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(54) Title: LED ILLUMINATION DEVICE

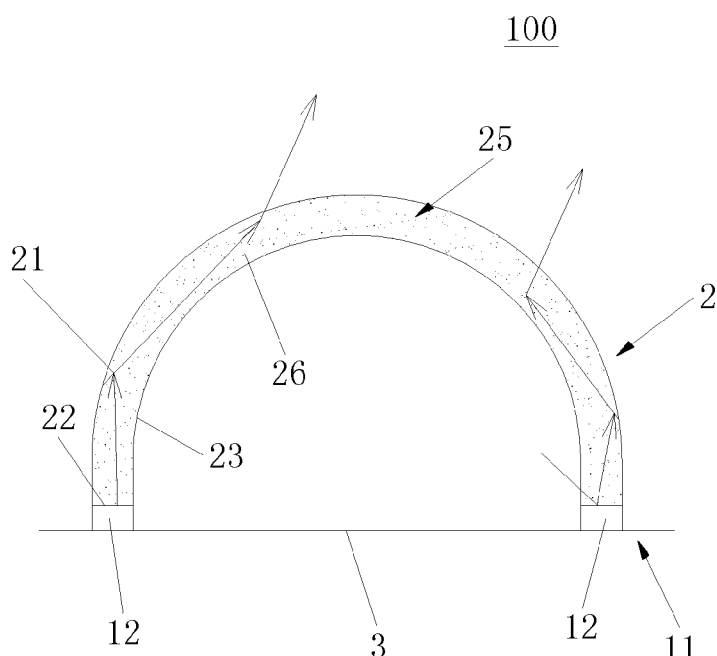


Figure 4

(57) Abstract: The present invention relates to an LED illumination device (100) comprising an LED light engine (1), and a remote phosphor structure (2) comprising a first emergent surface (21) and an incident surface (22), wherein the remote phosphor structure (2) further comprises a second emergent surface (23) disposed opposite the first emergent surface (21), and at least one connection surface connected between the first emergent surface (21) and the second emergent surface (23), and the connection surface is configured as the incident surface (22), wherein light from the LED light engine (1) enters into the remote phosphor structure (2) through the incident surface (22), and emerges through the first emergent surface (21) and the second emergent surface (23).



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Description

LED Illumination Device

## 5   **Technical Field**

The present invention relates to an LED illumination device.

## **Background Art**

Most existing LED lamps use a single or multiple white LED light engines and LED light engines as light sources. The  
10 blue light emitted by the LED light engine is mixed with green and red light emitted by phosphors to obtain white light. Other solutions are to use converted greenish-white (mint) LED light engines in combination with red LEDs to generate white light, and the so-generated white light has a low  
15 color temperature (2700K-4000K), and higher color rendering index compared with pure phosphor conversion solutions. However, in all the solutions, a portion of the light is lost by either direct emission or back-reflection onto the chip or into the LED package. Both of the chip and the LED package  
20 have a typical reflectivity below 90%.

A solution providing high optical efficiency is the remote phosphor structure technique. A typical configuration is shown in Fig. 1. As can be seen from the figure, the light emitted from the blue LED light engine 1 travels to an optical member, which is a remote phosphor structure 2 made of a  
25 transparent material (typically a polymer material, such as polycarbonate or PMMA, but other materials based on glass or ceramic are also feasible) filled with phosphor. Light conversion takes place in the remote phosphor structure in the  
30 same way as in the converted LED light engine. If the regions

surrounding the LED light engine (i.e., all the portions of the space enclosed by the housing) are highly reflective, the light emitted or back-reflected from the lamp housing can be efficiently recycled. In addition, the temperature of the phosphor in the remote phosphor structure 2 will be lower than the temperature of the phosphor in the conventional LED package, resulting in higher conversion efficiency of the phosphor. Thus, the remote phosphor structure solution can be dozens of percent more efficient than similar solutions based on white LED package.

The remote phosphor structure solution can be applied in some products, e.g., bulb-shaped LED retrofit lamps or Fortimo light engines, both from Philips. However, they have the following three major disadvantages:

1. The consumption of phosphor for a remote phosphor structure is much higher than that for an ordinary converted LED. This is due to the requirement that, at a given conversion level, blue rays transmitting either the on-chip conversion layer or the remote phosphor structure need to hit the same number of phosphor particles. The amount of the phosphor scales with the area of the phosphor member, so the remote phosphor structure needs more phosphor. For some typical applications, especially for warm-white solutions, phosphor cost can become a considerable part of the overall product cost for a remote phosphor structure solution.

2. Due to the high concentration of phosphor, the remote phosphor structure has a yellowish appearance, which is undesired for many applications. In some solutions, the remote phosphor structure is hidden under a semi-transparent housing, which sacrifices efficiency.

3. The conversion process in the remote phosphor structure involves intrinsic losses, which generates heat and reduces the conversion efficiency of the phosphor. In many typical applications, the size of the remote phosphor structure member needs to be determined by a compromise between the cost (requiring a smaller size) and heat dissipation efficiency (requiring a larger size).

### Summary of the invention

In order to solve the above technical problem, the present invention provides an LED illumination device. The LED illumination device according to the present invention has high light conversion efficiency, smaller size and low cost.

The object of the present invention is achieved by an LED illumination device, comprising an LED light engine, and a remote phosphor structure comprising a first emergent surface and an incident surface, wherein the remote phosphor structure further comprises a second emergent surface disposed to face the first emergent surface, and at least one connection surface connected between the first emergent surface and the second emergent surface, and the connection surface is configured as the incident surface, wherein light from the LED light engine enters into the remote phosphor structure through the incident surface, and emerges through the first emergent surface and the second emergent surface. The LED illumination device according to the present invention can allow the light from the LED light engine to travel as far as possible in the remote phosphor structure, and as the travelling distance becomes longer, the light travelling in the remote phosphor structure can hit as much phosphor as possible in the remote phosphor structure, so as to achieve the purpose of efficiently converting the light, which advanta-

geously reduces the amount of the phosphor in the remote phosphor structure, thereby largely reduces the manufacture cost of the remote phosphor structure, and further reduces the entire cost of the LED illumination device. Further,

5 since the amount of the phosphor is reduced, the impact of the phosphor on the color and appearance of the remote phosphor structure is reduced, and the remote phosphor structure of the LED illumination device according to the present invention is nearly transparent. Finally, due to the small

10 amount of the phosphor in the remote phosphor structure, when the LED illumination device works, the temperature of the phosphor is relatively low, which enables the remote phosphor structure of the LED illumination device according to the present invention to have higher conversion efficiency.

15 Preferably, the LED illumination device further comprises a reflector which is disposed to face the first emergent surface or the second emergent surface. The LED illumination device is designed for projecting light onto a region with a predetermined range, and the arrangement of a reflector can

20 advantageously reflect the light that may emit to an undesired region to the predetermined region to be illuminated, which largely improves the efficiency of the LED illumination device according to the present invention and reduces light loss.

25 According to a preferred design solution of the present invention, the remote phosphor structure comprises at least two connection surfaces, wherein one or more connection surfaces, which allow light to travel a longer distance in the remote phosphor structure, are configured as the incident surface.

30 Since the remote phosphor structure may have two or more connection surfaces, these connection surfaces all can be used as incident surfaces, however, if one or more of these con-

nection surfaces allow the light to travel farthest in the remote phosphor structure, then the one or more connection surfaces are preferred as incident surfaces. Thus, the light from the connection surface(s) can hit the most phosphor in the remote phosphor structure, such that the remote phosphor structure of the LED illumination device according to the present invention can achieve the highest conversion efficiency.

Preferably, the remote phosphor structure is configured as an elongated body having an arc-shaped section, wherein the elongated body comprises an inner surface, an outer surface, and two opposite end surfaces serving as the connection surfaces, which are connected between the inner surface and the outer surface and are in a longitudinal direction of the elongated body, and one or both end surfaces are configured as the incident surfaces. In this design solution, the remote phosphor structure is similar to a tube which is intercepted, i.e. a sector of a tube intercepted through a section along the longitudinal axis of the tube or a section parallel with this section. The LED illumination device using such a remote phosphor structure is advantageously used to, for example, replace a traditional lamp tube. In this design solution, one or both end surfaces of the elongated body, or the elongated sector are designed as the incident surfaces, such that the light can extend the longest distance in the elongated body, so as to hit the most phosphor, and further improves the light conversion efficiency of the entire remote phosphor structure.

Optionally, the remote phosphor structure is configured to be plate-like, wherein the remote phosphor structure comprises an upper surface and a lower surface which respectively serve as the first emergent surface and the second emergent sur-

face, and four circumferential surfaces, opposite each other, which are connected between the upper surface and the lower surface as the connection surfaces, wherein one or more of the circumferential surfaces with the longest distance there-  
5 between are configured as the incident surfaces. In this design solution, it is also necessary to make the light travel the longest distance in the remote phosphor structure, so two or more of the circumferential surfaces with the longest distance therebetween are selected as the incident surfaces.

10 This type of design solution can, for example, advantageously replace the conventional plate glass, when it does not work, it can serve as simple and transparent glass, and when it works, it can provide illumination.

According to another preferred design solution of the present  
15 invention, the remote phosphor structure comprises only one connection surface that is configured to be ring-like. In a particular design solution, the remote phosphor structure is configured to be bulb-like, wherein the bulb-like remote phosphor structure comprises an inner surface and an outer  
20 surface which serve as the first emergent surface and the second emergent surface, respectively, a ring-like support surface which is connected between the inner surface and the outer surface as the connection surface is formed at an opening end of the bulb-like remote phosphor structure, and the  
25 ring-like support surface is configured as the incident surface. The LED illumination device employing this type of remote phosphor structure is used to replace a traditional incandescent lamp. In this design solution, the bulb-like remote phosphor structure comprises only one opening end, a  
30 ring-like support surface is formed at the opening end, and the light from the LED light engine enters into the remote phosphor structure from the ring-like support surface.

Advantageously, the remote phosphor structure further comprises a total internally reflective lens disposed on the incident surface, and at least a portion of light from the LED light engine enters into the remote phosphor structure through the incident surface after being totally internally reflected in the total internally reflective lens. The total internally reflective lens enables the light of the LED light engine to enter into the remote phosphor structure at a favorable angle, such that the light extends as far as possible in the remote phosphor structure, which further improves the light conversion efficiency of the remote phosphor structure.

Advantageously, the total internally reflective lens is configured to be ring-like, and comprises a lens incident surface and a lens emergent surface, wherein the lens emergent surface has the same shape as the ring-like support surface. Such type of total internally reflective lens is capable of guiding all the light of the LED light engine into the remote phosphor structure, which thereby further avoids light loss.

Optionally, the lens incident surface defines an accommodation cavity for accommodating a luminous body of the LED light engine. The accommodation cavity completely encloses the luminous body, which prevents the light emitted by the luminous body from directly emitting to the ambient.

According to the present invention, the LED light engine comprises a circuit board and at least one LED chip disposed on the circuit board, wherein the LED chip is disposed to face the incident surface. Thus, the light emitted by the LED chip can be directly incident upon the incident surface, and further travels in the remote phosphor structure.

Preferably, the circuit board is at least partially formed as

a reflector. In the solution of configuring the remote phosphor structure to be bulb-like, as the bulb-like remote phosphor structure will be disposed on the circuit board and supported on the LED chip using the ring-like support surface, and the inner surface of the bulb will face the circuit board, it is very advantageous to configure a portion of the circuit board facing the inner surface as a reflector. In other design solutions of the present invention, the reflector may be an independent reflective plate additionally provided.

According to the present invention, the remote phosphor structure comprises a transparent body and phosphor filling the transparent body. Preferably, the transparent body is made of polycarbonate, PMMA, glass or ceramic materials.

It is to be understood that the features of the various exemplary embodiments described herein may be combined with each other, unless specifically noted otherwise.

### **Brief Description of the Drawings**

The drawings constitute a portion of the Description for further understanding of the present invention. These drawings illustrate the embodiments of the present invention and explain the principle of the present invention together with the Description. In the drawings, the same part is represented by the same reference sign. In the drawings,

Fig. 1 is a schematic diagram of an LED illumination device in the prior art, comprising a remote phosphor structure;

Fig. 2 is a schematic diagram of a first embodiment of the LED illumination device according to the present invention;

Fig. 3 is a schematic diagram of a second embodiment of the LED illumination device according to the present invention;

Fig. 4 is a schematic diagram of a third embodiment of the LED illumination device according to the present invention;

5 and

Fig. 5 is a schematic diagram of an improved solution of the third embodiment of the LED illumination device according to the present invention.

### **Detailed Description of the Embodiments**

10 In the following detailed Description, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. In this regard, directional terminology, such as "upper", "lower", "inner",  
15 "outer", "circumferential", "longitudinal" etc., is used with reference to the orientation of the Figure(s) being described. Because components of embodiments can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and is in no way  
20 limiting. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present in-  
25 vention is defined by the appended claims.

Fig. 2 is a schematic diagram of the first embodiment of the LED illumination device 100. As can be seen from the figure, the LED illumination device 100 comprises an LED light engine 1, and a remote phosphor structure 2 comprising a first emer-

gent surface 21 and an incident surface 22, wherein the remote phosphor structure 2 further comprises a second emergent surface 23 disposed to face the first emergent surface 21, and at least one connection surface connected between the first emergent surface 21 and the second emergent surface 23, and the connection surface is configured as the incident surface 22, wherein light from the LED light engine 1 enters into the remote phosphor structure 2 through the incident surface 22, and emerges through the first emergent surface 21 and the second emergent surface 23. The remote phosphor structure 2 comprises a transparent body 25 and phosphor 26 filling the transparent body 25. The transparent body 25 is made of polycarbonate, PMMA, glass or ceramic materials.

In some design solutions of remote phosphor structure 2, the remote phosphor structure 2 comprises at least two connection surfaces, wherein the connection surface, which allows light to travel a longer distance in the remote phosphor structure 2, is configured as the incident surface 22. In some other design solutions of remote phosphor structure 2, the remote phosphor structure 2 comprises only one connection surface that is configured to be ring-like.

In the present embodiment, the remote phosphor structure 2 is configured as an elongated body having an arc-shaped section, wherein the elongated body comprises an inner surface, an outer surface, and two opposite end surfaces serving as the connection surfaces, which are connected between the inner surface and the outer surface and are in a longitudinal direction of the elongated body, the end surfaces being configured as the incident surfaces 22. In the present embodiment, the remote phosphor structure 2 comprises a plurality of connection surfaces. As can be seen from the figure, the remote phosphor structure 2 is similar to a tube which is inter-

cepted, i.e. a sector of a tube intercepted through a section along the longitudinal axis of the tube or a section parallel with this section. The LED illumination device 100 using such a remote phosphor structure 2 is advantageously used to, for example, replace a traditional lamp tube. In the embodiment, the two end surfaces of the elongated body, or the elongated sector are designed as the incident surfaces 22, such that the light can extend the longest distance in the elongated body, so as to hit the most phosphor, and further improves the light conversion efficiency of the entire remote phosphor structure 2.

In addition, as can be further seen from Fig. 2, the LED illumination device 100 further comprises a reflector. In the present embodiment, the region facing the first emergent surface 21 is a region to be illuminated, and thus, it is required that all the light emerges through the first emergent surface 21. However, in practice, some light emerges through the second emergent surface 23, then it is necessary to reflect this portion of light back to the remote phosphor structure 2 and make it emerge from the first emergent surface 21, and thus, the reflector 3 is disposed to face the second emergent surface 23. However, if it is necessary to make all the light finally emerge through the second emergent surface 23, the reflector 3 may be disposed to face the first emergent surface 21.

Further, the LED light engine 1 comprises a circuit board 11 and at least one LED chip 12 disposed on the circuit board 11, wherein the LED chip 12 is disposed to face the incident surface 22. In Fig. 2, the circuit board 11 is not shown for the purpose of simplification, and only the LED chip 12 is shown. However, this does not mean that there is no circuit board 11 in the embodiment shown in Fig. 2.

The basic design principle of the present invention is to make the light travel as far as possible in the remote phosphor structure. The object is: the light travelling in the remote phosphor structure 2 can hit as much phosphor 26 as possible in the remote phosphor structure 2, so as to achieve the purpose of efficiently converting the light, which advantageously reduces the amount of the phosphor 26 in the remote phosphor structure 2, thereby largely reduces the manufacture cost of the remote phosphor structure 2, and further reduces the entire cost of the LED illumination device 100. Further, since the amount of the phosphor 26 is reduced, the impact of the phosphor 26 on the color and appearance of the remote phosphor structure 2 is reduced, and the remote phosphor structure 2 of the LED illumination device 100 according to the present invention is nearly transparent. Finally, due to the small amount of the phosphor 26 in the remote phosphor structure 2, when the LED illumination device 100 works, the temperature of the phosphor 26 is relatively low, which enables the remote phosphor structure 2 of the LED illumination device 100 according to the present invention to have higher conversion efficiency.

For the present embodiment, a plurality of LED chips 12 are directly arranged on the two end surfaces of the elongated sector that have the longest distance therebetween, viz. the end surfaces of the two opening ends defining the tube. Thus, the light of the LED chip 12 enters into the remote phosphor structure 2, viz. the elongated body, from the end surfaces. Obviously, the light incident at this position can travel the longest distance in the remote phosphor structure 2, and thereby hit the most phosphor 26. In practice, the remote phosphor structure 2 is actually similar to a light conductor, the light entering the light conductor will be totally reflected between the two emergent surfaces, and further hit

the phosphor 26, in order to excite the phosphor to emit light, the excited light is mixed with the light emitted by the LED chip 12 to obtain light having an expected color, e.g., the LED chip 12 emits blue light, and the yellow phosphor is used, then white light is obtained. However, the light may also emerge from the second emergent surface 23, which is undesired as the region facing the first emergent surface 21 is expected to be the illuminated region, then an individual reflector 3 is provided, and the reflector 3 reflects the light emerging from the second emergent surface 23 back to the remote phosphor structure 2, and make the light emerge from the first emergent surface 21.

Fig. 3 is a schematic diagram of a variant of a second embodiment of the LED illumination device 100 according to the present invention. The difference between the solution shown in Fig. 3 and the solution shown in Fig. 2 merely lies in the shape of the remote phosphor structure 2. In the variant shown in Fig. 3, the remote phosphor structure 2 is configured to be plate-like, wherein the remote phosphor structure 2 comprises an upper surface and a lower surface which respectively serve as the first emergent surface 21 and the second emergent surface 23, and four circumferential surfaces, opposite each other, which are connected between the upper surface and the lower surface as the connection surfaces, wherein two of the circumferential surfaces with the longest distance therebetween are configured as the incident surfaces 22. As can be seen in Fig. 3, the remote phosphor structure 2 is actually a rectangular plate-like hexahedron, wherein four surfaces of the hexahedron having a smaller width serve as the circumferential surfaces of the remote phosphor structure 2, and the circumferential surfaces having a smaller length serve as the incident surfaces 22, and the LED chips are disposed on the circumferential surfaces. In

the present variant, it is also necessary to make the light travel the longest distance in the remote phosphor structure 2, so two circumferential surfaces with the longest distance therebetween are selected as the incident surfaces 22. This type of solution can, for example, advantageously replace the conventional plate glass, when it does not work, it can serve as simple and transparent glass, and when it works, it can provide illumination.

In addition, for the sake of simplification, the reflector 3 and the printed circuit board 11 are not shown in Fig. 3.

Fig. 4 is a schematic diagram of a third embodiment of the LED illumination device 100 according to the present invention. In this embodiment, the remote phosphor structure 2 comprises only one connection surface, wherein the remote phosphor structure 2 is configured to be bulb-like, wherein the bulb-like remote phosphor structure 2 comprises an inner surface and an outer surface which serve as the first emergent surface 21 and the second emergent surface 23, respectively, a ring-like support surface which is connected between the inner surface and the outer surface as the connection surface is formed at an opening end of the bulb-like remote phosphor structure 2, and the ring-like support surface is configured as the incident surface 22. Different from the prior art solution shown in Fig. 1, the LED chip 12 disposed on the circuit board 11 is not disposed within the bulb-like remote phosphor structure 2, that is, the space defined by the second emergent surface 23, but is disposed on the connection surface between the first emergent surface 21 and the second emergent surface 23. In this way, the light emitted by the LED chip 12 will enter into the remote phosphor structure 2 at the position of the connection surface. As can be seen from the figure, the light travels obviously farther in the

remote phosphor structure 2, as compared with the prior art solution shown in Fig. 1.

In addition, in the present embodiment, the circuit board 11 is at least partially formed as the reflector 3. In the solution of configuring the remote phosphor structure to be bulb-like, as the remote phosphor structure 2 which serves as a bulb, will be disposed on the circuit board 11 and supported on the LED chip 12 using the ring-like support surface, and the inner surface of the bulb will face the circuit board 11, it is very advantageous to configure a portion of the circuit board 11 facing the inner surface as a reflector.

Fig. 5 is a schematic diagram of an improved solution of the third embodiment of the LED illumination device 100 according to the present invention. The differences between the solution shown in Fig. 5 and the solution shown in Fig. 4 lie in that, the remote phosphor structure 2 further comprises a total internally reflective lens 24 disposed on the incident surface 22, viz. the ring-shaped support surface, and at least a portion of light from the LED chip 12 enters into the remote phosphor structure 2 through the incident surface 22 after being totally internally reflected in the total internally reflective lens 24. The total internally reflective lens 24 enables the light of the LED chip 12 to enter into the remote phosphor structure 2 at a favorable angle, such that the light extends as far as possible in the remote phosphor structure 2, which further improves the light conversion efficiency of the remote phosphor structure 2.

As can be further seen from the figure, the total internally reflective lens 24 is configured to be ring-like, and comprises a lens incident surface 241 and a lens emergent surface 242, wherein the lens emergent surface 242 has the same

shape as the ring-like support surface. In addition, the lens incident surface 241 defines an accommodation cavity 243 for accommodating the LED chip 12. Such type of total internally reflective lens is capable of guiding all the light of the  
5 LED light engine into the remote phosphor structure 2, which thereby further avoids light loss.

The above is merely preferred embodiments of the present invention but not to limit the present invention. For the person skilled in the art, the present invention may have various alterations and changes. Any alterations, equivalent sub-  
10 stitutions, improvements, within the spirit and principle of the present invention, should be covered in the protection scope of the present invention.

## List of reference signs

|    |     |                                  |
|----|-----|----------------------------------|
| 1  |     | LED light engine                 |
| 11 |     | circuit board                    |
| 12 |     | LED chip                         |
| 5  | 2   | remote phosphor structure        |
| 21 |     | first emergent surface           |
| 22 |     | incident surface                 |
| 23 |     | second emergent surface          |
| 24 |     | total internally reflective lens |
| 10 | 241 | lens incident surface            |
|    | 242 | lens emergent surface            |
|    | 243 | accommodation cavity             |
|    | 25  | transparent body                 |
|    | 26  | phosphor                         |
| 15 | 3   | reflector                        |

## Claims

1. An LED illumination device (100) comprising an LED light engine (1), and a remote phosphor structure (2) comprising a first emergent surface (21) and an incident surface (22), characterized in that, the remote phosphor structure (2) further comprises a second emergent surface (23) disposed opposite the first emergent surface (21), and at least one connection surface connected between the first emergent surface (21) and the second emergent surface (23), and the connection surface is configured as the incident surface (22), wherein light from the LED light engine (1) enters into the remote phosphor structure (2) through the incident surface (22), and emerges through the first emergent surface (21) and the second emergent surface (23).
2. The LED illumination device (100) according to Claim 1, characterized in that, the LED illumination device (100) further comprises a reflector (3) which is disposed to face the first emergent surface (21) or the second emergent surface (23).
3. The LED illumination device (100) according to Claim 1 or 2, characterized in that, the remote phosphor structure (2) comprises at least two connection surfaces, wherein one or more connection surfaces, which allow light to travel a longer distance in the remote phosphor structure (2), are configured as the incident surface (22).
4. The LED illumination device (100) according to Claim 3, characterized in that, the remote phosphor structure (2) is configured as an elongated body having an arc-shaped

section, wherein the elongated body comprises an inner surface, an outer surface, and two opposite end surfaces serving as the connection surfaces, which are connected between the inner surface and the outer surface and are disposed opposite each other in a longitudinal direction of the elongated body, one or both end surfaces are configured as the incident surfaces (22).

5. The LED illumination device (100) according to Claim 3, characterized in that, the remote phosphor structure (2) is configured to be plate-like, the remote phosphor structure (2) comprises an upper surface and a lower surface which respectively serve as the first emergent surface (21) and the second emergent surface (23), and four circumferential surfaces, opposite each other, which are connected between the upper surface and the lower surface as the connection surfaces, wherein two or more of the circumferential surfaces with the longest distance therebetween are configured as the incident surfaces (22).

6. The LED illumination device (100) according to Claim 1 or 2, characterized in that, the remote phosphor structure (2) comprises only one connection surface that is configured to be ring-like.

7. The LED illumination device (100) according to Claim 6, characterized in that, the remote phosphor structure (2) is configured to be bulb-like, wherein the bulb-like remote phosphor structure (2) comprises an inner surface and an outer surface which serve as the first emergent surface (21) and the second emergent surface (23), respectively, a ring-like support surface which is connected between the inner surface and the outer surface

as the connection surface is formed at an opening end of the bulb-like remote phosphor structure (2), and the ring-like support surface is configured as the incident surface (22).

- 5 8. The LED illumination device (100) according to Claim 7, characterized in that, the remote phosphor structure (2) further comprises a total internally reflective lens (24) arranged on the incident surface (22), and at least a portion of light from the LED light engine (1) is in-
- 10 cident into the remote phosphor structure (2) through the incident surface (22) after being totally internally reflected in the total internally reflective lens (24).
9. The LED illumination device (100) according to Claim 8, characterized in that, the total internally reflective
- 15 lens (24) is configured to be ring-like, and comprises a lens incident surface (241) and a lens emergent surface (242), wherein the lens emergent surface (242) has the same shape as the ring-like support surface.
10. The LED illumination device (100) according to Claim 9,
- 20 characterized in that, the lens incident surface (241) defines an accommodation cavity (243) for accommodating a luminous body of the LED light engine (1).
11. The LED illumination device (100) according to Claim 1 or 2, characterized in that, the LED light engine (1)
- 25 comprises a circuit board (11) and at least one LED chip (12) disposed on the circuit board (11), wherein the LED chip (12) is disposed to face the incident surface (22).
12. The LED illumination device (100) according to Claim 11, characterized in that, the circuit board (11) is at

least partially formed as the reflector (3).

13. The LED illumination device (100) according to Claim 1 or 2, characterized in that, the remote phosphor structure (2) comprises a transparent body (25) and phosphor (26) filling the transparent body (25).
- 5
14. The LED illumination device (100) according to Claim 13, characterized in that, the transparent body (25) is made of polycarbonate, PMMA, glass or ceramic materials.

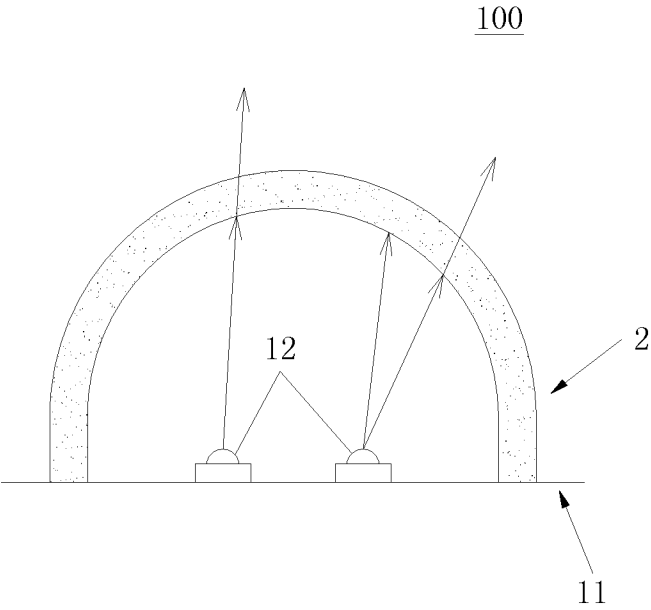


Figure 1

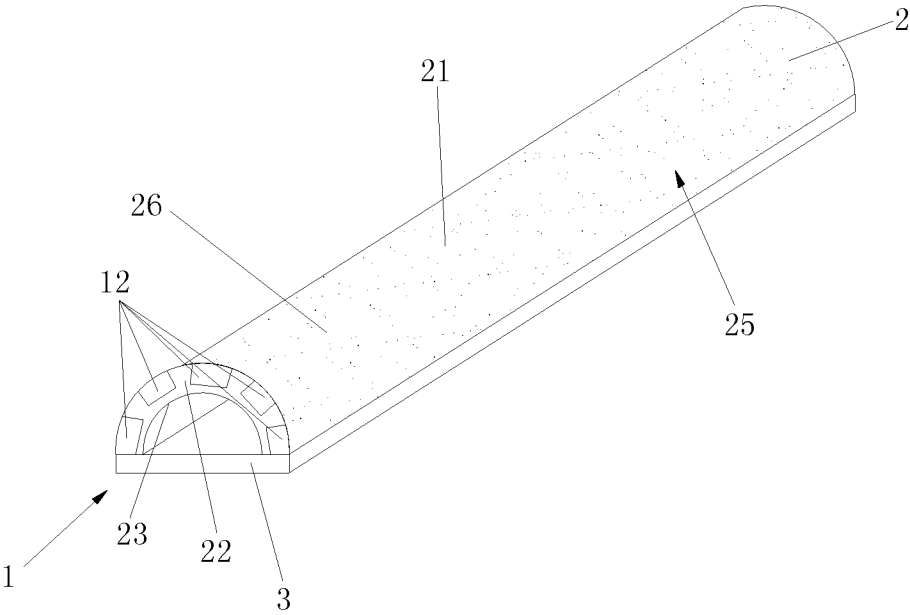


Figure 2

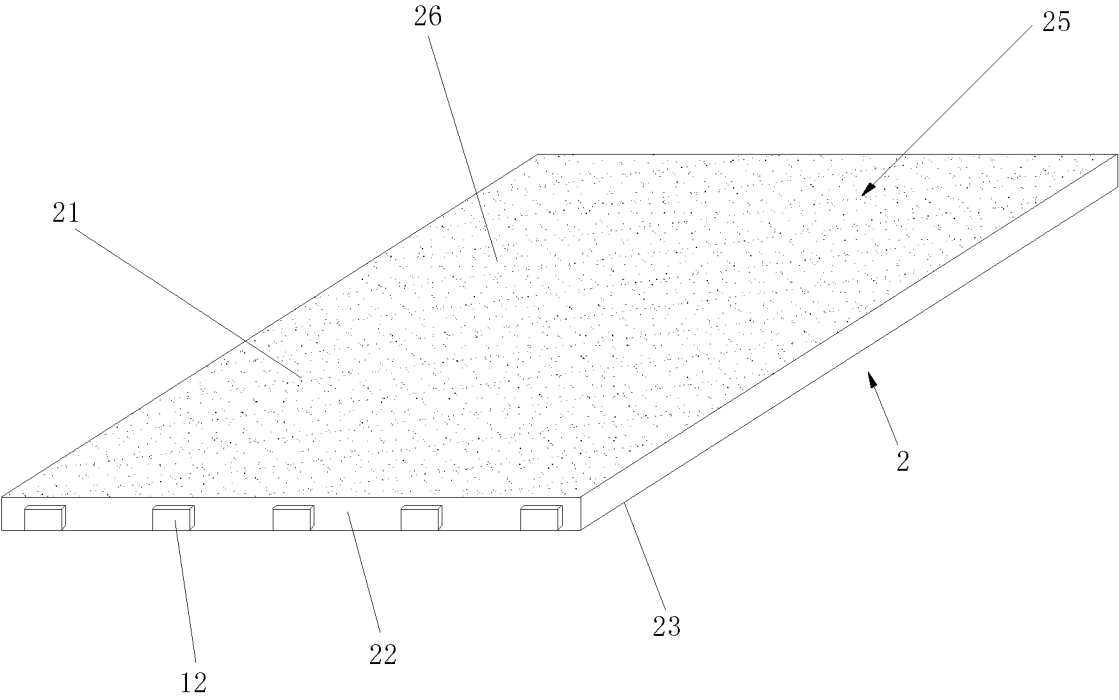


Figure 3

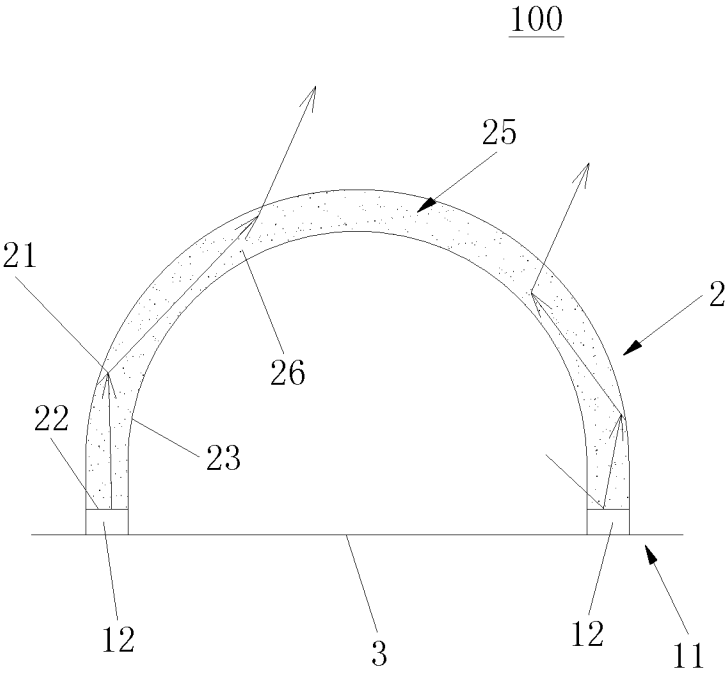
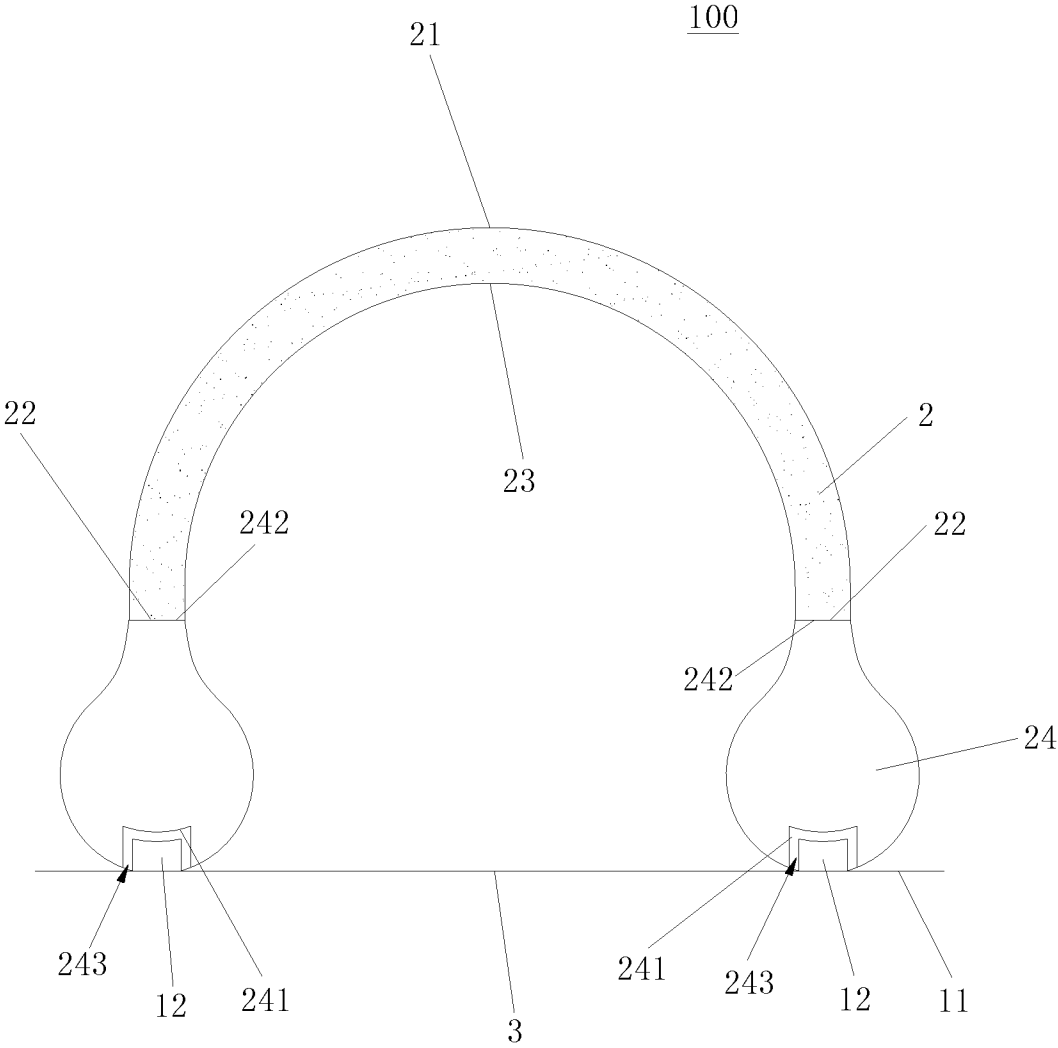


Figure 4



**Figure 5**

# INTERNATIONAL SEARCH REPORT

International application No  
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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| <b>A. CLASSIFICATION OF SUBJECT MATTER</b><br>INV. F21K99/00 G02B6/00<br>ADD. F21Y101/02 F21Y103/00                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |
| According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |
| <b>B. FIELDS SEARCHED</b><br>Minimum documentation searched (classification system followed by classification symbols)<br>F21K F21Y G02B F21V                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |
| 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)<br>EPO-Internal, WPI Data                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |
| Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Relevant to claim No. |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | WO 2010/116305 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; KURT RALPH [NL]; DRENTEN RONALD [])<br>14 October 2010 (2010-10-14)<br>page 7, paragraph 2<br>page 9, paragraph 3<br>figures 1, 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1-3,11,<br>13,14      |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | -----<br>US 2012/212931 A1 (KINOSHITA JUNICHI [JP] ET AL) 23 August 2012 (2012-08-23)<br>paragraphs [0020] - [0025]<br>paragraphs [0058] - [0060]<br>figures 11A, 10A, 10B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1,3,5,<br>11,13,14    |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | -----<br>WO 2012/042843 A1 (MATSUSHITA DENKI SANGYO KK) 5 April 2012 (2012-04-05)<br>abstract; figure 4A<br>-----<br><div style="text-align: right;">-/-</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1,2,6-14              |
| <div style="display: flex; justify-content: space-between;"> <span><input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.</span> <span><input checked="" type="checkbox"/> See patent family annex.</span> </div>                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |
| * Special categories of cited documents :                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |
| "A" document defining the general state of the art which is not considered to be of particular relevance<br>"E" earlier application or patent but published on or after the international filing date<br>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)<br>"O" document referring to an oral disclosure, use, exhibition or other means<br>"P" document published prior to the international filing date but later than the priority date claimed | "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention<br>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone<br>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art<br>"&" document member of the same patent family |                       |
| Date of the actual completion of the international search<br><br><div style="text-align: center;">25 September 2013</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Date of mailing of the international search report<br><br><div style="text-align: center;">04/10/2013</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       |
| Name and mailing address of the ISA/<br>European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016                                                                                                                                                                                                                                                                                                                                                                                                       | Authorized officer<br><br><div style="text-align: center;">Allen, Katie</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       |

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| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                                                                                                  |                       |
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Information on patent family members

International application No

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| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)                                                                                                      | Publication<br>date                                                                            |
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