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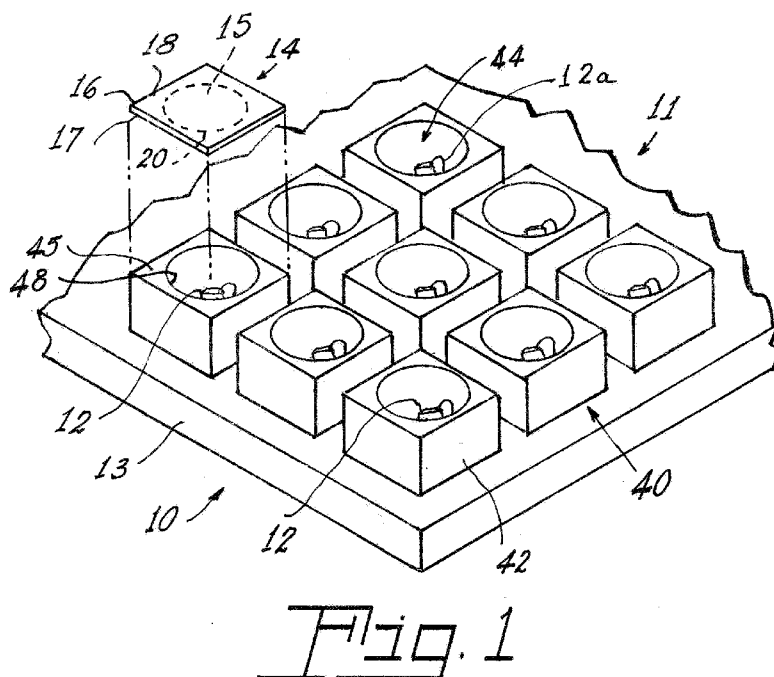
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Declarations under Rule 4.17:

— as to the identity of the inventor (Rule 4.17(i))

[Continued on next page]

(54) **Title:** LED PACKAGE USING PHOSPHOR CONTAINING ELEMENTS AND LIGHT SOURCE CONTAINING SAME



(57) **Abstract:** A light-emitting diode package is described comprising a body including a hollow having a rim that extends outwardly from an open end of the hollow. A light emitting diode is positioned in the hollow and opposite the open end. A non-gaseous transparent optical medium fills the hollow and a phosphor-containing element (PCE) is disposed over the hollow sealing the open end. The PCE has a solid body and a lateral portion including a periphery and dividing a top and a bottom. The bottom of the PCE is convex and in contact with the non-gaseous transparent optical medium and the periphery of the PCE is in contact with the rim.



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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- Published:**
- *with international search report (Art. 21(3))*

LED PACKAGE USING PHOSPHOR CONTAINING ELEMENTS AND LIGHT SOURCE CONTAINING SAME

5 TECHNICAL FIELD

[0001] This invention relates to lighting devices and more particularly to lighting devices employing light emitting diodes (LED or LEDs).

10 BACKGROUND OF THE INVENTION

[0002] An increasing number of lighting devices utilizing LEDs have been introduced in the recent past. Many of these devices serve as replacements for incandescent or fluorescent lamps. Since most LEDs emit light in a very narrow range (most
15 LEDs are considered to be single color emitters) it has been necessary to combine various colors (e.g., for example, red, green and blue) to provide white light. Recent advances in LEDs have provided LEDs that emit strongly in the blue and UV range such that, when combined with phosphors that emit in the yellow region of the spectrum, provide an acceptable version of white light. Current methods of
20 providing the phosphor component include applying a phosphor-containing silicone encapsulant; phosphor-coated or phosphor-filled plastic sheets; or phosphor-ceramic compositions. In all of these former constructions it is very difficult to control the dimensions of phosphor-containing elements. Also, since many LED devices include a hollow package, which is subsequently filled with a
25 transparent optical medium, the occasional introduction of air bubbles at the interface between the phosphor-containing element and the optical medium presents the industry with maintenance and quality control issues.

SUMMARY OF THE INVENTION

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[0003] It is, therefore, an object of the invention to obviate the above enumerated disadvantages of the prior art.

[0004] It is another object of the invention to enhance the operation of LED devices.

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[0005] Yet another object of the invention is the improvement of quality control in LED devices.

5 [0006] These objects are accomplished, in one aspect of the invention, by the provision of a light-emitting diode package comprising a body including a hollow having a rim that extends outwardly from an open end of the hollow. A light emitting diode is positioned in the hollow and opposite the open end. A nongaseous transparent optical medium fills the hollow and a phosphor-containing element (PCE) is disposed over the hollow sealing the open end. The PCE has a solid body and a lateral portion including a periphery and dividing a top and a bottom. The bottom of the PCE is convex and in contact with the nongaseous transparent optical medium and the periphery of the PCE is in contact with the rim.

15 [0007] In another aspect of the invention, there is provided a light source comprising an array of light emitting diodes. Each light emitting diode is positioned in a hollow having an outwardly extending rim. A plurality of phosphor-containing elements (PCE) is provided with each PCE disposed above a respective light emitting diode. A nongaseous transparent optical medium is disposed between each PCE and its respective light emitting diode. Each PCE comprises a solid body having a lateral portion dividing a top and a bottom. The bottom of each PCE is convex and its lateral portion has a periphery that may include at least one venting aperture. The bottom of each PCE in contact with the nongaseous transparent optical medium with its periphery in contact with the rim.

25 [0008] In a further aspect of the invention, the light source is a color modification assembly that comprises a plurality of PCEs at least some of which contain phosphors selected from the group of red, yellow, blue and green emitting phosphors.

30 [0009] The invention thus provides accurate dimensional control of the PCEs and, with the proper selection of PCEs for the color modification assembly, a wide control of the color output of the device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Fig. 1 is a perspective view of an embodiment of the invention;

5 [0011] Fig. 2 is an elevation view of a PCE employable with the invention;

[0012] Fig. 3 is an exploded perspective view of an LED package with a PCE;

[0013] Figs. 4 is an exploded sectional view of an LED package before assembly;

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[0014] Fig. 5 is a similar view of the assembled unit.

[0015] Fig. 6A is an elevation view of an alternate embodiment of the invention;

15 [0016] Fig. 6B is a plan view of the bottom of the embodiment of Fig. 6A;

[0017] Fig. 7 is a diagrammatic, perspective view of an assembly of the invention;

[0018] Fig. 8 is a sectional, elevation view of yet another embodiment.

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DETAILED DESCRIPTION OF THE INVENTION

[0019] For purposes of this application it is to be understood that when an element or layer is referred to as being “on,” “connected to” or “coupled to” another element or layer, it can be directly on, connected to or coupled to the other element or layer or intervening elements or layers may be present. In contrast, when an element is referred to as being “directly on,” “directly connected to” or “directly coupled to” another element or layer, there are no intervening elements or layers present. Like numbers refer to like elements throughout. The term “and/or” includes any and all combinations of one or more of the associated listed items.

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[0020] Although the terms “first,” “second,” “third” etc. may be used to describe various elements, components, regions, layers and/or sections, these elements,

components, regions, layers and/or sections are not to be limited by these terms as they are used only to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section could be termed a second element, component, region, layer or section without departing from the scope and teachings of the present invention.

[0021] Spatially relative terms, such as “beneath,” “below,” “upper,” “lower,” “above” and the like may be used herein for ease of description to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the drawings. These spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation shown in the drawings. For example, if the device in the drawings is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the exemplary term “below” can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0022] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. For example, as used herein, the singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms, “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0023] For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims taken in conjunction with the above-described drawings.

[0024] Referring now to the drawings with greater particularity, there is shown in Figs. 1 and 2 a light source 10 comprising an array 11 of light emitting diodes 12 appropriately fixed to a suitable substrate 13. The light emitting diodes are each connected to an electrical power source (not shown) through at least wire 12a. A plurality of phosphor-containing-elements 14 (PCE or PCEs), only one of which is shown in Fig. 1 in the interest of clarity, is associated with the array 11 of light emitting diodes 12 in a one-to-one relationship, each of the PCEs 14 having a solid body 15 comprising a lateral portion 16 dividing a top 18 and a bottom 20, the bottom 20 being convex. The lateral portion 16 includes a periphery 17 preferably having at least one venting aperture 19 therein. Each PCE 14 is disposed above its respective light emitting diode 12 such that the light emitted by the light emitting diode is directed at the bottom 20 of PCE 14. The top 18 of the PCE 14 can be planar, convex or any other configuration and, if convex, have a degree of curvature, whereby it can provide a lens function, if desired. As an example, in Figs. 3-5 the top 18 is shown as being hemispherical.

[0025] In a preferred embodiment of the invention, each of the light emitting diodes 12 emit a blue light in the range of 430-470 nm and the PCEs are solid, phosphor-filled, injection-molded silicone, polycarbonates, acrylics or similar material. Injection molding is preferred as this technique allows for very precise control of the PCE geometry. Because of the small size of the PCE, typically in the range of 1 mm to 20 mm on edge, a significantly smaller amount of phosphor will be utilized, generally in the range of 4-50 weight percent, although the actual amount will depend on the package on which it is mounted and the color point desired.

[0026] When activated by the light emitted from said light emitting diodes 12, the PCEs 14 emit light having a different, and generally longer, wavelength than the light emitted by the light emitting diodes. This allows for the provision of a color modification assembly 30, as shown in Fig. 7, which comprises a plurality of PCEs 14 at least some of which contain phosphors selected from the group of red, yellow, blue and green emitting phosphors. A plurality of PCEs 14 which emit in different colors, for example, in the red, yellow, blue and green areas of the

spectrum (and are represented diagrammatically in Fig. 7 as R₁₄, Y₁₄, B₁₄ and G₁₄ respectively), can be assigned to bins 31 in a compartmentalized container 32. Since the PCEs 14 are made independently of the LED package, the PCEs can be matched to a particular package to maximize the package wavelengths that can be used while minimizing the color variability between the packages.

[0027] Because the initial wavelength available from the LEDs is in the range of 430-470 nm, it is preferred that the phosphors selected for the assembly be excited to emission by wavelengths in that range.

[0028] Table I illustrates the approximate C.I.E. color coordinates of exemplary phosphors that can be employed with the invention, all of these phosphors being excited to luminescence by radiation in the 430-470 nm range, such as that available from an InGaN LED.

PHOSPHOR	C.I.E. Color Coordinates (x,y)
Y ₃ Al ₅ O ₁₂ :Ce ³⁺	(0.45, 0.52)
Y ₃ Al _{5-x} Ga _x O ₁₂ :Ce ³⁺	(0.44, 0.53)
(Lu,Y) ₃ (Al,Ga) ₅ O ₁₂ :Ce ³⁺	(0.42, 0.56)
Ca ₈ Mg(SiO ₄) ₄ Cl ₂ :Eu ²⁺	(0.20, 0.62)
SrSi ₂ O ₂ N ₂ :Eu ²⁺	(0.36, 0.60)
Ca _{1-x} Sr _x Si ₂ O ₂ N ₂ :Eu ²⁺	(0.38, 0.57)
SrBaSi ₂ O ₂ N ₂ :Eu ²⁺	(0.45, 0.58)
Ca ₂ Si ₅ N ₈ :Eu ²⁺	(0.58, 0.39)
Ca _{5-d} Al _{4-2d} Si _{8+2d} N ₁₈ Eu ²⁺	(0.59, 0.39)
Sr _{2-x} Ca _x Si ₅ N ₈ :Eu ²⁺	(0.65, 0.32)
Ba _{2-x} Sr _x Si ₅ N ₈ :Eu ²⁺	(0.59, 0.37)

TABLE I

[0029] A representative light-emitting diode package 40 is shown in Figs. 3-5 and comprises a body 42 with a hollow 44 having a rim 45 extending outwardly from open end 48. The open end 48 has a diameter D₁. A light emitting diode 12 is positioned in the hollow 44 and a nongaseous transparent optical medium 46, such as silicone, epoxy or other optical adhesive, fills the hollow 44. A PCE 14 seals the hollow 44 with the periphery 17 of the PCE 14 in contact with the rim 45 and completes the package 40. The convex bottom 20 of the PCE displaces some of

the nongaseous transparent optical medium 46 and insures that no air bubbles exist at the interface. It is also advisable to place a vent or vents 19 about the periphery 17 of the lateral portion 16 to further aid in the removal of any air bubbles. The vents can take the form of apertures 19 as shown in Figs. 3-5 or grooves 19a as shown in the embodiment described below.

[0030] In an alternate embodiment, shown in Figs. 6A and 6B, the PCE 14 can be provided with longitudinal grooves 19a in place of or in addition to the apertures 19. As with previous embodiments the convex bottom 20 has a diameter D_2 wherein D_2 preferably is approximately equal to D_1 so that any air that might be otherwise trapped underneath the PCE 14 is shunted to the grooves. Moreover, the grooves allow for any excess of the transparent medium 46 displaced by the convex bottom 20 to flow into the grooves to relieve any pressure when seating the PCE 14 to the package 40 and also provide for additional bonding between the periphery and the rim.

[0031] In yet another embodiment, shown in Fig. 8, the lateral portion 16 of the solid body 15 can terminate in a curb or lip 50 that fits about the external edge of the body 42 to aid in alignment of the PCE 14 to the body 42 of package 40.

[0032] The PCEs can be provided on an individual basis or with an assembly that allows a considerable range of color matching or correcting. The peripheral rim of the lateral portion, together with the convex bottom and the venting apertures assures a good bond with no distorting air bubbles in the transparent optical medium or the interface between the medium and convex bottom.

[0033] While there have been shown and described what are at present considered to be the preferred embodiments of the invention, it will be apparent to those skilled in the art that various changes and modifications can be made herein without departing from the scope of the invention as defined by the appended claims.

GLOSSARY OF REFERENCE NUMERALS USED HEREIN

	10	light source
	11	array of diodes
5	12	diodes
	12a	wire
	13	substrate
	14	phosphor containing elements (PCEs)
	15	solid body of PCEs
10	16	lateral portion of 15
	17	periphery of 16
	18	top of 16
	19	venting aperture in 17
	19a	venting groove in 17
15	20	bottom of 16
	30	assembly
	31	bins
	32	container
	40	light-emitting diode package
20	42	body of 40
	44	hollow in 42
	46	nongaseous transparent optical medium
	48	open end
	50	curb on 16
25	D ₁	diameter of 48
	D ₂	diameter of 20

CLAIMS**What is claimed is:**

- 5 1. A light-emitting diode package 40 comprising:
a body 42 including a hollow 44 having a rim 45, said rim extending outwardly
from an open end 48 of said hollow 44;
a light emitting diode 12 positioned in said hollow 44 and opposite said open end
48;
10 a nongaseous transparent optical medium 46 filling said hollow 44; and
a phosphor-containing element (PCE) 14 disposed over said hollow 44 and sealing
said open end 48, said PCE 14 having a solid body 15 and a lateral portion 16 including a
periphery 17 dividing a top 18 and a bottom 20, said bottom 20 being convex and in
contact with said nongaseous transparent optical medium 46 and said periphery 17 being
15 in contact with said rim 45.
2. The light-emitting diode package 40 of Claim 1 wherein said periphery 17
includes at least one venting aperture 19.
- 20 3. The light-emitting diode package 40 of Claim 1 wherein said top 18 is convex.
4. The light-emitting diode package 40 of Claim 3 wherein said top 18 has a greater
convexity than said bottom 20.
- 25 5. The light-emitting diode package 40 of Claim 1 wherein said light emitting diode
12 emits in the range of 430-470 nm.
6. The light-emitting diode package 40 of Claim 1 wherein said PCE 14 contains at
least one phosphor selected from the group of red-, yellow-, blue- and green-emitting
30 phosphors.

7. The light-emitting diode package 40 of Claim 1 wherein said open end 48 has a diameter D_1 and said convex bottom 20 has a diameter D_2 which is approximately equal to D_1 .

5 8. The light-emitting diode package 40 of Claim 7 wherein said periphery 17 includes at least one longitudinal groove 19a.

9. The light-emitting diode package 40 of Claim 1 wherein said lateral portion 16 of said solid body 15 terminates in a curb 50.

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10. A light source 10 comprising:
an array 11 of light emitting diodes 12;
each light emitting diode 12 being positioned in a hollow 44 having an outwardly extending rim 45;

15 a plurality of phosphor-containing elements 14 (PCE), each PCE 14 disposed above a respective light emitting diode 12;

a nongaseous transparent optical medium 46 disposed between each PCE 14 and its respective light emitting diode 12;

said PCEs 14 comprising:

20 a solid body 15 having a lateral portion 16 dividing a top 18 and a bottom 20, said bottom 20 being convex, said lateral portion 16 having a periphery 17, said bottom 20 being in contact with said nongaseous transparent optical medium and said periphery being in contact with said rim.

25 11. The light source 10 of Claim 10 wherein said light emitting diodes are disposed in bins in a compartmentalized container.

12. The light source 10 of Claim 10 wherein said hollow 44 has an open end 48 having a diameter D_1 and said convex bottom 20 has a diameter D_2 which is
30 approximately equal to D_1 .

13. The light source 10 of Claim 10 wherein said periphery 17 includes at least one venting aperture 19.

14. The light source 10 of Claim 13 wherein said venting aperture 19 is a longitudinal groove 19a.

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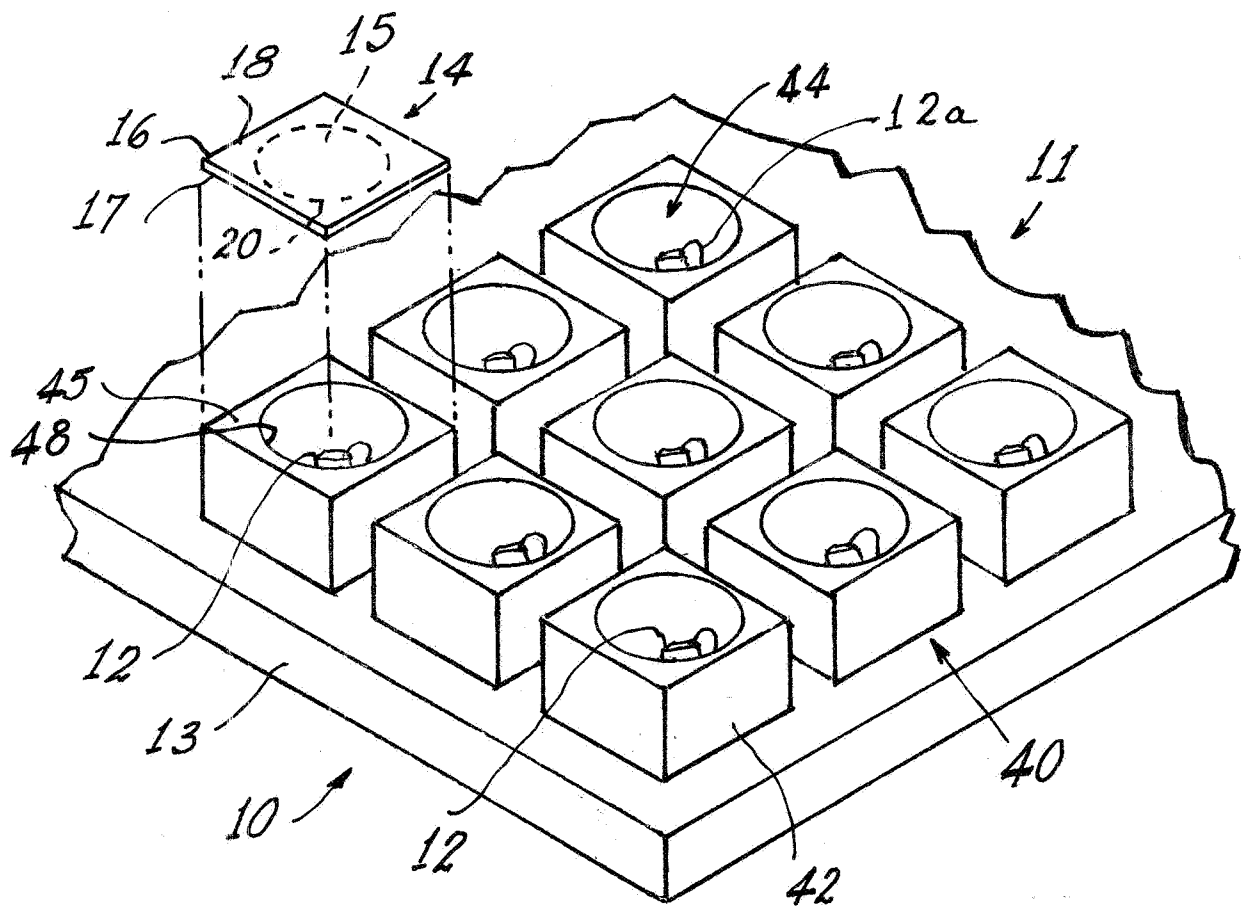


Fig. 1

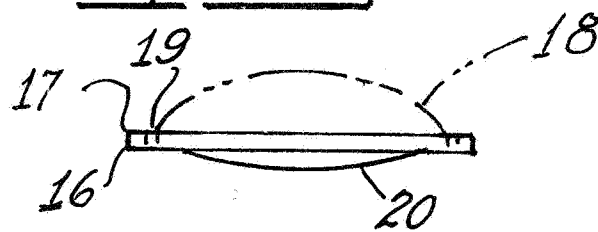


Fig. 2

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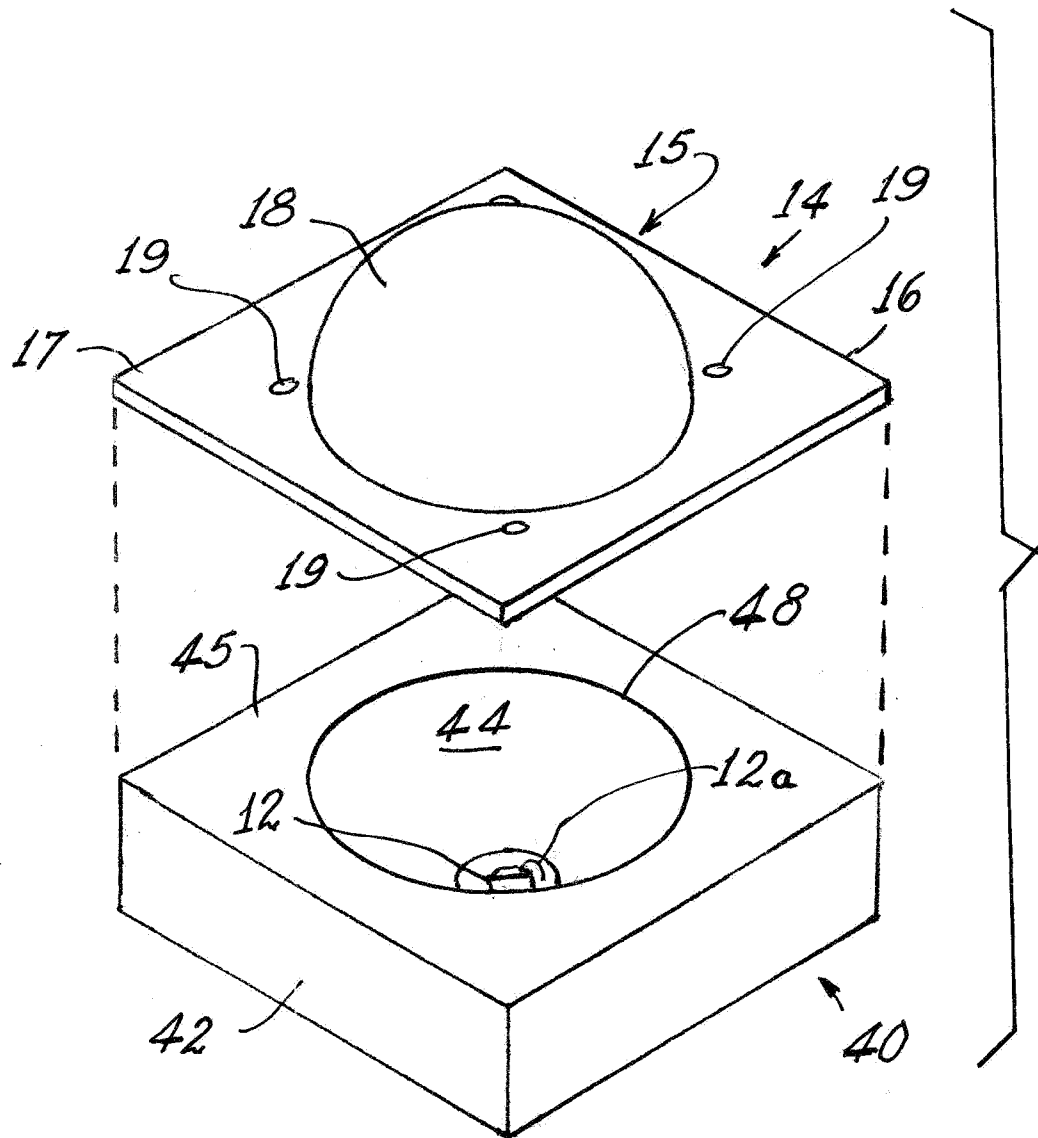


Fig. 3

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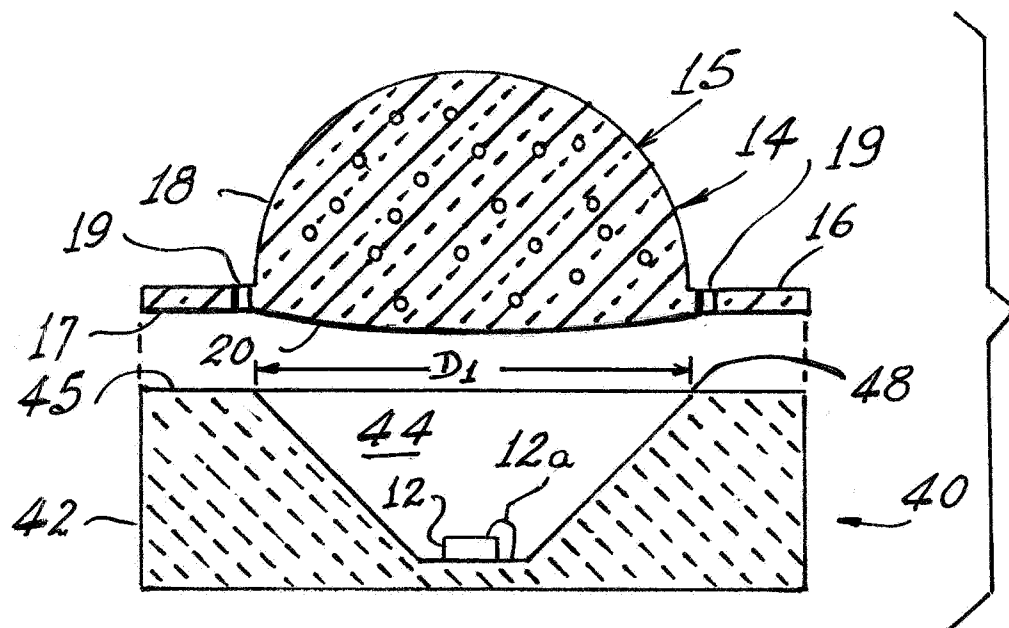


Fig. 4

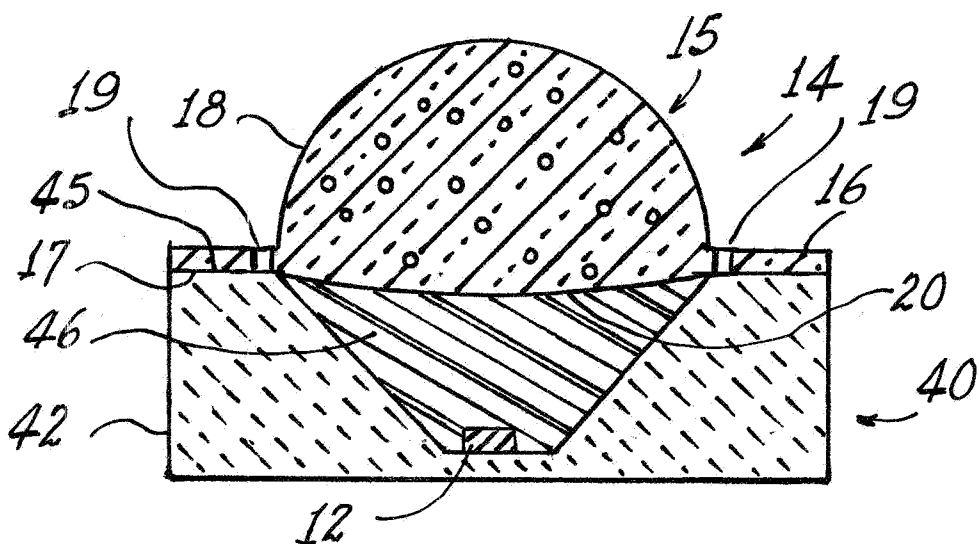


Fig. 5

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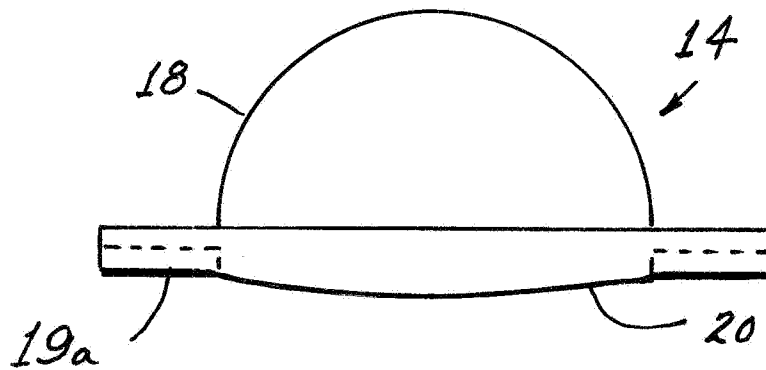


Fig. 6A

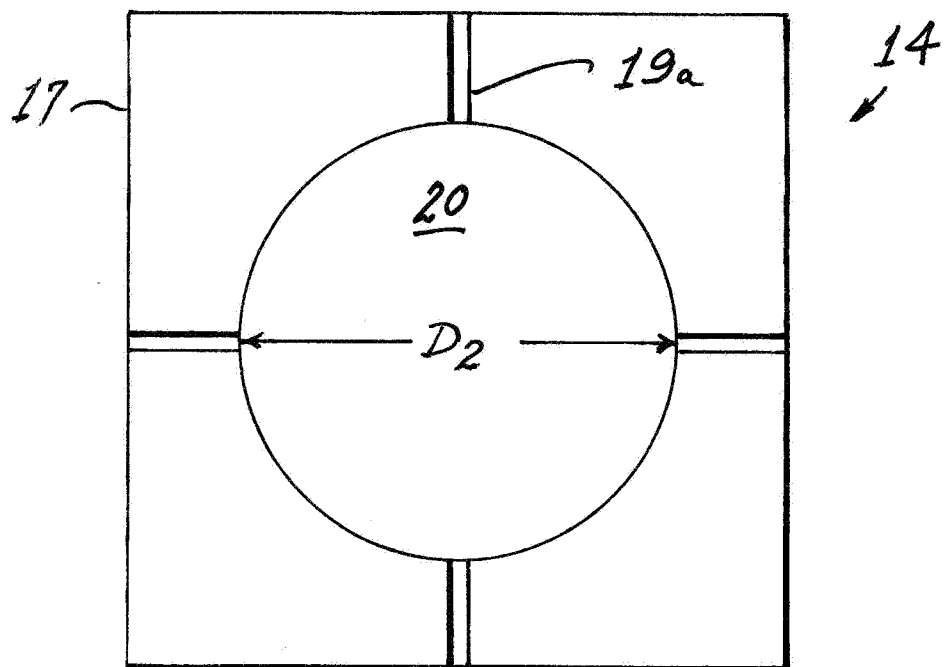


Fig. 6B

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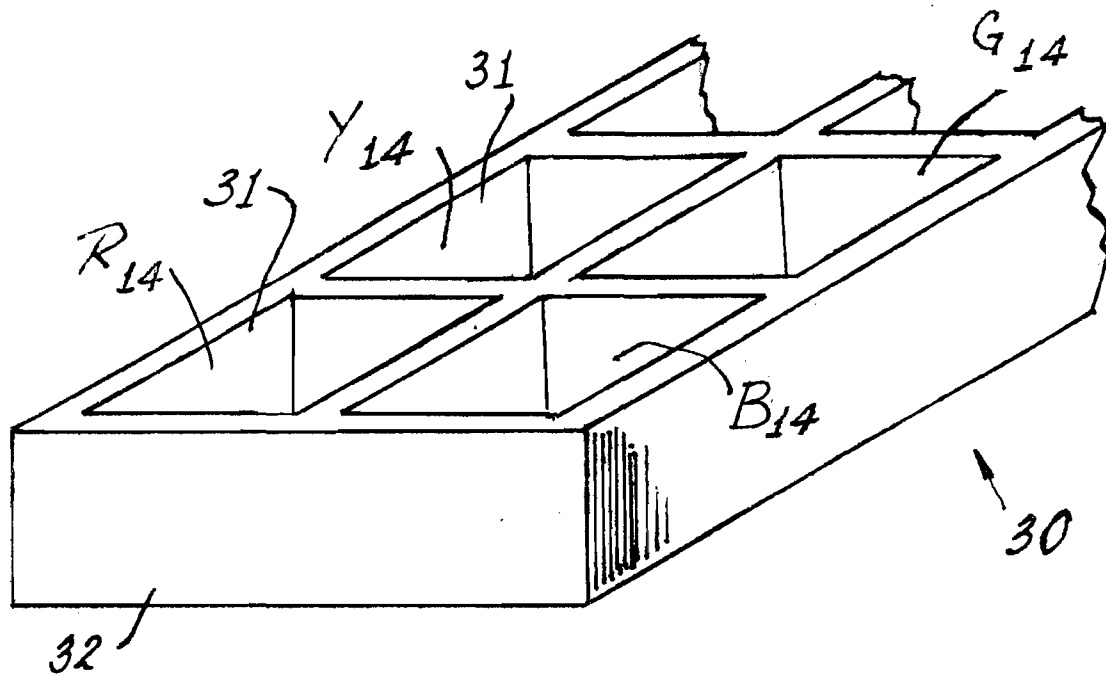


Fig. 7

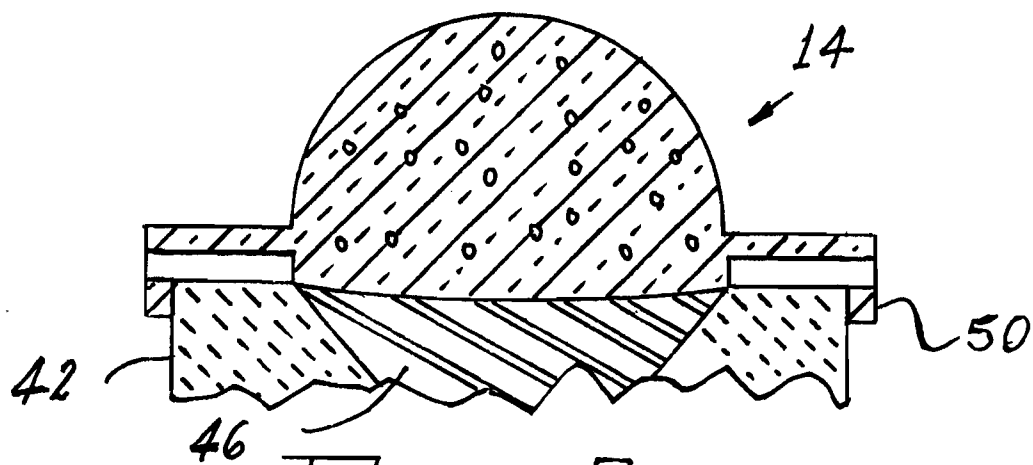


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/027362

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L33/50
ADD. F21K99/00

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

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X	US 2009/152582 A1 (CHANG C-M ET AL) 18 June 2009 (2009-06-18) paragraph [0025] -----	1-14
X	US 2010/277932 A1 (CHEN M-H ET AL) 4 November 2010 (2010-11-04) paragraphs [0070] - [0075] -----	1-14
X	US 2009/184333 A1 (WANG C-W ET AL) 23 July 2009 (2009-07-23) paragraphs [0030] - [0031] ----- -/-	1-14



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

22 May 2012

Date of mailing of the international search report

30/05/2012

Name and mailing address of the ISA/

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Authorized officer

van der Linden, J

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/027362

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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