12 are provided, adapted to be ideally considered all identical.

[0035] Concurringly (i.e. before, after or simultaneously to the execution of step 100), a corresponding set of optical inserts 16 may be provided, which are to be coupled with bodies 12.

[0036] In one or more embodiments, said provision of optical inserts 16 may take place in two different ways, i.e. by providing (e.g. in the step exemplified in block 102a) a first subset of inserts 16, which may be defined as "a first type", while in the step exemplified in block 102b, a second subset of optical inserts 16 may be provided.

[0037] It is assumed that the optical inserts of the first set provided in step 102a are different (e.g. as regards shape and/or material) from the inserts of the second subset of step 102b.

[0038] In subsequent operations, denoted as 104a and 104b, it is then possible to respectively couple (according to the previously described methods, e.g. via co-moulding or via a mechanical coupling, as exemplified in Figure 2) inserts 16 of the subset according to step 102a with inserts 16 of the subset according to step 102b.

[0039] The result consists in two subsets of optical elements, ideally represented by blocks 106a and 106b which, although having identical optical bodies 12, may have different optical characteristics, especially as regards the features of the light radiation to be emitted from output surface 14. This is due to the fact that such different emission characteristics derive from inserts 16 provided in steps 102a and 102b, with mutually different features.

[0040] For simplicity, the example shown in Figure 3 refers to only two subsets (102a, 102b) of different inserts 16, adapted to originate two corresponding subsets (106a, 106b) of optical elements 10 having mutually different characteristics.

[0041] The same principle exemplified herein with reference to two different types may of course be extended to a higher number (three or more) of different types of inserts 16 and, correspondingly, of resulting optical elements 10.

[0042] The representation of Figure 3, the final step of which is END, exemplifies the advantage deriving from the possibility of obtaining different optical elements while

using bodies 12 identical to each other.

[0043] Moreover, especially in embodiments as exemplified in Figure 2, wherein the coupling of insert 16 with body 12 is removable (because an insert 16 may be removed from body 12 in order to be optionally replaced with an insert 16 of a different kind), the use of one or more embodiments may also represent an advantage for the final user.

[0044] As a matter of fact, the final user can change the characteristics of optical element 10, e.g. according to application needs or according to aesthetics and tastes which change in time, by simply replacing insert 16 without replacing the optical element 10 as a whole.

[0045] Generally, the embodiments described in the foregoing may be used for any kind of lighting application, including lighting devices both for external applications (such as flood lights, street lights, decorative external lights, gallery lights) or internal applications (such as lighting devices for halls or offices). Usually, such lighting devices comprise an optical element with uniform optical characteristics, which at most may comprise lateral reflectors. Conversely, various embodiments of the present description are based on an optical element 10 comprising at least two parts:

- a body 12 of a light-permeable material configured to define a light radiation propagation path for the light source L towards a light emitting surface; and
- an insert 16, adapted to be coupled with body 12, e.g. by means of co-moulding, so as to be interposed in at least part of the light propagation path through the optical element 10.

[0046] Specifically, in various embodiments, the optical characteristics of the body 12 and the insert 16 are different.

[0047] Generally, the optical element 10 may have any form, and has not necessarily a rotational symmetric form with respect to an optical axis as shown in Figure 2. Similarly, the radiation source L may be arranged central, e.g. in the axis of a rotational symmetric optical element 10, or any other position still permitting that the light emitted by the radiation source L enters the optical element 10.

[0048] For example, Figure 4 shows an embodiment of a lighting device again comprising a light radiation source L and an optical element 10, wherein the light radiation source L is located at a side 12a of the body 12. For example, in the embodiment considered, the light radiation source L, such as one or more LEDs, is mounted on support 20, such as a printed circuit board, which may be coupled to the side 12a of the optical element 10.

[0049] In the embodiment considered, the optical element 10 comprises again a body 12 in a material having a first refraction index and an insert 16 having a second refraction index, which is different from the first refraction index, e.g., the first refraction index may be smaller than the second refraction index. For example, in various embodiments, the refraction indices for the body 12 and the insert 16 may be between 1.41 (e.g. for silicon) and 1.74 (e.g. for plastic materials doped with oxides). Accordingly, the body 12 and/or the insert 16 may be realized, e.g., with silicon, acrylic (polymethyl methacrylate, PMMA), polycarbonate (PC), polypropylene (PP) or a combination thereof. Generally, as mentioned before, the optical element may be implemented by coupling the insert 16 to the body 12, e.g. by means of extrusion/co-extrusion, co-moulding, injection moulding, compression moulding, exjection or a combination thereof.

[0050] Accordingly, in the embodiment considered, the light emitted by radiation source L will pass first through a first refraction surface B' represented by the internal surface of the body 12 enclosing the light source L, thereby entering the body 12. Specifically, a first portion of the light will then exit a refraction surface B represented by the external surface of the body 12 not being in contact with the insert 16, thereby exiting the optical element 10 without passing through the insert 16. Conversely, a second portion of the light will pass a refraction surface B'' represented by the external surface of the body 12 being in contact with the insert 16, thereby entering the insert 16. The second portion of the light will then pass a refraction surface B''' represented by the external surface of the insert 16, thereby exiting the insert 16 and the optical element 10.

[0051] Accordingly, in the embodiment considered, the second portion of the light may be influenced differently by the optical characteristics of the insert 16. For example, in the embodiment considered, the body 12 and the insert 16 (and thus the whole optical element 10) have a rotational symmetric form with respect of an optical axis, wherein the light source L is arranged on the optical axis.

[0052] As mentioned before, the refraction index of the body 12 may be smaller than the refraction index of the insert 16. In this case, the insert 16 represents a lens insert, which may be used to focus the second portion of the light exiting though the fourth refraction surface B'''. Conversely, the second refraction surface B may be used to emit also light laterally.

[0053] Figure 5a shows an embodiment of a rotation symmetric optical element 10 comprising also a lateral reflector R. Specifically, the embodiment shows that the light may also exit only through the surface B''' of the insert 16, e.g., because the surface B described with respect to Figure 4 is covered with reflective material, thereby implementing a total internal reflection wall. Moreover, Figure 5a shows that a part of the light emitted by the light source L may directly enter the insert 16 without passing through the body 12.

[0054] Figure 5b show that the optical element 10 may also comprise a plurality of inserts, i.e. the optical element 10 may comprise three zones 12, 16 and 16s having different optical characteristics. For example, in the embodiment considered, the optical element 10 is again rotation symmetric, but by using materials with different refraction indices for the zones 12 and 16s, the optical

element 10 may generate an asymmetric light distribution.

[0055] Figures 6a and 6b show an embodiment of an optical element 10 having as a whole a rotation symmetric form (similar to what has been described with respect to Figure 4), but the insert 16 is displaced with respect to the optical axis. Accordingly, also in this case, an asymmetric light distribution may be obtained.

[0056] Accordingly, in various embodiment, the optical element 10 may have a rotational symmetric form with respect to an optical axis, wherein the light source L may be arranged on this optical axis. Similarly, also the insert 16 may have a rotational symmetric form with respect to an optical axis, which may or may not corresponds to the optical axis of the whole optical element 10.

[0057] Generally, the sections of the optical elements described in the foregoing may also be used to implement linear optical elements having the same section. For example, Figure 7 shows an embodiment of a linear optical element 10 having the section of Figure 6a.

[0058] Specifically, in the embodiment considered, the optical element is a linear optical element having a symmetric and preferably constant section with respect to a plane. In this case, one or more light sources L may be arranged along this plane.

[0059] Generally, as also highlighted by the embodiment shown in Figures 8a and 8b, the body 12 and the insert 16 may have any form, wherein preferably the surface B'' of the body 12 is complementary to the respective surface of the insert 16. Moreover, the body 12 (and possibly also part of the insert 16) may be covered with a reflective material R.

[0060] As alternative to a covering with a reflective material R, a total internal reflection surface may also be implemented by means of the shape of the optical element 10. Specifically, total internal reflection of light occurs also in case a light ray is directed to a flat surface between two materials (e.g., the refraction surface B between the body 16 and air, the refraction surface B'' between the body 16 and the insert 12, or the refraction surface B''' between the insert and air) with different refraction index (n1, n2), when the light arrives from a material with higher refraction index (n1). In this case, if the angle θ of the light ray with respect to the normal of the surface exceeds a given threshold angle θ_C, the light will be reflected totally at the respective surface, with:

$$\theta_C = \arcsin(n2/n1)$$

[0061] Generally, in addition or as alternative to materials having different refraction indices, the body 12 and the insert (s) 16 may also have a different diffusive behaviour. For example, the diffusive material may be in a range of 1 to 30% of the material implementing the body 12 and/or the insert 16. For example, the previously mentioned materials may be used for this purpose a base material, and additional diffusive particles mixed to the base material, such as coloured particles.

[0062] For example, with respect to the embodiment shown in Figure 5a, the body 12 may have a slight diffusive behaviour. Accordingly, while the light near the optical axil will be focused, the lateral light will be broadened. For example, in this case, the floor of a corridor may be illuminated specifically with a stronger intensity, while the lateral walls are illuminated via the diffused lateral light with less intensity. For example, in this case, also the use of a linear optical element 10 may be particular useful.

[0063] Without prejudice to the basic principles, the details and the embodiments may vary, even appreciably, with respect to what has been described herein by way of non-limiting example only, without departing from the extent of protection.

[0064] Said extent of protection is defined by the annexed claims.

Claims

1. A method of producing optical elements (10) for lighting devices (L, 10), the method including:

   - providing (100) a set of identical optical bodies (12) for said optical elements (10),
   - providing (102a, 102b) a set of optical inserts (16) coupleable with said bodies (12), wherein said set of inserts includes at least one first subset (102a) of inserts and at least one second subset (102b) of inserts, the inserts in said first subset (102a) being different from the inserts in said second subset (102b), and
   - coupling (104a, 104b) said inserts (16) with said bodies (12) by producing at least one first subset (106a) and at least one second subset (106b) of optical elements, the optical elements in said first subset (106a) being different from the optical elements in said second subset (106b).

2. The method of claim 1, wherein said coupling (104a, 104b) includes co-moulding said bodies (12) and said inserts (16).

3. The method of claim 1, wherein:

   - said bodies (12) include a resilient material,
   - said coupling includes inserting said inserts (16) into said resilient material, wherein said inserts (16) are mechanically retained (120a) by said bodies (12).

4. An optical element (10) for lighting devices (L, 10), the element including:

- a body (12) of the optical element (10), the body (12) providing a light propagation path towards a light emitting surface (14) of the optical element (10),
- an insert (16) coupled with said body (12), the insert (16) interposed in said light propagation path, wherein the optical characteristics of light emitted from said light emitting surface (14) are a function of at least one of the shape, position, material and/or texture of said insert (16).

5. The optical element (10) of claim 4, wherein said body (12) and said insert (16) are co-moulded together.

6. The optical element (10) of claim 4, wherein:

- said body (12) includes a resilient material,
- said insert (16) is inserted into said resilient material, wherein the insert (16) is mechanically retained (120a) by said body (12).

7. The optical element (10) of any of claims 4 to 6, wherein said insert (16) includes a material different from the material of said body (12).

8. The optical element (10) of any of claims 4 to 7, wherein said insert (16) and said body (12) have different refraction indices and/or different diffusive behaviours, wherein preferably the refraction index of said body (12) is smaller than the refraction index of said insert (16).

9. The optical element (10) of any of claims 4 to 8, wherein the insert (16) is coupled to the body (12) at a coupling surface (162), wherein the optical characteristics of light emitted from said light emitting surface (14) are a function of at least one of the shape and texture of said coupling surface (162).

10. The optical element (10) of any of claims 4 to 9, wherein:

- said optical element (10) has rotational symmetric form with respect to an optical axis, wherein a light source (L) is preferably arranged on said optical axis; or
- said optical element (10) is a linear optical element having preferably a symmetric section with respect to a plane, wherein one or more light sources (L) are arranged along said plane.

FIG. 1

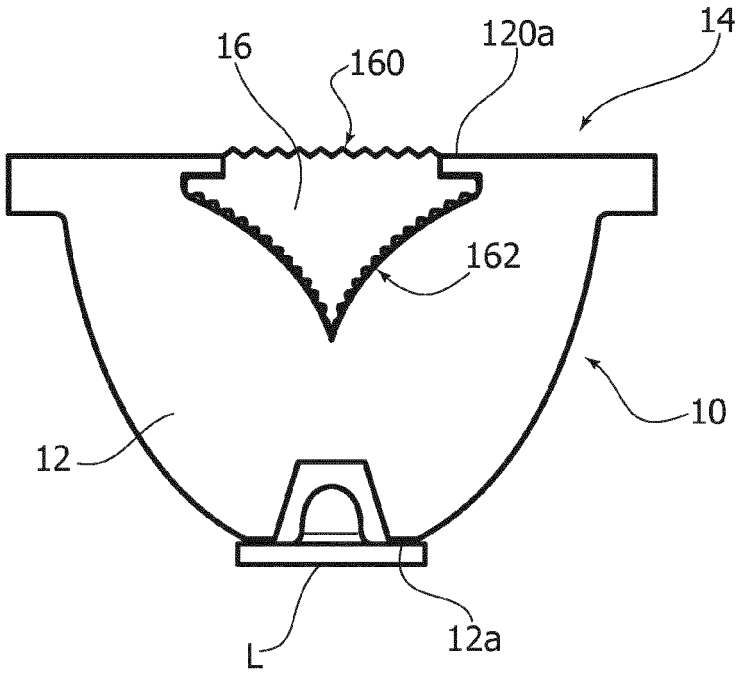

16
160
120a
14
162
10
12
L
12a

FIG. 2

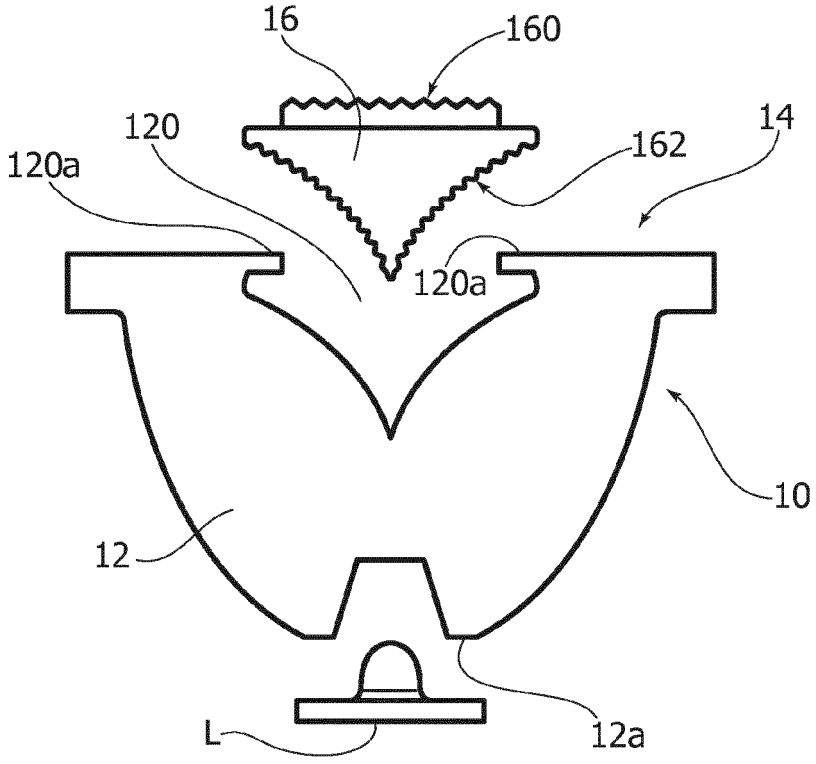

16
160
120
14
120a
162
120a
10
12
L
12a

FIG. 3

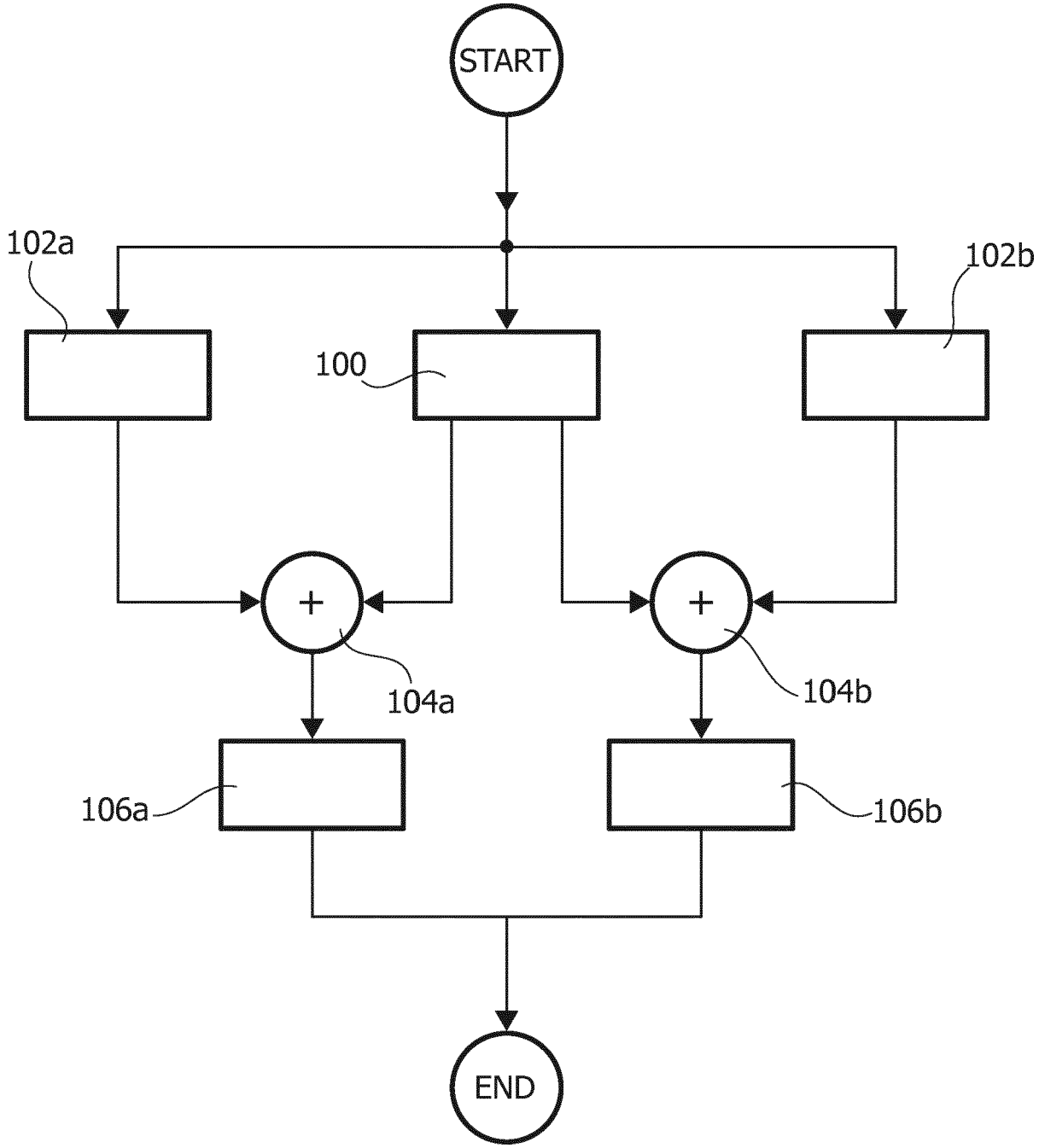


FIG. 4

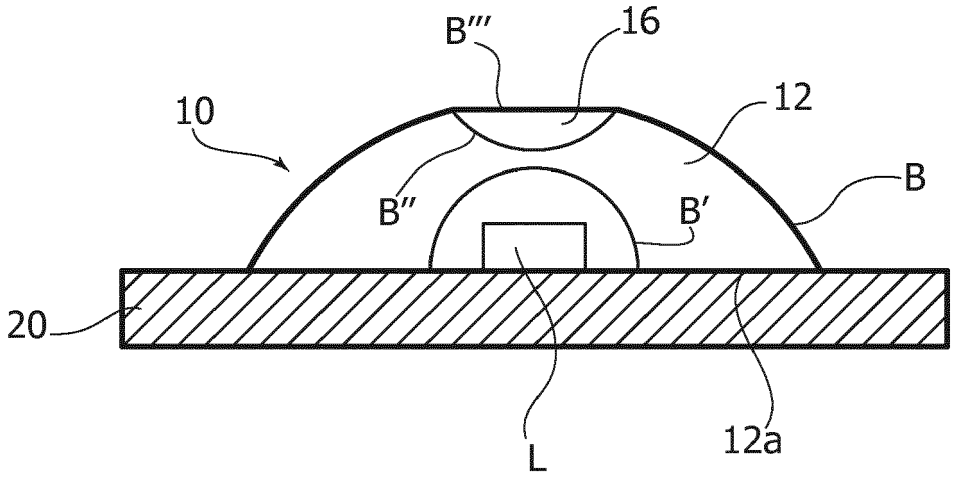


FIG. 5A

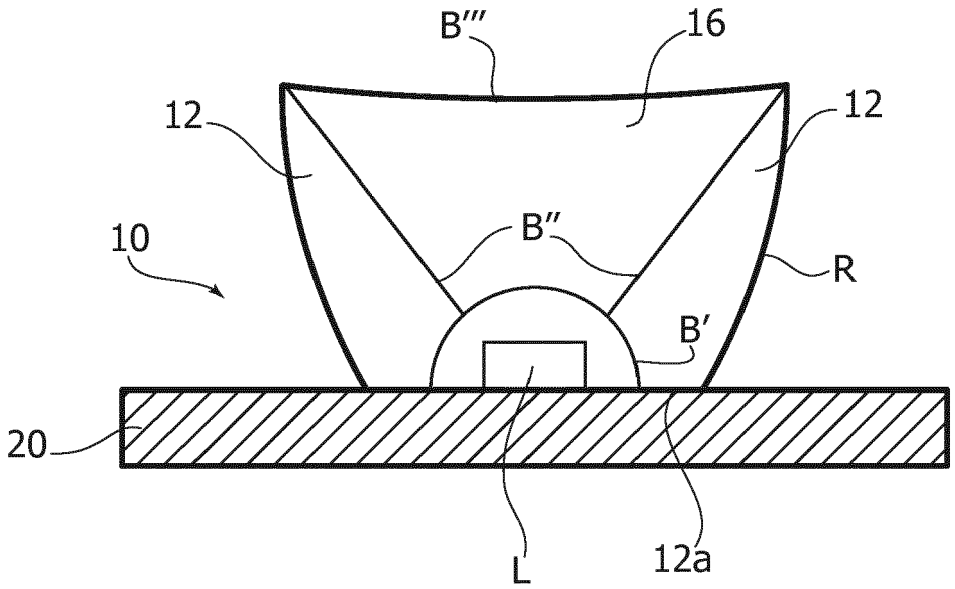


FIG. 5B

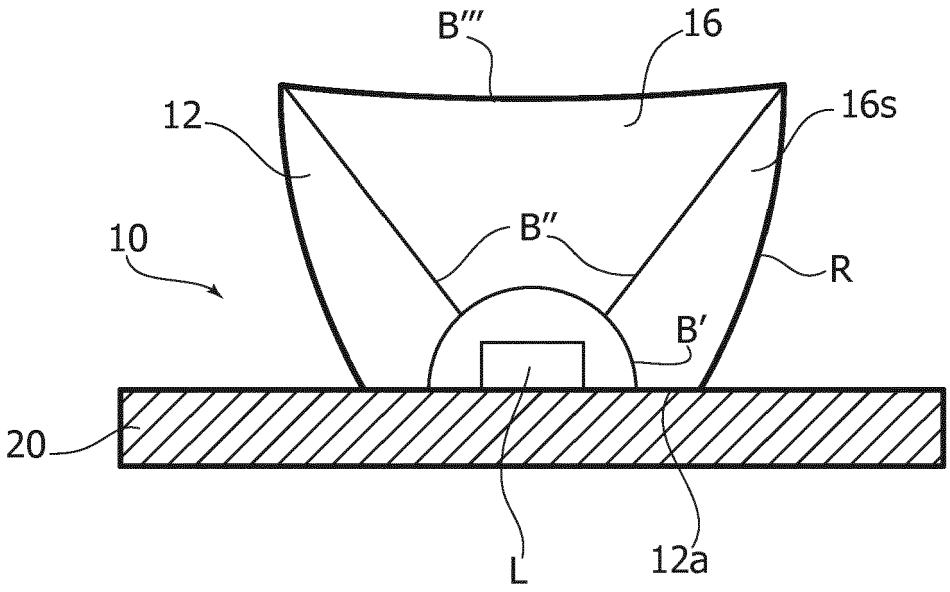


FIG. 6A

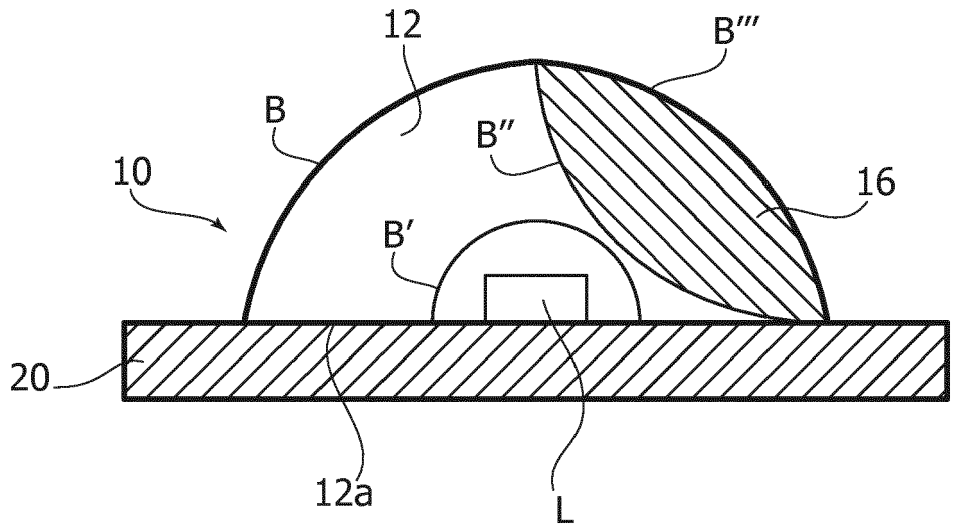


FIG. 6B

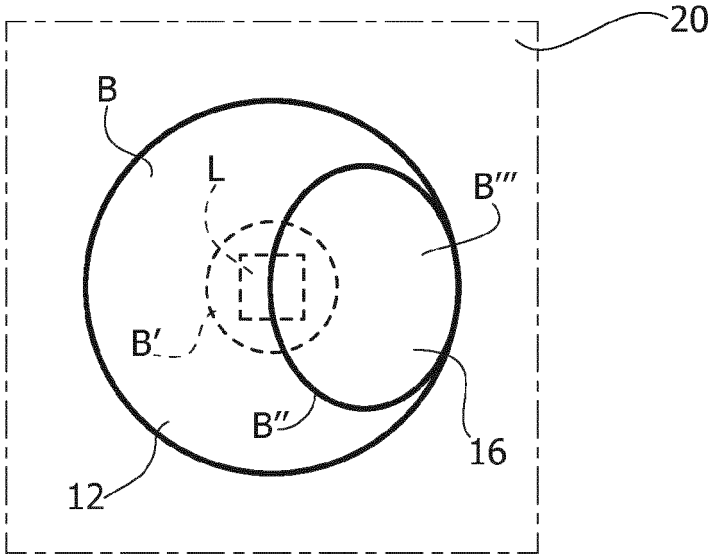


FIG. 7

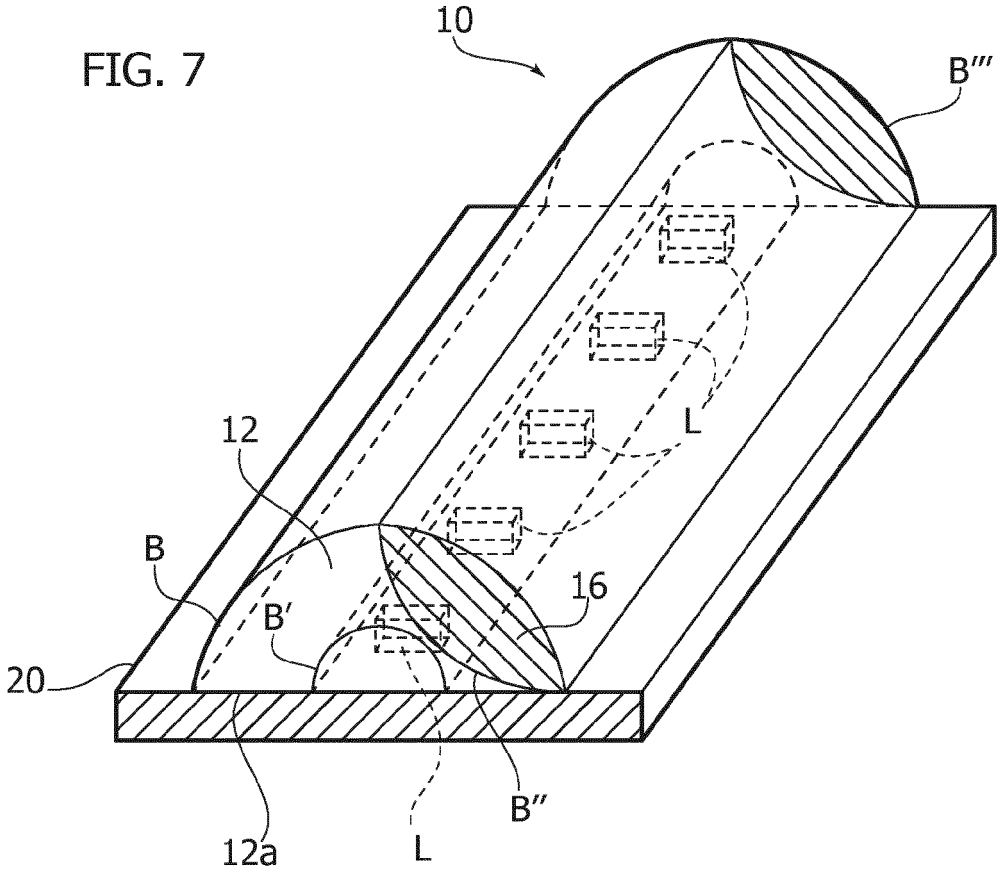


FIG. 8A

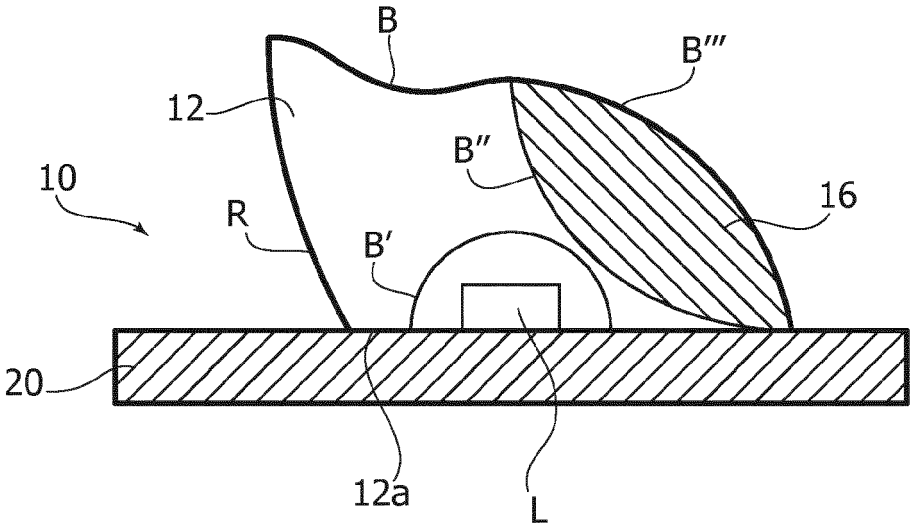
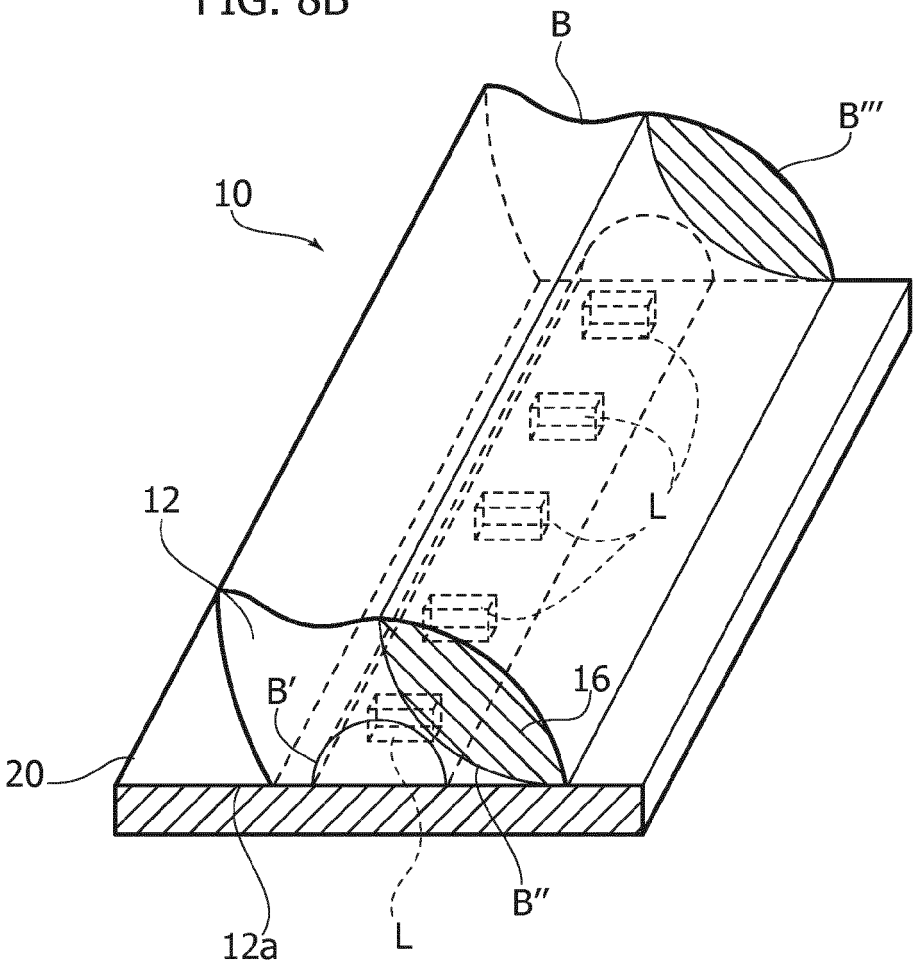


FIG. 8B



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European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 17 8407

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2016/057580 A1 (ZHAO FENG [US]) 14 April 2016 (2016-04-14) * page 9, paragraph 4 * * page 11, paragraph 3 * * page 14, paragraph 3 * * page 15, paragraph 2 * * page 18, paragraph 2 * * figures 9, 10, 16, 17 *	1,4,7-10	INV. F21V5/00 ADD. F21Y115/10
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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