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(54) Title: LIGHTING DEVICE

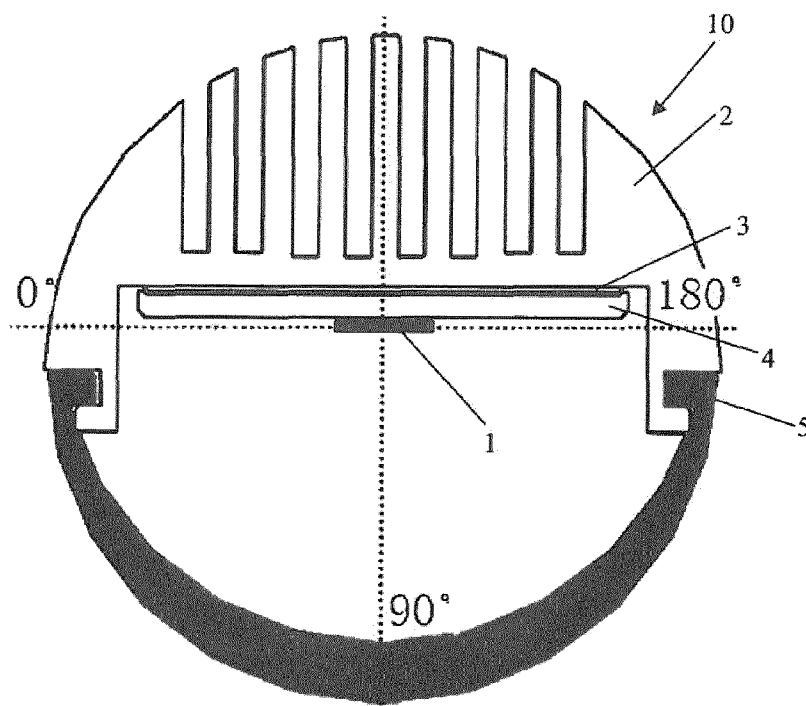


Figure 4

[Continued on next page]



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(57) Abstract: The present invention relates to a lighting device (10), comprising a circuit board (4) and a LED lighting chip (1) provided on one side of the circuit board (4), characterized by, further comprising a phosphor layer (5) arranged to enclose the LED lighting chip (1), wherein the phosphor layer (5) has different thicknesses at different light emergence angles. The lighting device according to the present invention can achieve significantly improved CCT uniformity.

Description

Lighting device

5 **Technical Field**

The present invention relates to a lighting device.

Background Art

Currently, light emitting diode (LED) lighting devices has been widely used in daily life. Such lighting devices may
10 emit white light or white-like light. However, since white light is mixed light, ideal white light is obtained mainly by a light mixing process in the LED lighting devices in the prior art. The emitted white light directly passes through the cover of the lighting device to be incident on an object.

15 There exists a technical concept of using a blue LED for realizing the emission of white light, in which white light is obtained by mixing light through setting the blue LED and a phosphor layer, viz. the blue light emitted by the blue LED passes through the phosphor layer to be converted into yellow
20 light and this yellow light and the rest of blue light are mixed to become white light.

Since the light distribution from the LED is usually not uniform in all directions in the prior art, the blue/yellow ratio is not a fixed value in different directions when the
25 blue light interacts with the phosphor layer to form white light, leading to non-uniform angular CCT distribution.

Summary of the Invention

The object of the present invention lies in providing a lighting device, which may realize uniform angular CCT distribution.

The lighting device according to the present invention comprises a circuit board and a LED lighting chip provided on one side of the circuit board, characterized by, further comprising an phosphor layer arranged to enclose the LED lighting chip, wherein the phosphor layer has different thicknesses at different light emergence angles.

10 The present invention provides a solution of compensating CCT by adjusting the thickness of the phosphor layer so as to realize relatively uniform CCT. The inventor has found that, in the case where the thickness of the phosphor layer is unchanged, CCT values at respective angels decrease in a direction from the position where light is emitted perpendicularly to the positions at two sides where the light is emitted horizontally, and the above difference is very large. The inventor firstly provide the solution that the ratio of the light generated by a LED to the light generated by exciting the phosphor layer is adjusted by adjusting the thickness of the phosphor layer at different light emergence angles so as to realize uniform CCT.

Preferably, the thickness of the phosphor layer increases with the increase of the intensity of light incident on the phosphor layer. Accordingly, the thickness of the phosphor layer is larger at the position where the light intensity is higher, while the thickness of the phosphor layer is smaller at the position where the light intensity is lower, such that the ratio of the light generated by the LED to the light generated by exciting the phosphor layer is adjusted to realize uniform CCT.

Preferably, the phosphor layer is arc-shaped. Other suitable shape also may be considered.

Preferably, the LED lighting chip is a blue LED chip, such that the ratio of blue light to yellow light is adjusted to realize uniform CCT. Other LED lighting chips generating white light by mixing fluorescent light may certainly be used.

Preferably, the phosphor layer has a thickness matching with the light distribution of the blue LED chip and has a thickness distribution gradually decreasing from the position where the light emergence angle is 90° in a direction towards 0° or 180° .

Preferably, the maximum thickness of the phosphor layer at the position where the light emergence angle is 90° is 1.5 mm and the minimum thickness thereof at the position where the light emergence angle is 0° or 180° is 0.7 mm. The above values can achieve excellent CCT distribution.

Preferably, the phosphor layer is distributed in a range of light emergence angle from 0 to 180° , thereby forming a semi-circular phosphor layer.

Preferably, the phosphor layer is arranged a certain distance away from the LED lighting chip. This means that a certain distance exists between the phosphor layer and the LED chip, thereby ensuring that the heat generated by the LED in the operating state slightly affects the temperature of the phosphor in the phosphor layer. Preferably, in the case where a plurality of the LED lighting chips are arranged, the distance is greater than or equal to a distance between every two LED lighting chips. Thus, the negative effect of the

heat to the phosphor can be substantially eliminated.

According to one preferred solution of the present invention, the phosphor layer is made of plastic doped with phosphor. Such design may advantageously reduce the weight of the lighting device itself and reduce the interface passed by the emitted light. The phosphor suitable for the LED light source may be, e.g., YAG phosphor, nitride phosphor, and silicate phosphor.

According to one alternative preferred solution of the present invention, there is also included a light-transmissive cover, the inner surface of which facing the LED lighting chip is coated with the phosphor layer, thereby allowing for a relatively simple manufacturing process.

Preferably, the phosphor layer comprises phosphor and silicon epoxy.

Preferably, the lighting device further comprises a heat sink, which is provided on the other side of the circuit board and engages the phosphor layer or the light-transmissive cover coated with the phosphor layer to define an enclosed cavity accommodating the circuit board provided with the LED lighting chip. The flexible engagement of the plastic phosphor layer with the heat sink realizes a simply-structured locking configuration.

Preferably, the heat sink and the phosphor layer or the light-transmissive cover coated with the phosphor layer define a tubular profile, thereby obtaining a solution with a simpler structure, a better appearance, and higher universality.

Preferably, a heat conducting glue is provided between the heat sink and the circuit board, which may fix the heat sink and the circuit board in a simple way and achieve better heat conduction performance.

- 5 The lighting device according to the present invention may achieve uniform angular CCT distribution, which improves significantly the performance of the lighting device.

It shall be understood that the above general description and the following detailed description are both for illustrative
10 and explanative purposes so as to provide further description of the claimed present invention.

Brief Description of the Drawings

Multiple preferred embodiments according to the present invention are hereinafter illustrated with reference to the
15 figures, wherein

Fig. 1 is a view of typical LED light intensity distribution;

Fig. 2 is another curve chart of a change of CCT value when using a lighting device having a phosphor layer with a uniform thickness;

- 20 Fig. 3 is a stereoscopic view of a lighting device according to the present invention;

Fig. 4 is an enlarged cross-sectional view of a lighting device according to the present invention, wherein the structure of a phosphor layer is shown clearly; and

- 25 Fig. 5 is a view of CCT distribution of a lighting device according to the present invention, wherein it is clearly shown

that the lighting device according to the present invention achieves uniform CCT distribution.

Detailed Description of the Embodiments

Fig. 1 is a view of typical LED light intensity distribution (lambertian type). From the figure, it can be seen that the LED light intensities are different in respective directions. Generally, the light intensity at the perpendicular angular position is the highest and is the lowest at the horizontal angular position. The thick black line indicates a uniform phosphor layer. It can be seen that the ratios of the LED light intensity to the amount of phosphor are different in different directions, resulting in that the CCT is non-uniform.

Fig. 2 is another curve chart of a change of CCT value when using a lighting device having a phosphor layer, wherein it can be seen that the difference between the CCT value of the perpendicular angular position and that of the horizontal angular positions at two sides is up to 500K, resulting in obvious non-uniform CCT distribution.

Fig. 3 is a stereoscopic view of a lighting device according to the present invention. The lighting device is merely used for illustrating the overall layout of the lighting device. The phosphor layer having different thicknesses at different light emergence angles, as mentioned in the present invention, is shown clearly in said figure (as can also be seen from Fig. 4). The lighting device according to the present invention comprises a circuit board 4, a LED lighting chip 1 provided on one side of the circuit board 4 and a heat sink 2 provided on the other side of the circuit board 4, wherein the heat sink 2 and the phosphor

layer 5 engage with each other to define a tubular profile and an enclosed cavity accommodating the circuit board 4 provided with the LED lighting chip 1. A heat conducting glue 3 is provided between the heat sink 2 and the circuit board 4 for realizing the functions of adhesion and heat dissipation, wherein the LED lighting chip 1 is preferably a blue LED chip, by which yellow light is generated via exciting the phosphor layer 5 and is mixed to emit white light. Since the thickness of the phosphor layer 5 is designed as non-uniform and varies with the light intensity, better CCT distribution can be achieved.

The lighting device according to the present invention may be designed as a tubular shape, which has high universality. Certainly, other different shapes may be designed depending on the application fields.

Fig. 4 is an enlarged cross-sectional view of a lighting device 10 according to the present invention, wherein the structure of the phosphor layer 5 is shown clearly. The thickness of the phosphor layer 5 is designed as non-uniform, viz. said thickness is not constant but varies continuously with the angular position. According to Fig. 1 and Fig. 2, it can be determined that the CCT at the perpendicular angular position is far higher than that at the position close to the horizontal angular position when using the phosphor layer with a constant thickness. In order to reduce the difference between the CCT value of the perpendicular angular position and that of the horizontal angular position, the phosphor layer of the present invention decreases continuously in a direction from the perpendicular angular position to the horizontal angular position. The thickness at the perpendicular angular position is designed as a maximum value, such that a lower CCT value can be obtained by adjusting the ratio

of blue light to yellow light.

The phosphor layer 5 can be designed to be formed on a transparent cover 6 enclosing at least one LED lighting chip. The inner surface of the transparent cover 6 facing the LED lighting chip 1 is coated with a phosphor layer comprising phosphor and silicon epoxy or the phosphor layer 5 may be made of plastic doped with phosphor. The transparent cover 6 coated with the phosphor layer 5 or the phosphor layer 5 made of plastic doped with phosphor may be designed as suitable shapes such as an arc shape or an arch shape and has a locking part which forms an enclosed space with the heat sink 2, forming a package structure for the LED lighting chip 1.

Fig. 5 is a view of CCT distribution of a lighting device according to the present invention, wherein it is clearly shown that the lighting device according to the present invention achieves uniform CCT distribution. The difference between the CCT value of the perpendicular angular position and that of the horizontal angular positions at two sides is merely 80K, and such a CCT difference may not be visualized.

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	LED lighting chip
2	heat sink
3	heat conducting glue
5 4	circuit board
5	phosphor layer
6	light-transmissive cover
10	lighting device

Patent claims

1. A lighting device (10), comprising a circuit board (4) and at least one LED lighting chip (1) provided on one side of the circuit board (4), characterized by, further comprising an phosphor layer (5) arranged to enclose the LED lighting chip (1), wherein the phosphor layer (5) has different thicknesses at different light emergence angles.
2. The lighting device (10) according to Claim 1, characterized in that, the thickness of the phosphor layer (5) increases with the increase of the intensity of light incident on the phosphor layer (5).
3. The lighting device (10) according to Claim 2, characterized in that, the LED lighting chip (1) is a blue LED chip.
4. The lighting device (10) according to Claim 3, characterized in that, the phosphor layer (5) has a thickness matching with the light distribution of the blue LED chip and has a thickness gradually decreasing from the position where the light emergence angle is 90° in a direction towards 0° or 180° .
5. The lighting device (10) according to any one of Claims 1 to 4, characterized in that, the maximum thickness of the phosphor layer (5) at the position where the light emergence angle is 90° is 1.5 mm and the minimum thickness thereof at the position where the light emergence angle is 0° or 180° is 0.7mm.
6. The lighting device (10) according to Claim 1, characterized in that, the phosphor layer (5) is distributed in a

range of light emergence angle from 0 to 180°.

7. The lighting device (10) according to any one of Claims 1 to 4, characterized in that, the phosphor layer (5) is arranged a certain distance away from the LED lighting chip (1).

8. The lighting device (10) according to Claim 7, characterized in that, the number of the LED lighting chip is more than one, and the distance is greater than or equal to a distance between every two LED lighting chips.

9. The lighting device (10) according to any one of Claims 1 to 4, characterized in that, the phosphor layer (5) is arc-shaped.

10. The lighting device (10) according to Claim 1, characterized in that, the phosphor layer (5) is made of plastic doped with phosphor.

11. The lighting device (10) according to Claim 1, characterized by, further comprising a light-transmissive cover (6), the inner surface of which facing the LED lighting chip (1) is coated with the phosphor layer (5).

12. The lighting device (10) according to Claim 11, characterized in that, the phosphor layer comprises phosphor and silicon epoxy.

13. The lighting device (10) according to Claim 10 or 11 characterized by, further comprising a heat sink (2), which is provided on the other side of the circuit board (4) and engages the phosphor layer (5) or the light-transmissive cover (6) coated with the phosphor layer (5) to define an en-

closed cavity accommodating the circuit board (4) provided with the LED lighting chip (1).

14. The lighting device (10) according to Claim 13, characterized in that, the heat sink (2) and the phosphor layer (5) or the light-transmissive cover (6) coated with the phosphor layer (5) define a tubular profile.

15. The lighting device (10) according to Claim 13, characterized in that, a heat conducting glue is provided between the heat sink (2) and the circuit board (4).

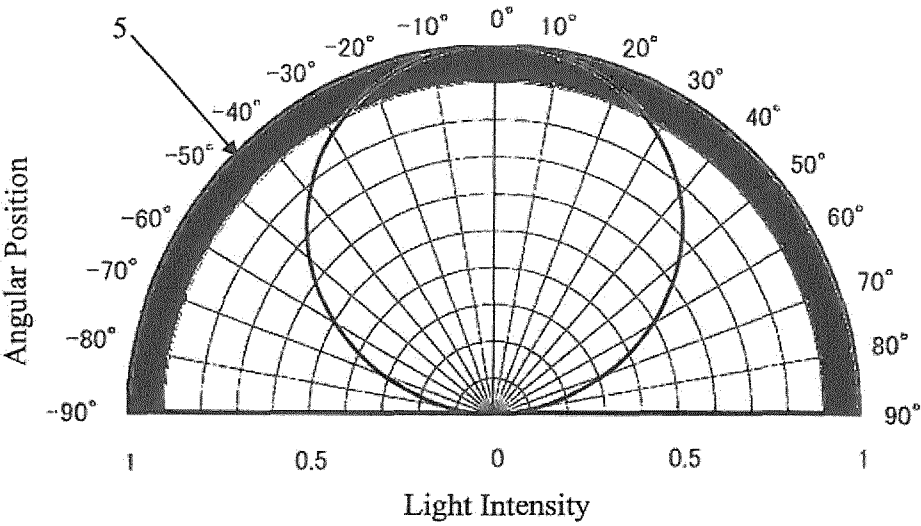
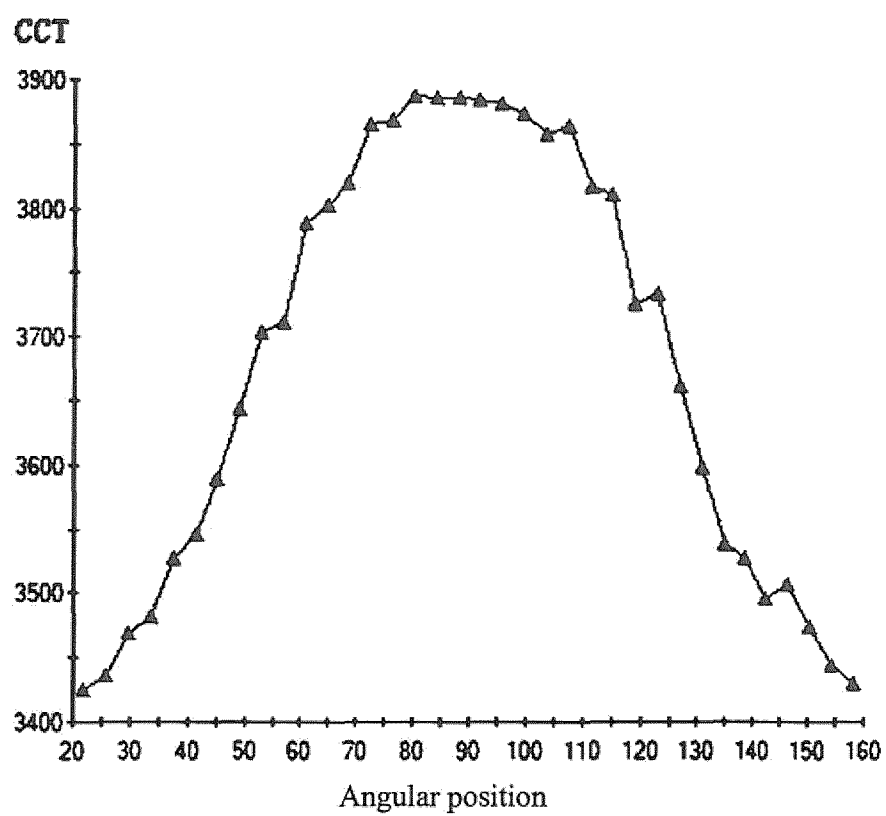
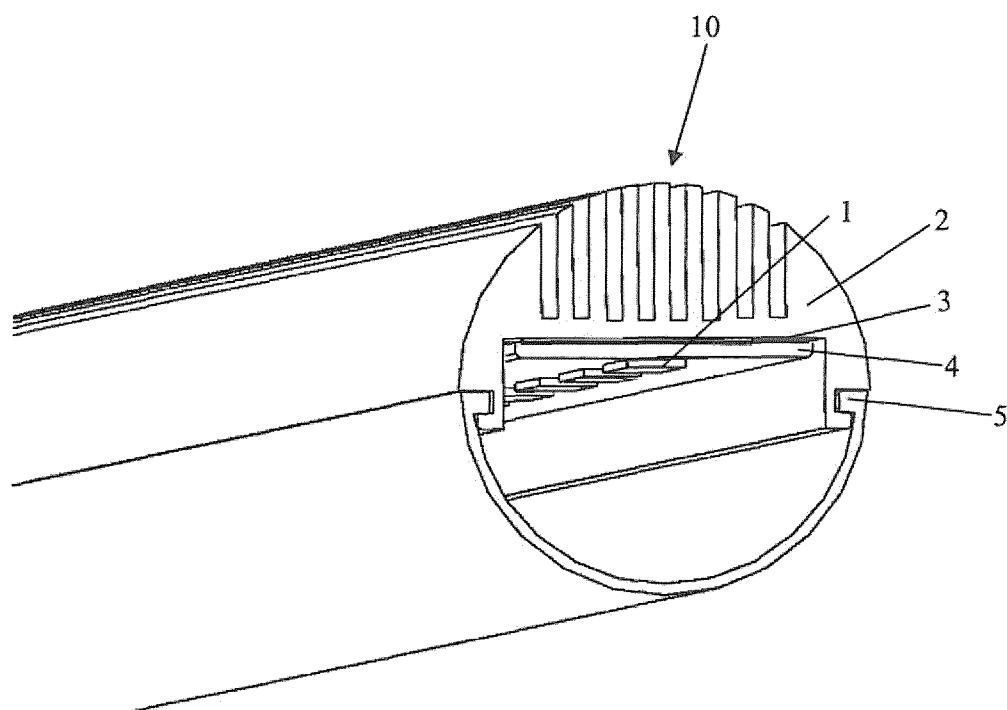


Figure 1

**Figure 2**

**Figure 3**

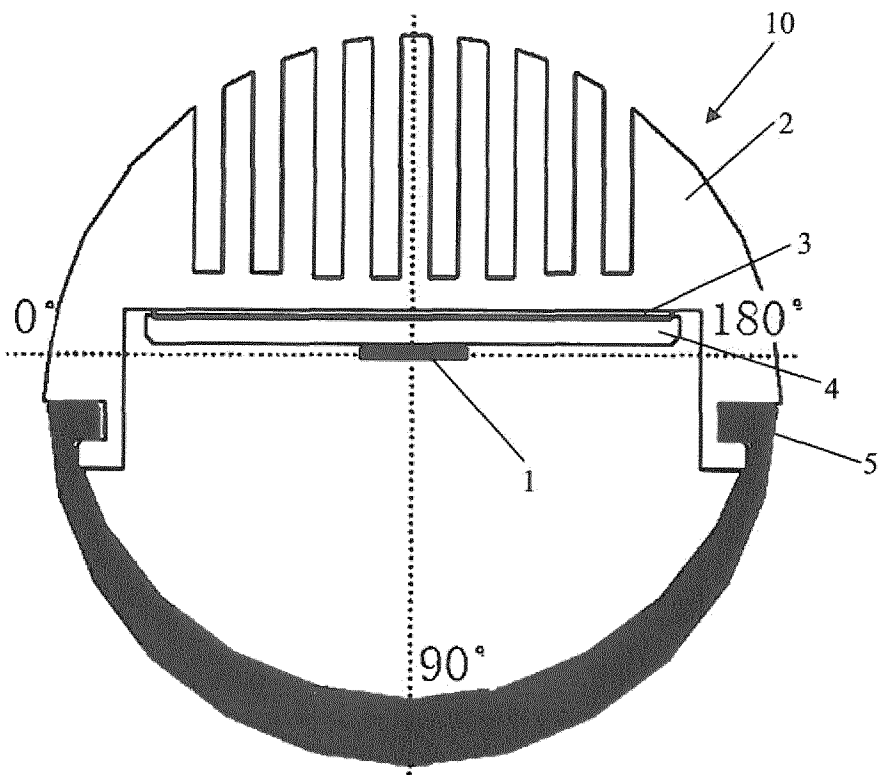
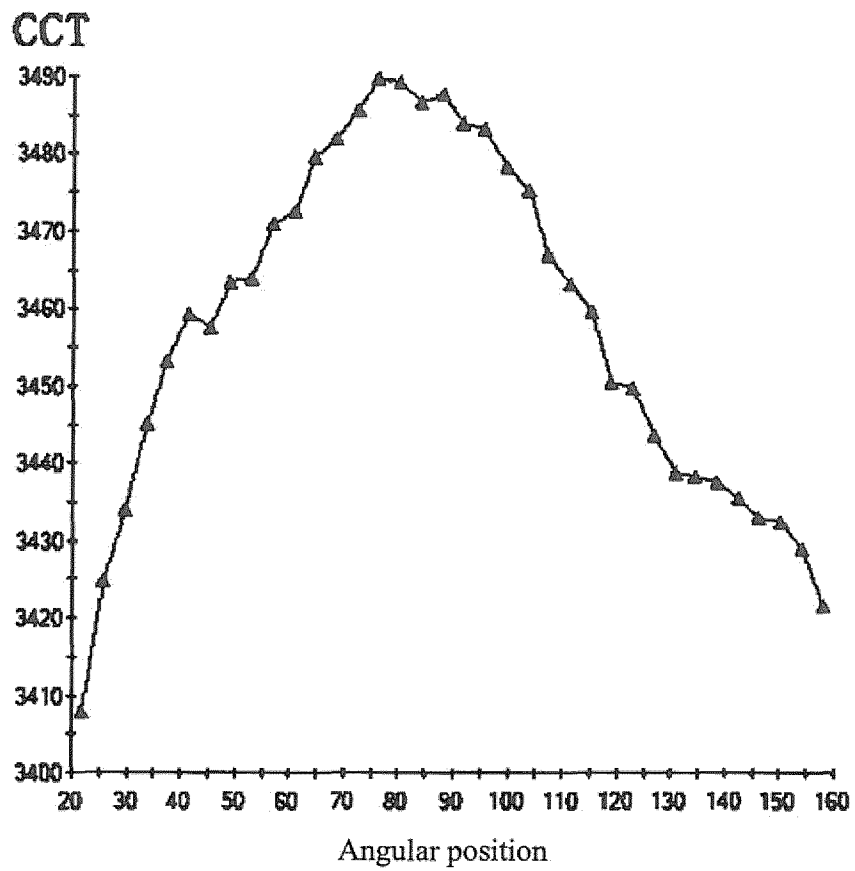


Figure 4

**Figure 5**

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/063727

A. CLASSIFICATION OF SUBJECT MATTER
INV. F21V3/02 H01L33/50
ADD.

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)
F21V H01L F21K

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/315051 A1 (WU CHIA-HAO [TW] ET AL) 24 December 2009 (2009-12-24) abstract; claim 1 paragraph [0023]; figure 2 -----	1-15
A	US 2010/327745 A1 (DASSANAYAKE MAHENDRA [US] ET AL) 30 December 2010 (2010-12-30) abstract paragraph [0088]; figures 15-16 -----	1



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

24 October 2012

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2012/063727

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