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(54) Title: LIGHTING DEVICE

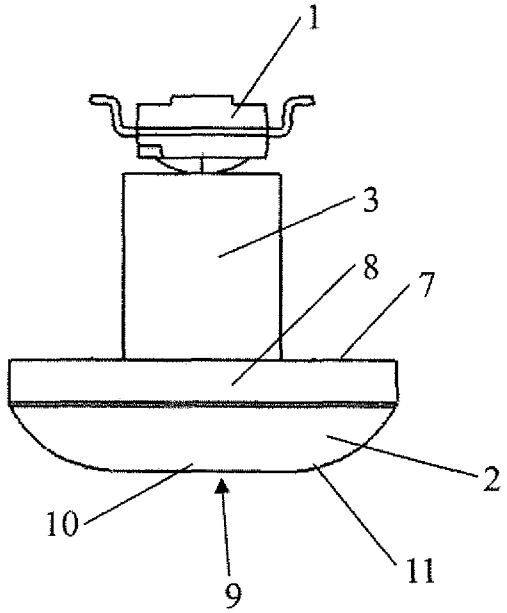


FIG.1

(57) Abstract: The present invention relates to a lighting device, comprising: a lighting module (1); phosphor (12) disposed at a light output side of the lighting module (1); and an optical lens (2) provided at the downstream of the lighting module (1), wherein, a light mixing element (3) is further disposed between the lighting module (1) and the optical lens (2), wherein the light of the lighting module (1) and the light emitted by the phosphor (12) due to the excitation of the light of the lighting module (1) are emitted from a light mixing element exit surface (4) of the light mixing element (3) and enter the optical lens (2), wherein at least a part of the light is emitted after being reflected in the light mixing element (3). The lighting device according to the present invention does not generate or only generates unobvious color ring and can obtain uniform color distribution and controllable light density distribution as well as relatively small light loss.

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Description

Lighting Device

Technical Field

The present invention relates to a lighting device which does not generate any or only generates unobvious color ring, and can obtain uniform color distribution and controllable light density distribution as well as relatively small light loss.

Background Art

In current lighting devices, especially in LED lighting modules, to obtain white light, usually a method of coating phosphor on an LED chip is used. Usually the phosphor has a wider distribution range than the LED chip, and then part of the light of the phosphor cannot be mixed with the light of the LED chip, so that color ring is generated at the periphery of an illuminated surface. To obtain an ideal light density distribution, LED lighting modules are usually equipped with a second optical lens, wherein, one method is to add a diffuser after an LED lens, and thus the color becomes uniform on the overall illuminated surface. However, the method has a disadvantage that the light density distribution of the light passing through the diffuser becomes uncontrollable and even unpredictable due to the physical structure characteristics of the diffuser. Another method is to fabricate the surface of the LED lens to a structure of a diffuser, and then the additional diffuser need not be used. However, this method also has the disadvantage that the light density distribution of the light is uncontrollable and unpredictable. In addition, light loss will be incurred regardless of adding the diffuser before or after the lens.

Summary of the Invention

Therefore, the present invention aims to provide a lighting device which does not generate any or only generates unobvious color ring, and can obtain uniform color distribution and controllable light density distribution as well as relatively small light loss.

The object of the present invention is realized in the following way, i.e., a lighting module; phosphor disposed at a light output side of the lighting module; and an optical lens provided at the downstream of the lighting module, wherein, a light

mixing element is further disposed between the lighting module and the optical lens, wherein the light of the lighting module and the light emitted by the phosphor due to the excitation of the light of the lighting module are emitted from a light mixing element exit surface of the light mixing element and enter the optical lens, wherein at least a part of the light is emitted after being reflected in the light mixing element. The lighting device according to the present invention can have the light from the lighting module and a part of the light emitted by the phosphor due to the excitation of the light of the lighting module reflected in the light mixing element and mixed at the light output surface of the lighting module with additional refracted or reflected light, thus obtaining light with uniform color distribution and controllable light density distribution.

According to a preferable design of the present invention, the light mixing element has at least one light reflecting surface, wherein, the at least one light reflecting surface is used to have at least a part of the light reflected in the light mixing element. In addition, the light mixing element further comprises a light mixing element incident surface parallel to the light mixing element exit surface, wherein, at least one light reflecting surface is perpendicular to the light mixing element exit surface and the light mixing element incident surface. In this type of structure of light mixing element, incident light is subjected to total reflection at a light reflecting surface after being projected to the light mixing element incident surface, then output from the light mixing element exit surface and mixed with other refracted and reflected light, thus obtaining uniform color distribution and controllable light density distribution. Also, as the light is subjected to total reflection in the light mixing element, only very small light loss is generated.

As put forward in a design according to the present invention, the distance from the light mixing element exit surface to the light mixing element incident surface is at least 1.5 times of the width of the light mixing element exit surface or the light mixing element incident surface, thereby ensuring that part of the light can be totally reflected at the light reflecting surface.

According to a preferable design of the present invention, the light mixing element exit surface is designed to be a diffusive surface having a diffusive structure. Light from the lighting module has been mixed in the light mixing element, and this structure of the light mixing element exit surface can further optimize the light density distribution. Of course, this diffusive surface cannot be designed to obtain expected light distribution, while the fabricating process of the diffusive surface can

be controlled, for example, controlling the size of the particles on the diffusive surface, to obtain stable light distribution. During experiments the light distribution is measured, and the optical lens is correspondingly designed according to result of the measurement to obtain the expected light distribution.

According to a preferable design of the present invention, a lens incident surface of the optical lens comprises a rotatably symmetric concave region, the light mixing element is provided in the concave region, and a lens exit surface of the optical lens comprises a central region with concave bending and an edge region with convex bending, and the central region has a smooth transition towards the edge region. The light mixed by the light mixing element is emitted into the lens at the concave region of the lens incident surface and is emitted from the central region and the edge region of the lens exit surface. This structure of the lens advantageously improves the light density of the light output from the lighting module, and then the plane illuminated by the lighting device is also advantageously amplified.

According to a preferable design of the present invention, the light mixing element is designed to be a cylinder, a cube or a prism, and thus can better match different types of structures of lighting modules.

Preferably, the optical lens and the light mixing element according to the present invention are made from any material of polycarbonate (PC), methyl methacrylate-styrene copolymer (NAS), nylon, ADC plastic (CR-39), polystyrene, styrene-acrylonitrile copolymer or silicon dioxide. Of course, it can also be made from other materials having fine transmittance to reduce the light loss of the light when passing through the light mixing element.

It should be understood that the above general description and the following detailed description are for listing and explanation, and aim to provide further explanation of the claimed invention.

Brief Description of the Drawings

The accompanying drawings constitute a part of the Description and are used to provide further understanding of the present invention. Such accompanying drawings illustrate the embodiments of the present invention and are used to describe the principles of the present invention together with the Description. In the accompanying drawings the same components are represented using the same

reference. As shown in the drawings:

Figure 1 is a schematic view of the lighting device according to the present invention;

Figure 2 is a schematic view of the light mixing element of the lighting device according to the present invention; and

Figures 3a-c illustrates different embodiments of the light mixing element of the lighting device according to the present invention.

Detailed Description of the Embodiments

Figure 1 is a schematic view of the lighting device according to the present invention. The lighting device comprises: a lighting module 1, being an LED module in this embodiment; phosphor (see Figure 2) disposed at a light output side of the lighting module 1; and an optical lens 2 provided at the downstream of the lighting module 1; and a light mixing element 3 disposed between the lighting module 1 and the optical lens 2, which is a light mixing rod in the present embodiment. The light from the LED module 1 and the light emitted from the phosphor due to the excitation of the light of the LED module 1 are mixed by the light mixing rod 3 and then outputted from the optical lens 2. In addition, also seen from Figure 1, a lens incident surface 7 of the optical lens 2 comprises a rotatably symmetric concave region 8, and the light mixing rod 3 is provided in the concave region 8. In addition, a lens exit surface 9 of the optical lens 2 includes a central region 10 with concave bending and an edge region 11 with convex bending, and the central region 10 has a smooth transition towards the edge region 11. The light mixed by the light mixing element 3 is emitted into the optical lens 2 at the concave region 8 of the lens incident surface 7 and is emitted from the central region 10 and the edge region 11 of the lens exit surface 9.

Figure 2 illustrates the schematic view of the light mixing element 3 of the lighting device according to the present invention. Seen from Figure 2, phosphor 12 is provided at the light output surface of the LED module 1, and covers and exceeds the light output surface of the LED module 1. The light (shown in solid line) emitted from the LED module 1 and the light (shown in broken line) emitted from the phosphor 12 are reflected at the light reflecting surface 6 of the light mixing rod 3 or pass through the light mixing rod 3, and are mixed with other light at the light

mixing element exit surface of the light mixing rod 3, and as shown in the figure, the crossing of the solid line and the broken line shows the mixing, thereby obtaining expected light. Seen from the figure, the light mixing rod 3 has a light mixing element exit surface 4 and a light mixing element incident surface 5 parallel to the same, wherein, the light reflecting surface 6 is perpendicular to the light mixing element exit surface 4 and the light mixing element incident surface 5. The distance from the light mixing element exit surface 4 to the light mixing element incident surface 5 is at least 1.5 times of the width of the light mixing element exit surface 4 or the light mixing element incident surface 5. In addition, the light mixing element exit surface 5 is designed to be a diffusive surface having a light diffusive structure.

Figures 3a-c illustrates different embodiments of the light mixing element of the lighting device according to the present invention. In Figure 3a the light mixing element is designed to be a cylinder, in Figure 3b the light mixing element is designed to be a cube, and in Figure 3c it is designed to be a hexagonal prism. Such light mixing elements all have the light mixing element exit surface 4 and the light mixing element incident surface 5, and at least one light reflecting surface 6 perpendiculars to the light mixing element exit surface 4 and the light mixing element incident surface 5. Of course, the light mixing element according to the present invention can also be designed to be in other shapes having at least one light reflecting surface 6.

The descriptions above are only preferable embodiments of the present invention and are not used to restrict the present invention. For those skilled in the art, the present invention may have various changes and variations. Any modifications, equivalent substitutions, improvements etc. within the spirit and principle of the present invention shall all be included in the scope of protection of the present invention.

List of reference signs

1	lighting module (LED module)
2	optical lens
3	light mixing element
4	light mixing element exit surface
5	light mixing element incident surface
6	light reflecting surface
7	lens incident surface
8	concave region of lens incident surface
9	lens exit surface
10	central region
11	edge region
12	phosphor

Claims:

1. A lighting device, comprising: a lighting module (1); phosphor (12) disposed at a light output side of the lighting module (1); and an optical lens (2) provided at the downstream of the lighting module (1), characterized in that a light mixing element (3) is further disposed between the lighting module (1) and the optical lens (2), wherein the light of the lighting module (1) and the light emitted from the phosphor (12) due to the excitation of the light of the lighting module (1) are emitted from a light mixing element exit surface (4) of the light mixing element (3) and enter the optical lens (2), wherein at least a part of the light is emitted after being reflected in the light mixing element (3).

2. The lighting device according to claim 1, characterized in that the light mixing element (3) has at least one light reflecting surface (6), wherein, at least one of the light reflecting surface (6) is used to have at least a part of the light reflected in the light mixing element (3).

3. The lighting device according to claim 2, characterized in that the light mixing element (3) further comprises a light mixing element incident surface (5) parallel to the light mixing element exit surface (4), wherein, at least one light reflecting surface (6) is perpendicular to the light mixing element exit surface (4) and the light mixing element incident surface (5).

4. The lighting device according to claim 2, characterized in that the distance from the light mixing element exit surface (4) to the light mixing element incident surface (5) is at least 1.5 times of the width of the light mixing element exit surface (4) or the light mixing element incident surface (5).

5. The lighting device according to claim 2, characterized in that the light mixing element exit surface (5) is designed to be a diffusive surface having a light diffusive structure.

6. The lighting device according to claim 1, characterized in that the center of a lens incident surface (7) of the optical lens (2) comprises a rotatably symmetric concave region (8), the light mixing element (3) is provided in the concave region (8), a lens exit surface (9) of the optical lens (2) includes a central region (10) with concave bending and an edge region (11) with convex bending, and the central region (10) has a smooth transition towards the edge region (11).

7. The lighting device according to any one of claims 1 to 6, characterized in that the light mixing element (3) is designed to be a cylinder, a cube or a prism.

8. The lighting device according to any one of claims 1 to 6, characterized in that the optical lens and the light mixing element (3) are made from any material of polycarbonate (PC), methyl methacrylate-styrene copolymer (NAS), nylon, ADC plastic (CR-39), polystyrene, styrene- acrylonitrile copolymer or silicon dioxide.

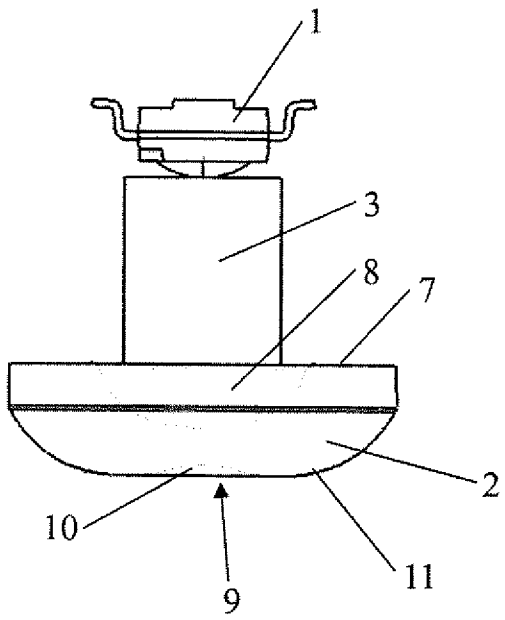


FIG.1

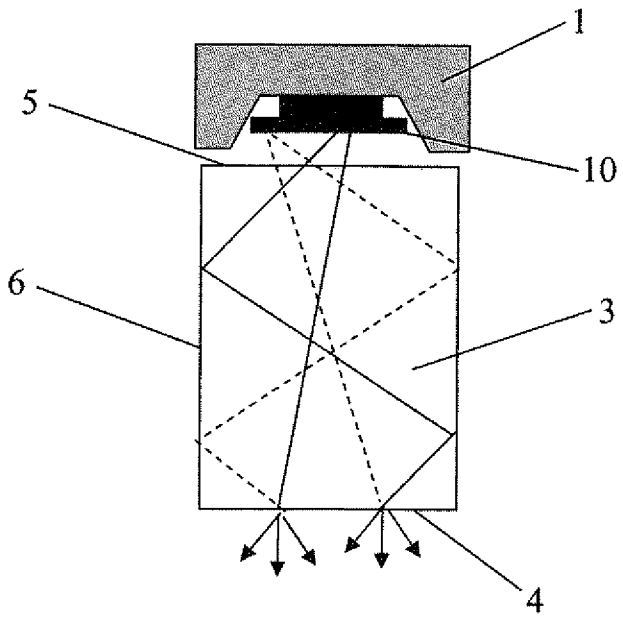


FIG.2

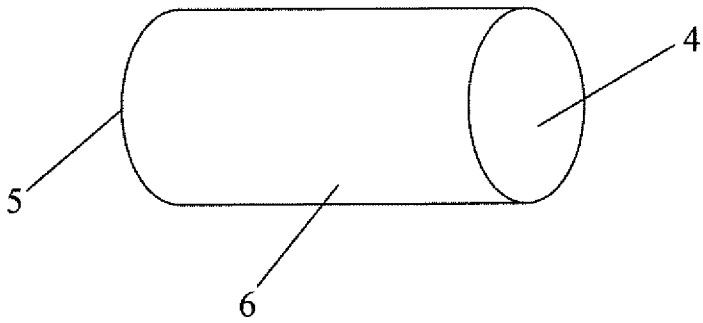


FIG.3a

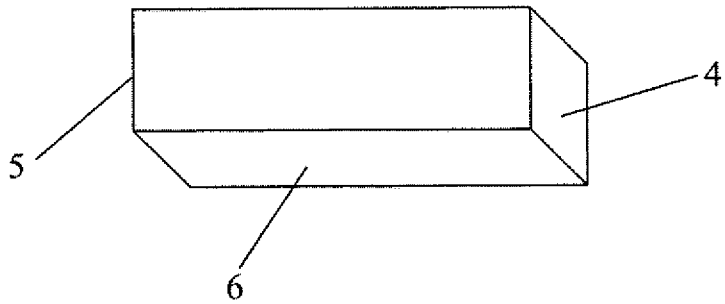


FIG.3b

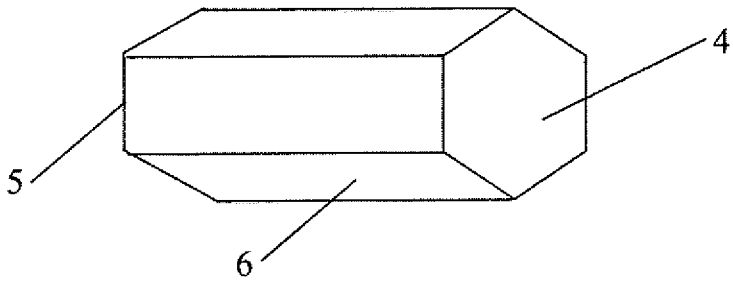


FIG.3c

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/064316

A. CLASSIFICATION OF SUBJECT MATTER
INV. F21K99/00
ADD. F21Y101/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F21K F21V G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/105646 A1 (TIR SYSTEMS LTD [CA]; SPEIER INGO [CA]) 12 October 2006 (2006-10-12) paragraph [0075] - paragraph [0153] figures 8-15	1-8
X	WO 2008/016895 A2 (3M INNOVATIVE PROPERTIES CO [US]) 7 February 2008 (2008-02-07) page 4, line 11 - page 9, line 8 figures 3,5,8,10,12,13	1-8
A	JP 2009 152142 A (PANASONIC ELEC WORKS CO LTD) 9 July 2009 (2009-07-09) paragraph [0001] - paragraph [0027] figure 4	1

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

☒ See patent family annex.

* Special categories of cited documents :

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"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

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Date of the actual completion of the international search	Date of mailing of the international search report
27 January 2012	06/02/2012

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/064316

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2006105646 A1	12-10-2006	CA 2620144 A1	12-10-2006
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