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(54) **BACKLIGHT MODULE WITH MJT LED AND BACKLIGHT UNIT INCLUDING THE SAME**

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(73) Assignee: **Seoul Semiconductor Co., Ltd.**, Ansan-si (KR)

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H05B 37/00 (2006.01)
H05B 39/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01L 33/145*** (2013.01); ***F21V 5/048*** (2013.01); ***H01L 27/153*** (2013.01);
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(58) **Field of Classification Search**
CPC H05B 33/0815; H05B 33/0827; H05B 33/083; H05B 33/0845; H05B 37/02;
(Continued)

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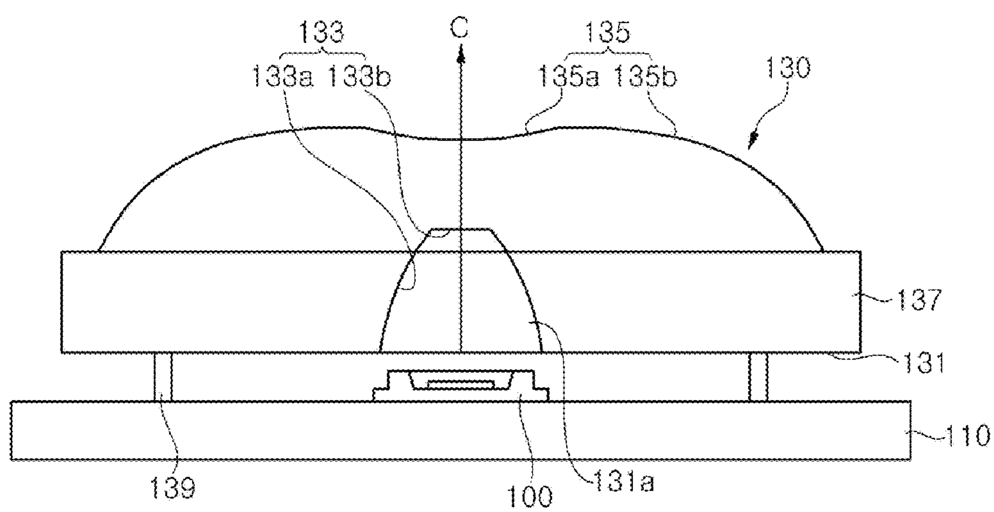
(57) **ABSTRACT**

Embodiments of the disclosure provide a backlight module using MJT LEDs and a backlight unit including the same. More specifically, embodiments of the disclosure provide a backlight module, which includes MJT LEDs configured to increase an effective light emitting area of each of light emitting cells and optical members capable of uniformly dispersing light emitted from the MJT LEDs. In addition, embodiments of the disclosure provide a backlight unit using the backlight module, thereby reducing the number of LEDs constituting the backlight unit while allowing operation at low current.

17 Claims, 16 Drawing Sheets



(51) **Int. Cl.**

H05B 41/00	(2006.01)
H01L 33/14	(2010.01)
F21V 5/04	(2006.01)
H01L 27/15	(2006.01)
H05B 33/08	(2006.01)
G02F 1/1335	(2006.01)
G09G 3/34	(2006.01)
H05B 37/02	(2006.01)
H01L 25/075	(2006.01)
H01L 33/62	(2010.01)

(52) **U.S. Cl.**

CPC ***H05B 33/086*** (2013.01); ***H05B 33/0815*** (2013.01); *G02F 1/1335* (2013.01); *G09G 3/3406* (2013.01); *H01L 25/0753* (2013.01); *H01L 33/62* (2013.01); *H01L 2224/4809* (2013.01); *H01L 2924/0002* (2013.01); *H05B 33/083* (2013.01); *H05B 33/0827* (2013.01); *H05B 37/02* (2013.01); *Y02B 20/347* (2013.01)

(58) **Field of Classification Search**

CPC Y02B 20/347; Y02B 20/346; H01L 2224/4809; H01L 27/14627; H01L 31/0522; H01L 31/0525; G09G 3/3406; G02F 1/1335; F21V 5/048

USPC ...... 315/186, 185 R, 291, 307; 345/102, 204

See application file for complete search history.

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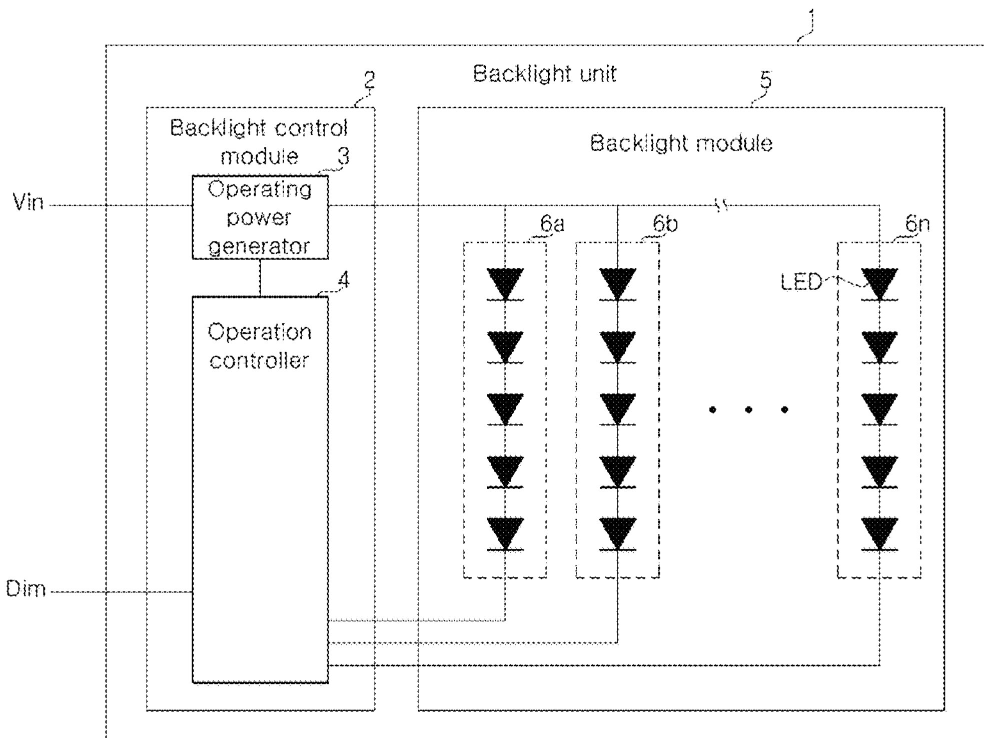
Fig. 1

(Related Art)



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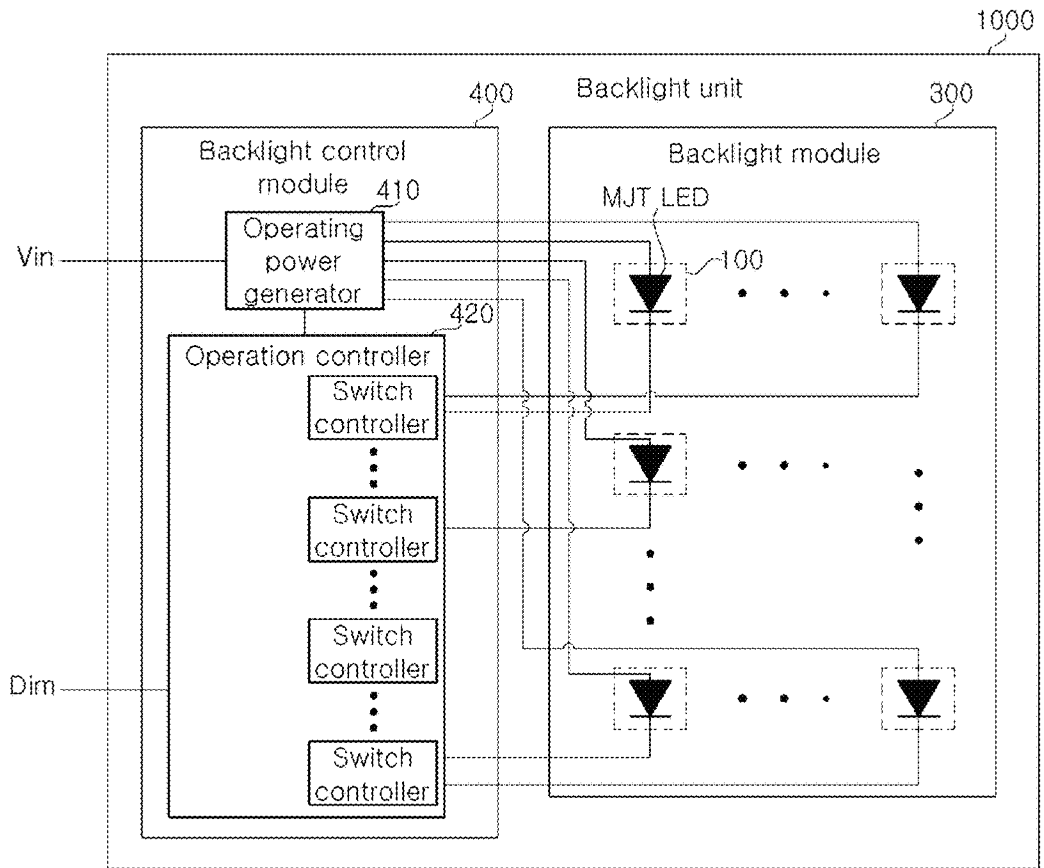

1000
Backlight unit
400
Backlight control module
410
Operating power generator
420
Operation controller
Switch controller
Switch controller
Switch controller
Switch controller
Vin
Dim
300
Backlight module
MJT LED
100

Fig. 3

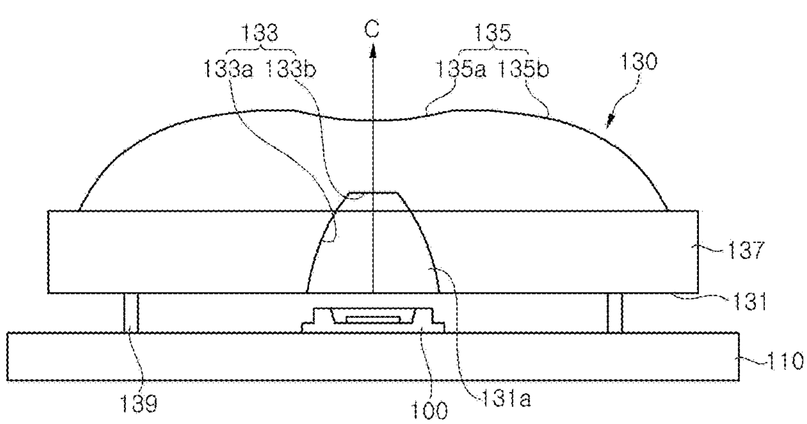

133
133a 133b
C
135
135a 135b
130
137
131
110
139
100
131a

Fig. 4

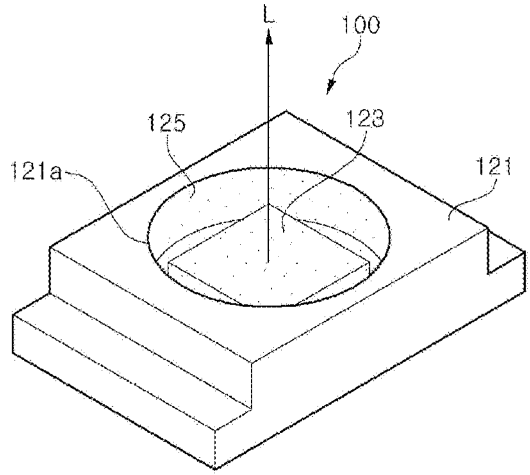


Fig. 5

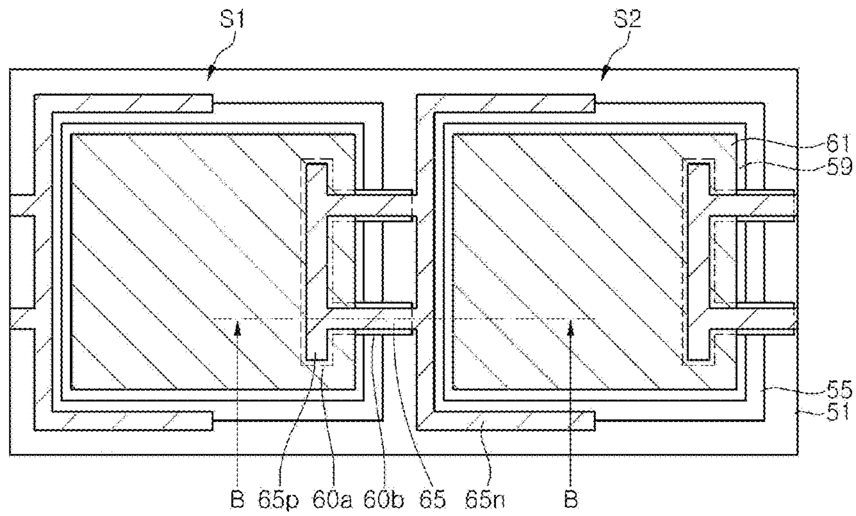
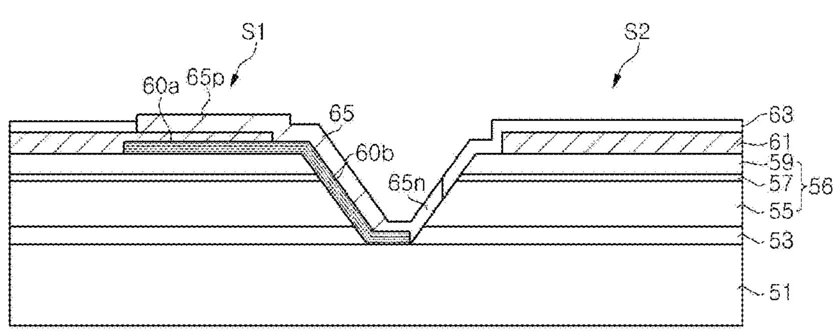


Fig. 6



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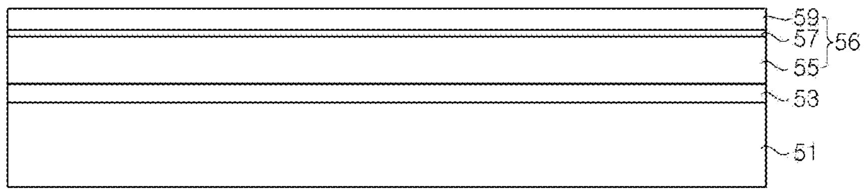

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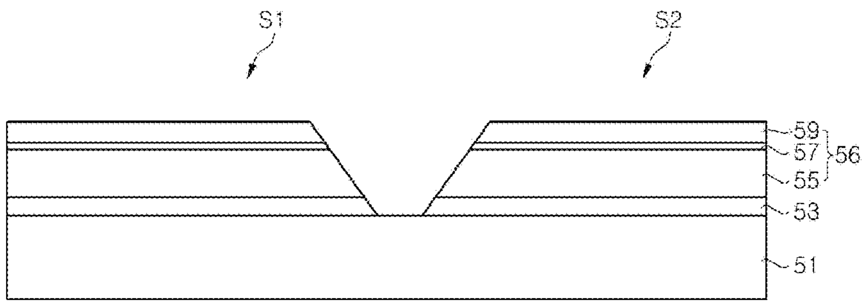


Fig. 9

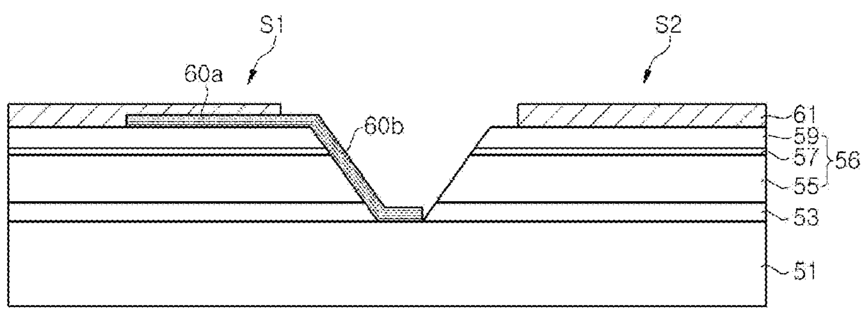
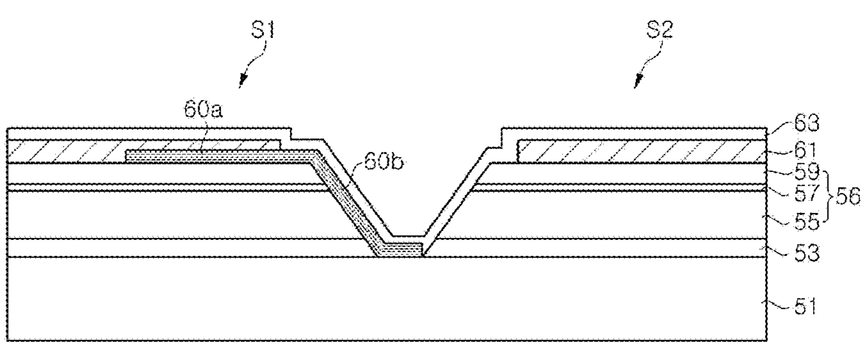


Fig. 10



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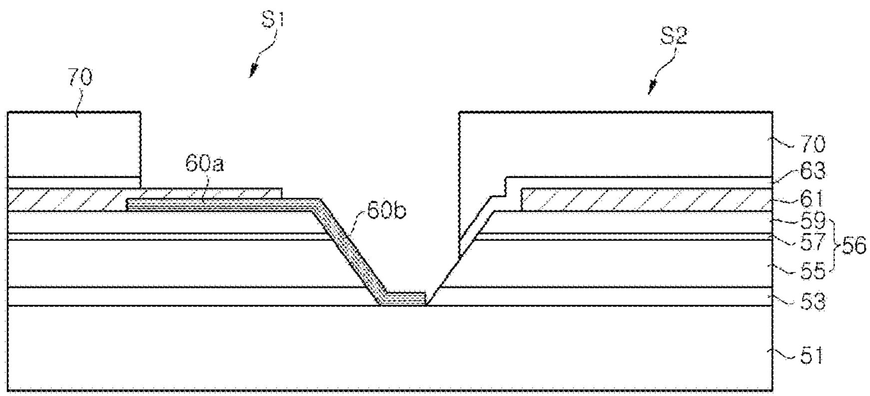

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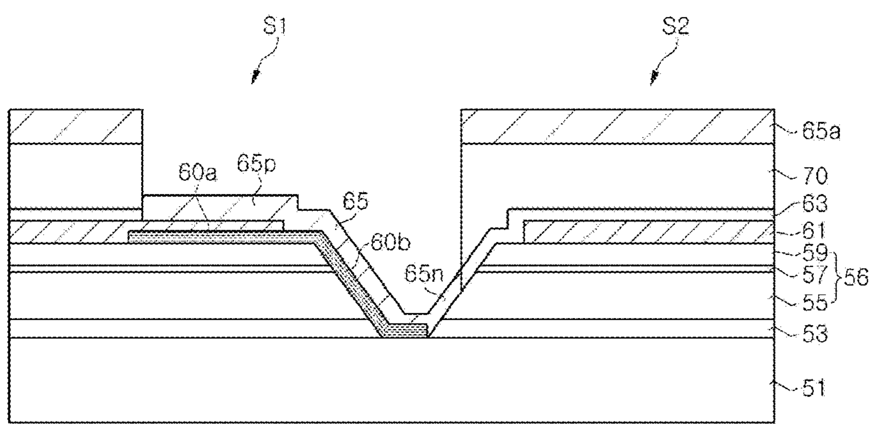

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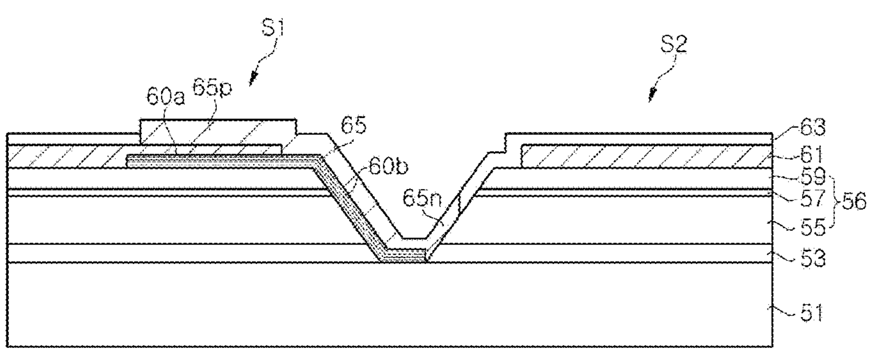

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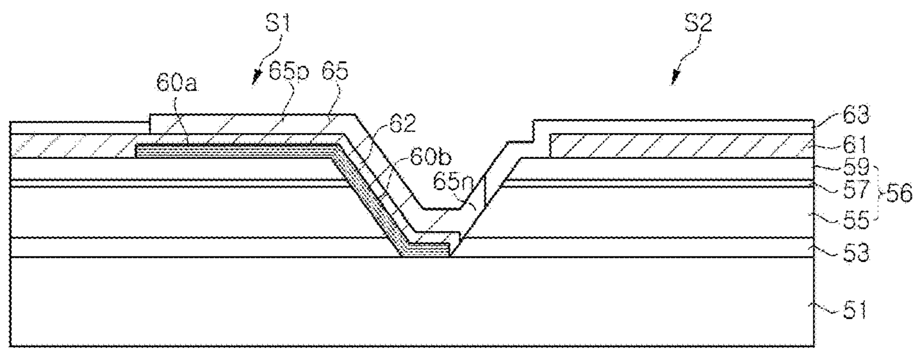

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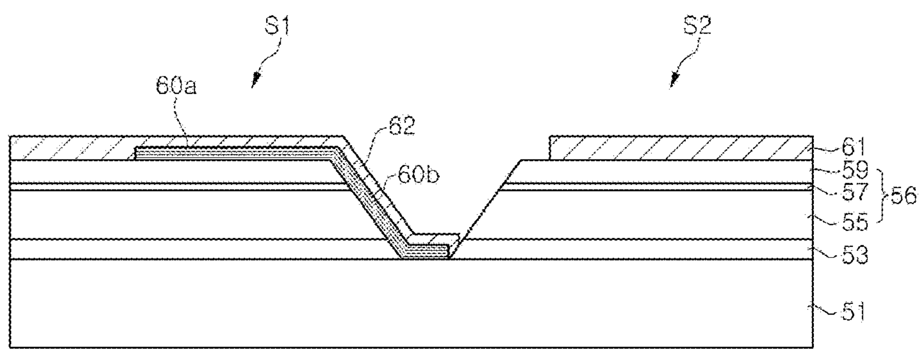

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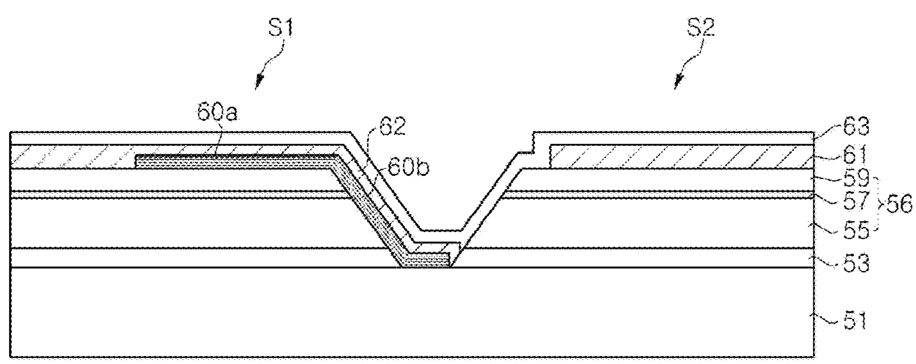

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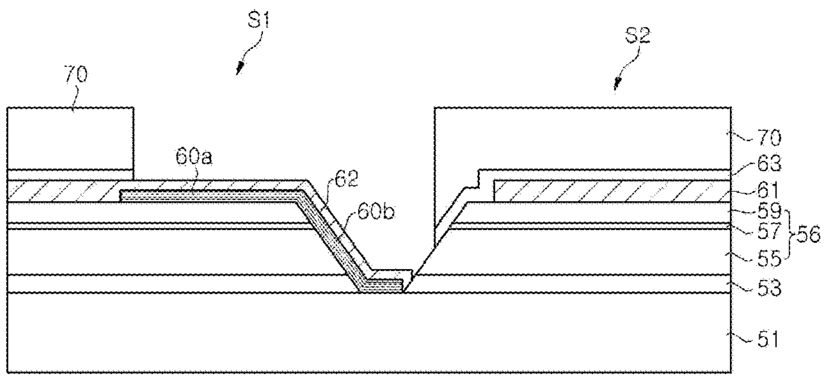

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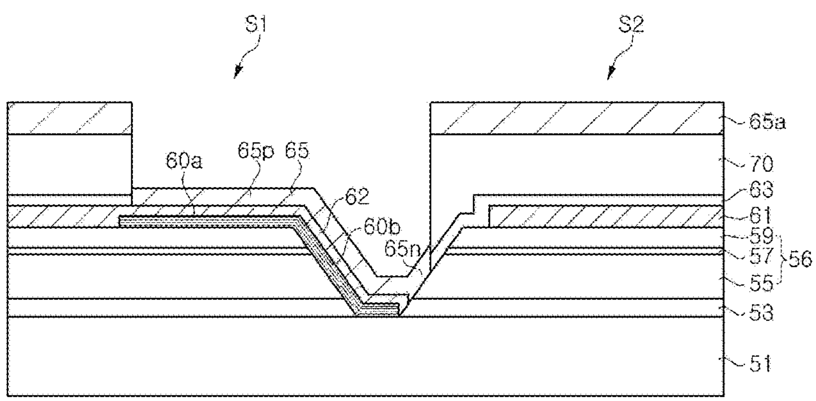

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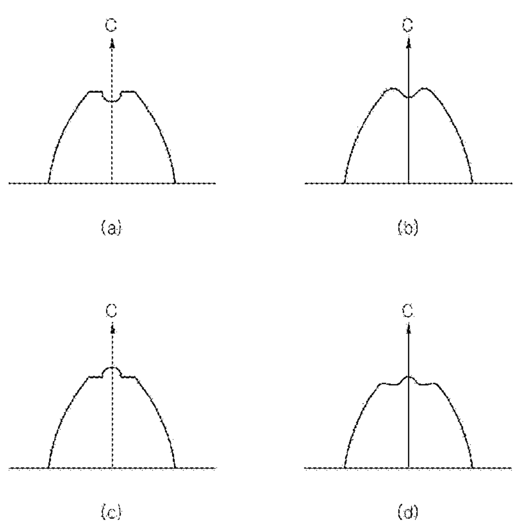

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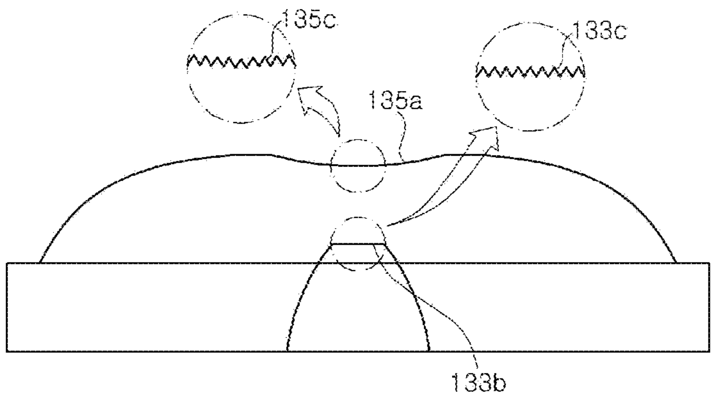
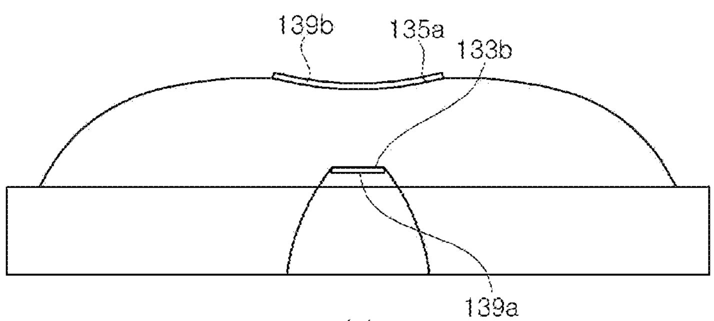
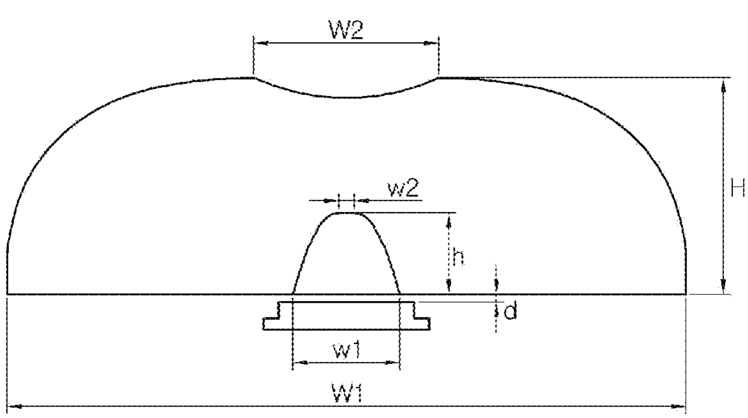


(a)



(b)

Fig. 21



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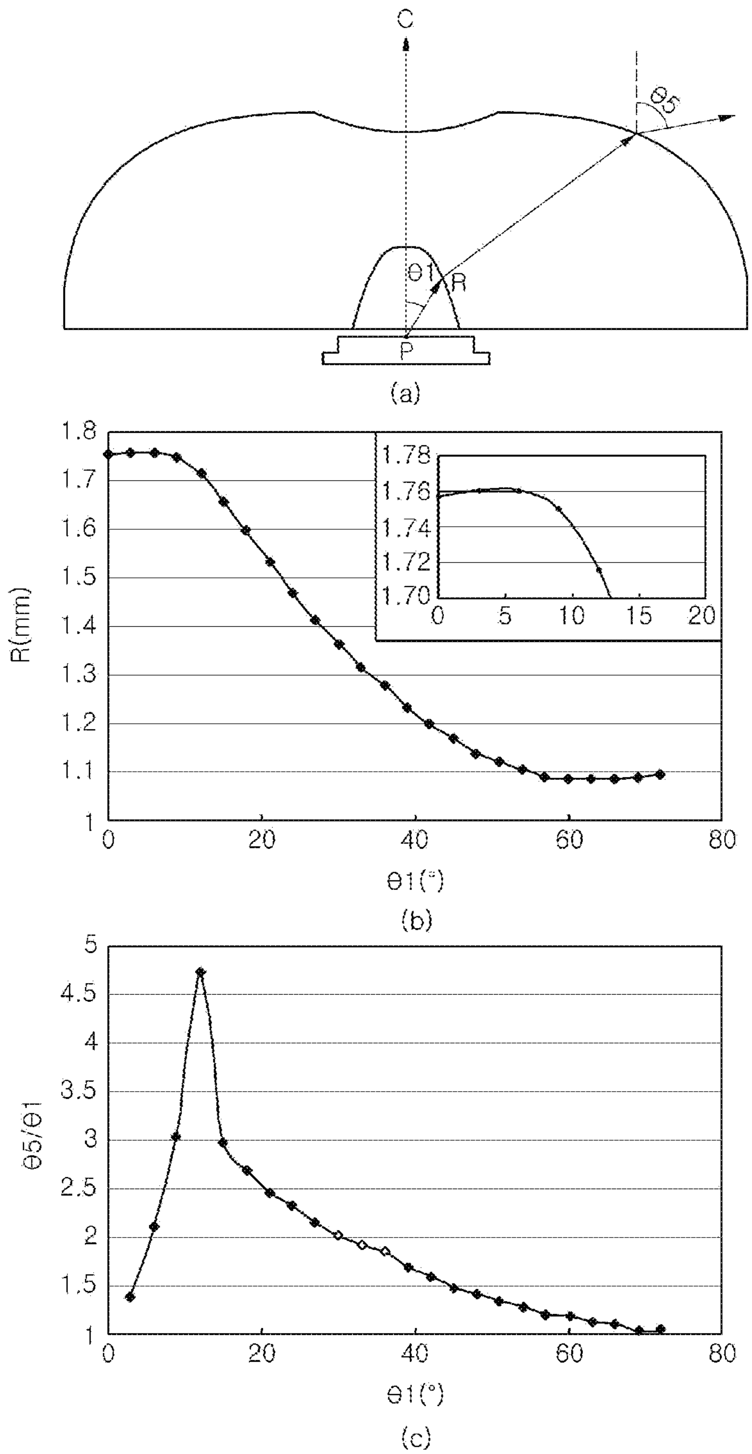

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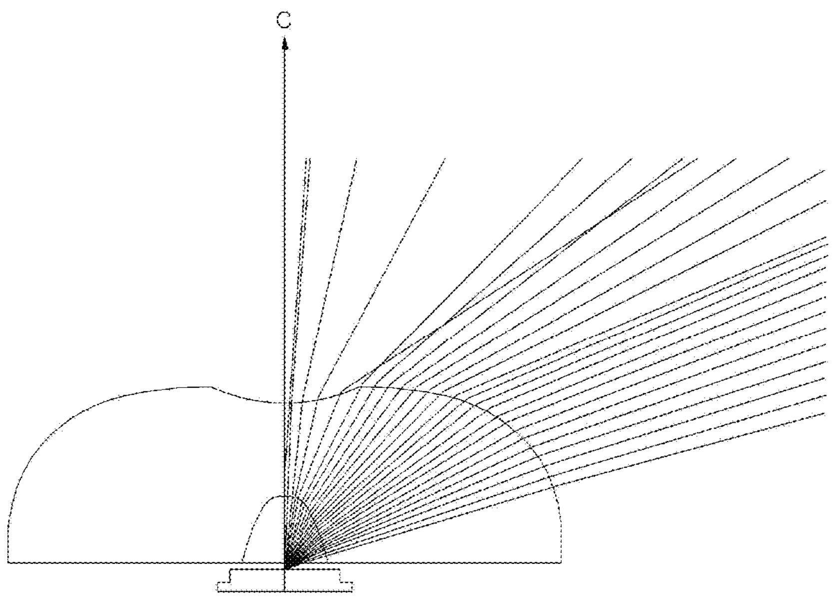

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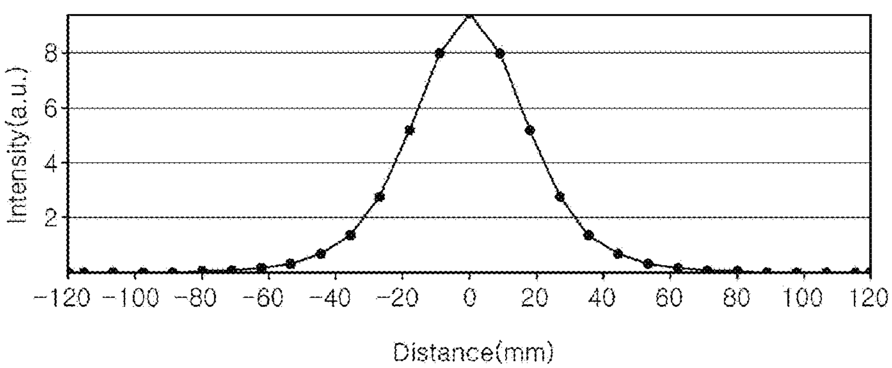
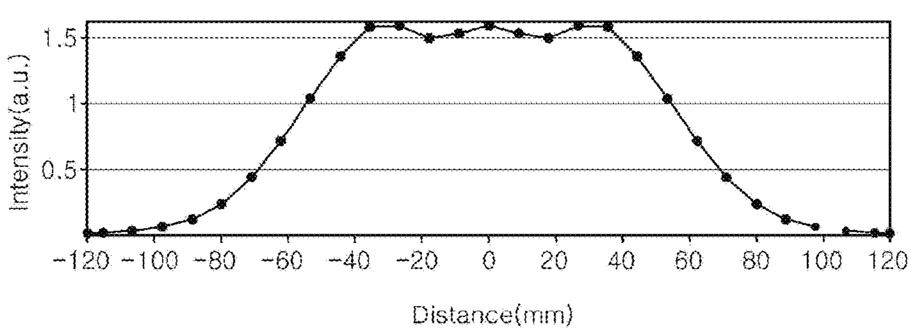
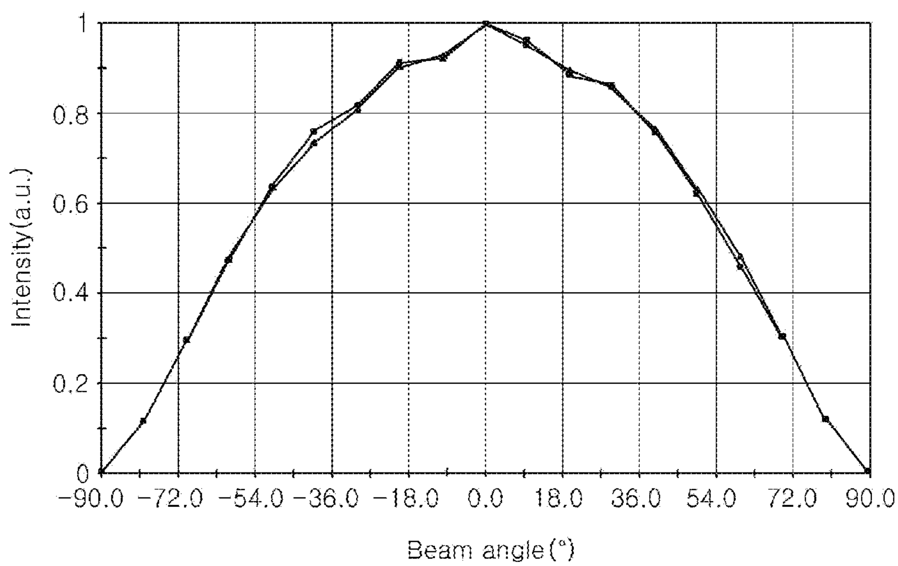


(a)



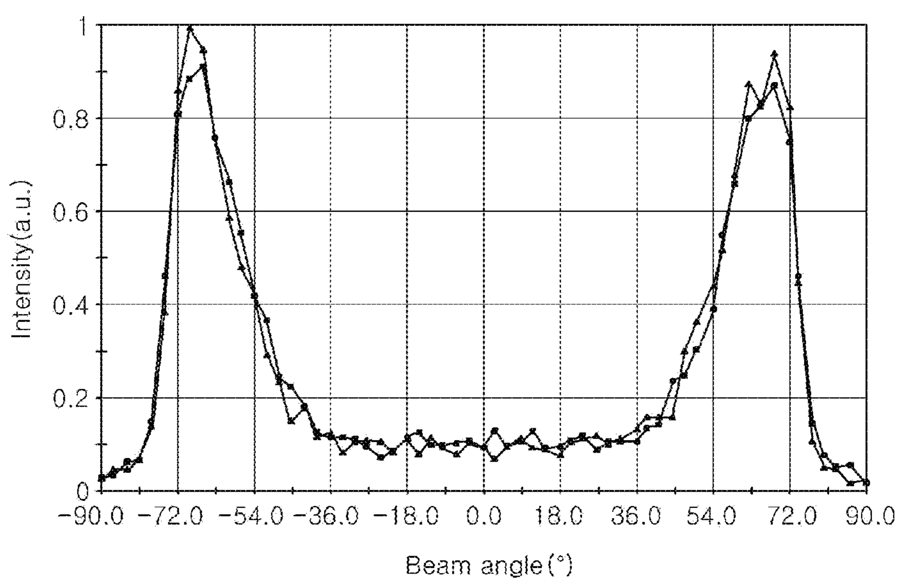
(b)

Fig. 25



Intensity(a.u.)
1
0.8
0.6
0.4
0.2
0
-90.0 -72.0 -54.0 -36.0 -18.0 0.0 18.0 36.0 54.0 72.0 90.0
Beam angle(°)

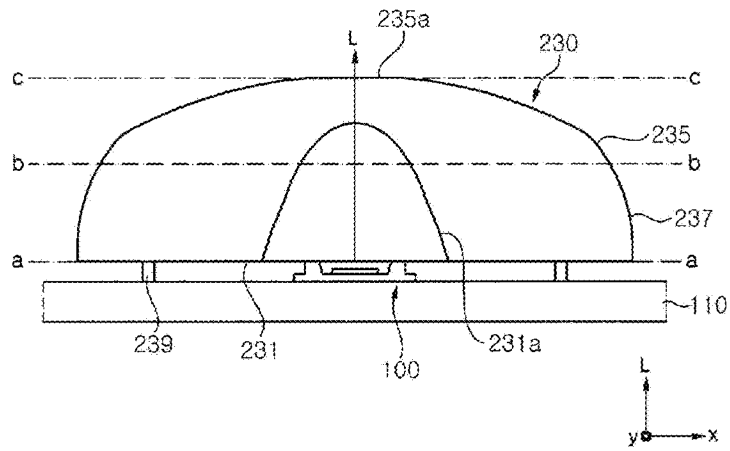
(a)



Intensity(a.u.)
1
0.8
0.6
0.4
0.2
0
-90.0 -72.0 -54.0 -36.0 -18.0 0.0 18.0 36.0 54.0 72.0 90.0
Beam angle(°)

(b)

Fig. 26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b
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239
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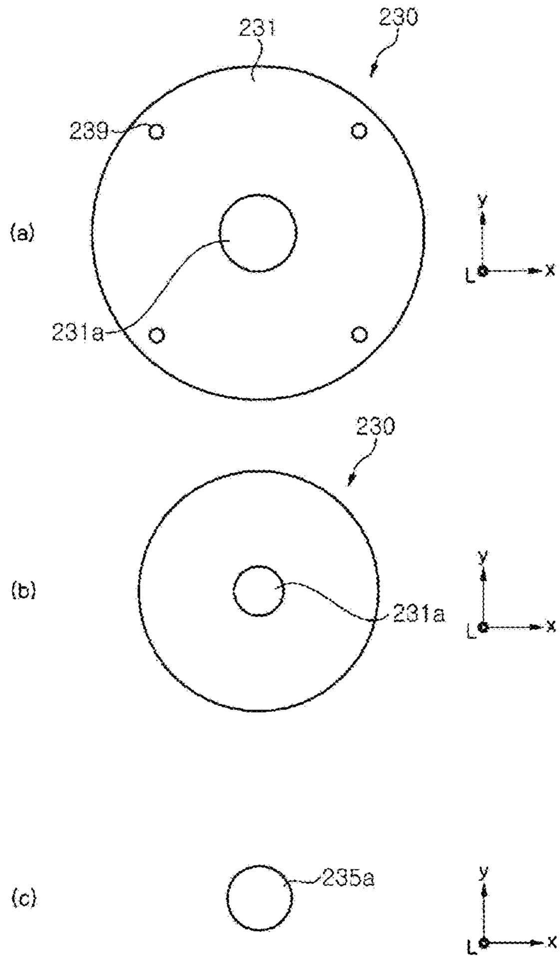
231a
L
y
x

Fig. 27


231
230
239
(a)
y
L
x
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230
(b)
231a
y
L
x
(c)
235a
y
L
x

Fig. 28

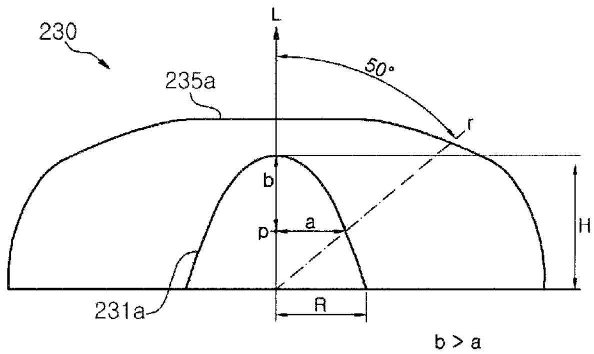
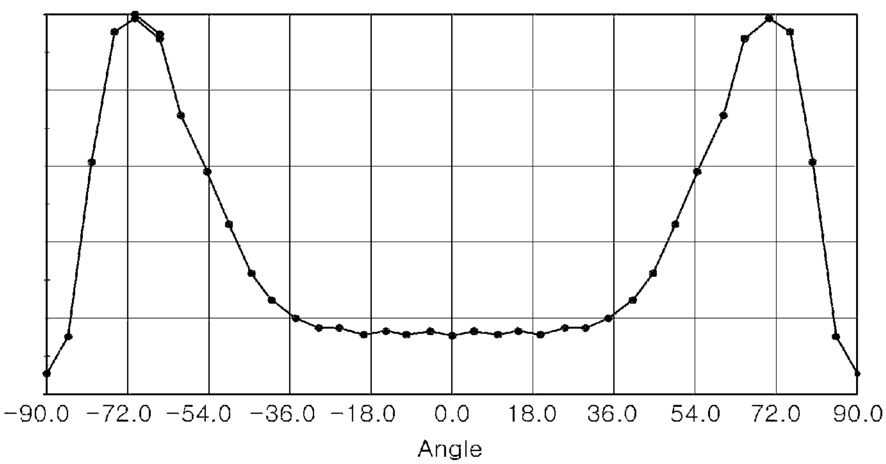


Fig. 29



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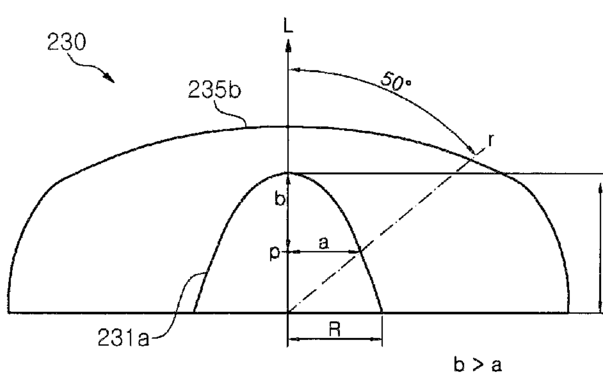


Fig. 31

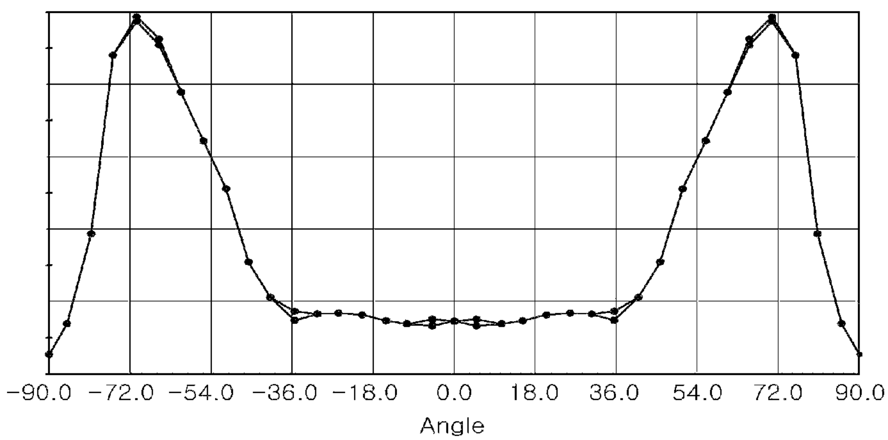


Fig. 32A

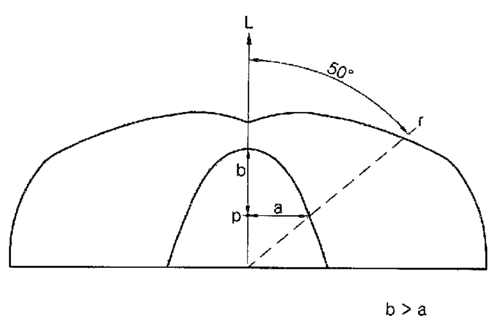


Fig. 32B

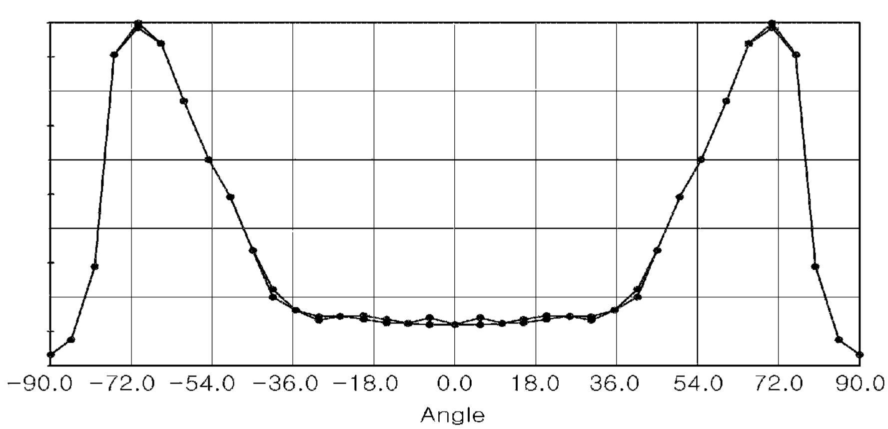


Fig. 33A

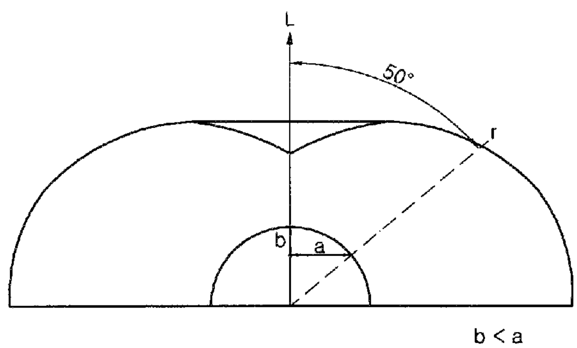


Fig. 33B

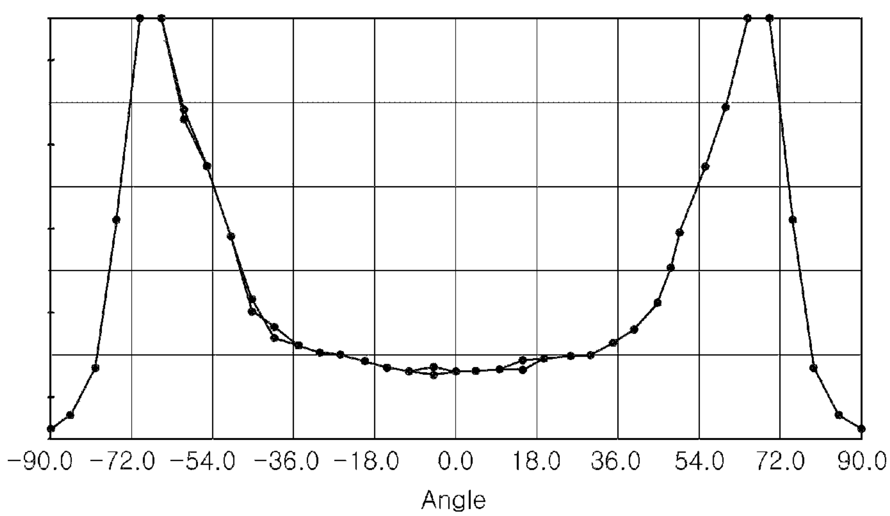
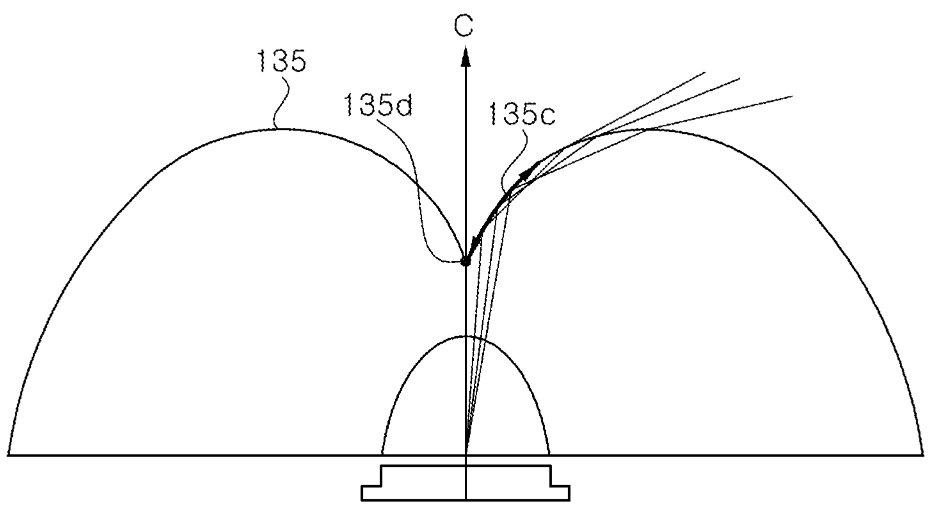


Fig. 34



BACKLIGHT MODULE WITH MJT LED AND BACKLIGHT UNIT INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority from and the benefit of Korean Patent Application No. 10-2014-0026574, filed on Mar. 6, 2014, which is hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND

Field

The present disclosure relates to a backlight module using a multi junction technology (MJT) light emitting diode (LED) and a backlight unit including the same. More particularly, the present disclosure relates to a backlight module which employs an MJT LED configured to increase an effective light emitting area of each of light emitting cells to allow operation at low current, and a backlight unit including the same.

Description of the Background

A liquid crystal display creates an image by controlling transmittance of a backlight light source. Although a cold cathode fluorescent lamp (CCFL) has generally been used as a backlight light source in the related art, light emitting diodes (hereinafter, LEDs) are being recently used due to various advantages such as low power consumption, long lifespan, eco-friendliness, and the like.

Backlight units can be classified into edge type backlight units and direct type backlight units according to the locations of LEDs for backlighting a liquid crystal display. In an edge type backlight unit, with LEDs arranged as light sources on a side surface of a light guide plate, light entering the light guide plate from the light sources is used for backlighting of a liquid crystal panel. Thus, the edge type backlight unit can reduce the number of LEDs and does not require strict control of quality deviation among the LEDs, thereby enabling manufacture of low power consumption products, which is advantageous in terms of cost. However, in the edge type backlight unit it is difficult to overcome contrast between a corner area and a central area of the liquid crystal display and it is difficult to create high quality images.

Alternatively, a direct type backlight unit is placed under a liquid crystal panel and allows light emitted from a surface light source, which has substantially the same area as that of the liquid crystal panel, to directly illuminate a front side of the liquid crystal panel. The direct type backlight unit can overcome contrast difference between a corner area and a central area of the liquid crystal display and can achieve high quality images.

However, in the direct type backlight unit, if each of the LEDs does not illuminate a relatively wide area for backlighting, a number of LEDs must be densely arranged, thereby causing increase in power consumption. Moreover, deviation in quality between the LEDs can make it difficult to secure a uniform screen illumination due to uneven backlighting of a liquid crystal panel.

Particularly, with the increasing size of liquid crystal panels, the size of the direct type backlight unit is also increased, thereby causing deterioration in stability or reliability of the direct type backlight unit. Specifically, since the LED backlight unit controls the operating current supplied to a plurality of LED groups, that is, LED arrays, through a plurality of LED drive circuits, the number of LED drive circuits and the number of LED corresponding arrays are significantly increased as the size of the LED backlight unit increases. As a result, a disconnection can occur between the plurality of LEDs or LED arrays arranged adjacent each other, whereby the drive circuits are damaged due to overcurrent, overvoltage, or overheating, thereby deteriorating the stability and reliability of the backlight unit.

FIG. **1** is a configuration block diagram of a typical backlight unit using LEDs in the related art. With reference to FIG. **1**, problems of the related art will be described in more detail. As shown in FIG. **1**, a typical backlight unit **1** includes a backlight control module **2** and a backlight module **5**.

The backlight control module **2** includes an operating power generator **3**, which generates/outputs DC power based on input voltage Vin input from an external power source, and an operation controller **4** controlling operation of each of a plurality of LED arrays **6***a*~**6***n* constituting the backlight module **5**. The operating power generator **3** generally generates DC voltages such as 12V, 24V, 48V, and the like as operating power.

The backlight module **5** includes a plurality of LED arrays **6***a*~**6***n* each formed by connecting a plurality of LEDs in series, and an optical unit (not shown) for enhancing efficacy of light emitted from the plurality of LED arrays **6***a*~**6***n*. In FIG. **1**, the backlight unit **5** includes n LED arrays **6***a*~**6***n* connected to each other in parallel and each including five LEDs connected to each other in series. Here, since each of the LEDs used in the backlight unit generally has a forward voltage level in the range from 3V to 6.5V and is difficult to individually control/operate when connected to the operating power generator **3**, plural LEDs are connected to each other in series to constitute LED arrays such that each of the LED arrays can be operated/controlled. In such a typical backlight unit **1** in the related art, the operation controller **4** is configured to control brightness of all of the LED arrays **6***a*~**6***n* constituting the backlight module **5** through pulse width modulation (PWM) control with respect to the operating power supplied to the backlight module **5** in response to an external dimming signal (Dim). Otherwise, in such a typical backlight unit **1**, the operation controller **4** adjusts the operating current flowing through a specific LED array among the n LED arrays **6***a*~**6***n* in response to an external dimming signal (Dim) to control brightness of the specific LED array.

LEDs used in such a typical backlight unit **1** are generally single-cell LEDs capable of being operated at low voltage and high current. For example, such a single-cell LED has an operating voltage of 3.6V and can be operated at an operating current of 250~500 mA. Thus, in order to control operation of the backlight module **5** constituted by such single-cell LEDs, peripheral circuits including the operation controller **4** in the related art must be constituted by large capacity electronic devices capable of handling large current, thereby causing increase in manufacturing costs of the backlight unit **1**. In addition, the peripheral circuits including the operation controller **4** are damaged due to the high current operation characteristics of the aforementioned typical single-cell LEDs, thereby causing deterioration in stability or reliability of the backlight unit **1**. In addition, the high current operation characteristics of the single-cell LEDs cause an increase in power consumption and a droop phenomenon.

SUMMARY

The present disclosure is aimed at providing a backlight module which can be operated at low current using an MJT

LED including a plurality of light emitting cells and a backlight unit including the same.

In addition, the present disclosure is aimed at providing an MJT LED chip, which can increase an effective light emitting area of a light emitting cell, and a method of manufacturing the same.

Further, the present invention is aimed at providing a backlight unit, which allows a backlight module to be operated at low current using the aforementioned MJT LED, thereby improving stability and reliability of drive circuits for controlling operation of the backlight module, and enabling reduction in manufacturing costs.

Further, the present disclosure is aimed at providing a backlight unit, which allows a backlight module to be operated at low current using the aforementioned MJT LED, thereby improving power efficiency and luminous efficacy while preventing a droop phenomenon due to operation at high current.

Further, the present disclosure is aimed at providing a backlight unit, in which a backlight module is constituted by MJT LEDs, thereby minimizing the number of LEDs while enabling individual control of the MJT LEDs.

The above and other objects and advantageous effects of the present disclosure can be obtained by the following features of the present disclosure.

In accordance with one aspect of the present disclosure, a backlight module includes a printed circuit board; a plurality of MJT LEDs disposed on the printed circuit board; and a plurality of optical members disposed on the MJT LEDs or the printed circuit board so as to correspond to the MJT LEDs and each including a light incident face through which light emitted from the corresponding MJT LED enters the optical member and a light exit face through which light exits the optical member at a wider beam angle than that of the corresponding MJT LED, wherein each of the MJT LEDs includes a first light emitting cell and a second light emitting cell separated from each other on a growth substrate; a first transparent electrode layer placed on the first light emitting cell and electrically connected to the first light emitting cell; a current blocking layer placed between the first light emitting cell and the first transparent electrode layer and separating a portion of the first transparent electrode layer from the first light emitting cell; an interconnection line electrically connecting the first light emitting cell to the second light emitting cell; and an insulation layer separating the interconnection line from a side surface of the first light emitting cell. Here, the second light emitting cell has a slanted side surface; and the interconnection line includes a first connection section for electrical connection to the first light emitting cell and a second connection section for electrical connection to the second light emitting cell. The first connection section contacts the first transparent electrode layer within an upper area of the current blocking layer, and the second connection section contacts the slanted side surface of the second light emitting cell.

In one aspect, each of the MJT LEDs includes first to N-th light emitting cells (N being a natural number of 2 or more), and the N-th light emitting cell may be electrically connected to a (N−1)th light emitting cell using the same structure as a connection structure between the first light emitting cell and a second light emitting cell.

In one aspect, the first to N-th light emitting cells are connected to each other in series and each operated by an operating voltage of 2.5V to 4 V. Here, each of the MJT LEDs may be operated at an operating voltage of at least 10 V or more.

In one aspect, each of the MJT LEDs includes three light emitting cells each being operated at an operating voltage of 3V to 3.6V, and is operated at an operating voltage of 12V to 14V.

In one aspect, the light exit face includes a concave section formed near a central axis of the optical member and a convex section extending from the concave section and separated from the central axis of the optical member.

In one aspect, the light exit face includes a total internal reflection surface so as to form an apex under the central axis of the optical member.

In one aspect, the light incident face includes an opening formed near the central axis of the optical member, and the height of the opening is 1.5 times or more a width thereof.

In one aspect, each of the optical members has a light scattering pattern formed on at least a portion of a bottom surface facing the printed circuit board.

In one aspect, each of the optical members includes a lower surface having a concave section, through which light emitted from the MJT LED enters the optical member; and an upper surface through which light entering the optical member through the concave section exits the optical member. Here, the upper surface includes a concave surface placed at the central axis of the optical member, and the concave section of the lower surface includes at least one of a perpendicular surface relative to the central axis and a downwardly convex surface, and the at least one of the perpendicular surface relative to the central axis and the downwardly convex surface may be placed within a narrower area than an area for an entrance of the concave section.

In one aspect, the upper surface and the concave section of the optical member form a mirror symmetry structure relative to a plane passing through the central axis of the optical member.

In one aspect, the upper surface and the concave section of the optical member form a rotational body shape relative to the central axis of the optical member.

In one aspect, each of the optical members has a light scattering pattern formed on the at least one of the perpendicular surface relative to the central axis and the downwardly convex surface within the concave section of the lower surface and on a surface closer to the central axis than the at least one surface.

In one aspect, each of the optical members has a light scattering pattern formed on the concave surface of the upper surface.

In one aspect, each of the optical members further includes a material layer having a different index of refraction than the optical member on the at least one of the perpendicular surface relative to the central axis and the downwardly convex surface within the concave section of the lower surface and on a surface closer to the central axis than the at least one surface.

In one aspect, each of the optical members further includes a material layer having a different index of refraction than the optical member on the concave surface of the upper surface.

In one aspect, the at least one of the perpendicular surface relative to the central axis and the downwardly convex surface is defined within a narrower area than an area surrounded by an inflection curve at which the concave surface of the upper surface meets the convex surface thereof.

In one aspect, the at least one of the perpendicular surface relative to the central axis and the downwardly convex surface is defined within a narrower area than an area of a light exit face of the light emitting diode.

In one aspect, each of the optical members further includes a flange connecting the upper surface and the lower surface and the at least one of the perpendicular surface relative to the central axis and the downwardly convex surface within the concave section is placed above the flange.

In one aspect, each of the optical members has an optical axis L, a light incident section, and a light exit face, and is formed of a material, the index of refraction of which is higher than that of a material adjoining the light incident section and that of a material adjoining the light exit face.

In one aspect, the light incident section is formed such that the shortest distance from a point (p) on the optical axis L to an apex of the light incident section is greater than the shortest distance (a) from the point (p) to a side surface of the light incident section within an angle of 50° or less from the optical axis L.

In one aspect, an upper center of the light exit face is formed of a flat surface or a convex curve.

In one aspect, the light incident section includes a lower entrance placed adjacent the light emitting diode and having a circular shape, and has a shape gradually converging to the apex while maintaining a circular shape.

In one aspect, the light incident section has a height which is 1.5 times greater than a radius of the lower entrance.

In one aspect, the material adjoining the light incident section is air.

In one aspect, the material adjoining the light exit face is air.

In one aspect, the optical members are formed of a resin or glass.

In accordance with another aspect of the present disclosure, a backlight unit includes the aforementioned backlight module; and a backlight control module supplying DC operating voltage to the plurality of MJT LEDs within the backlight module and independently controlling operation of each of the plurality of MJT LEDs.

In one aspect, the backlight control module supplies the DC operating voltage to each of the plurality of MJT LEDs within the backlight module, and performs pulse width modulation control with respect to the DC operating voltage supplied to at least one MJT LED among the plurality of MJT LEDs in response to a dimming signal to perform dimming control of the at least one MJT LED.

In one aspect, the backlight control module allows independent detection and control of operating current of each of the plurality of MJT LEDs within the backlight module, and controls operating current of at least one MJT LED among the plurality of MJT LEDs in response to a dimming signal to perform dimming control of the at least one MJT LED.

According to embodiments of the present disclosure, the backlight module is fabricated using MJT LEDs having low current operation characteristics, thereby enabling low current operation of the backlight module and the backlight unit including the same.

In addition, according to the embodiments of the present disclosure, one connection section of the interconnection line electrically contacts a slanted side surface of light emitting cell, thereby increasing an effective light emitting area of each of light emitting cells in an MJT LED chip.

Further, according to the embodiments of the present disclosure, it is possible to enhance stability and reliability of drive circuits for controlling operation of the backlight module while reducing manufacturing costs.

Further, according to the embodiments of the present disclosure, the backlight unit has improved power efficiency and luminous efficacy, and can prevent a droop phenomenon due to operation at high current.

Further, according to the embodiments of the present disclosure, it is possible to minimize the number of LEDs constituting the backlight module and to allow individual operation of the MJT LEDs constituting the backlight module.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects, features, and advantages of the present disclosure will become apparent from the detailed description of the following embodiments in conjunction with the accompanying drawings, in which:

FIG. **1** is a configuration block diagram of a typical backlight unit including LEDs in the related art;

FIG. **2** is a schematic block diagram of a backlight unit employing MJT LEDs according to one exemplary embodiment of the present disclosure;

FIG. **3** is a schematic sectional view of an MJT LED module according to one exemplary embodiment of the present disclosure;

FIG. **4** is a schematic perspective view of the MJT LED according to the one exemplary embodiment of the present disclosure;

FIG. **5** is a schematic plan view of an MJT LED chip according to one exemplary embodiment of the present disclosure;

FIG. **6** is a schematic sectional view of the MJT LED chip taken along line B-B of FIG. **5**;

FIG. **7** to FIG. **13** are schematic sectional views illustrating a method of fabricating an MJT LED chip according to one exemplary embodiment of the present disclosure;

FIG. **14** is a schematic sectional view of an MJT LED chip according to another exemplary embodiment of the present disclosure;

FIG. **15** to FIG. **18** are schematic sectional views illustrating a method of fabricating an MJT LED chip according to another exemplary embodiment of the present disclosure;

FIG. **19** shows sectional views of various modifications of an optical member according to the present disclosure;

FIG. **20** shows sectional views of an optical member, illustrating an MJT LED module according to a further exemplary embodiment of the present disclosure;

FIG. **21** is a sectional view illustrating dimensions of an MJT LED module used for simulation;

FIG. **22** shows graphs depicting a shape of an optical member of FIG. **21**;

FIG. **23** shows traveling directions of light beams entering the optical member of FIG. **21**;

FIG. **24** shows graphs depicting illuminance distribution, in which (a) is a graph depicting illuminance distribution of an MJT LED, and (b) is a graph showing illuminance distribution of an MJT LED module using an optical member;

FIG. **25** shows graphs depicting light beam distributions, in which (a) is a graph depicting a light beam distribution of an MJT LED and (b) is a graph depicting a light beam distribution of an MJT LED module using an optical member;

FIG. **26** is a sectional view of an MJT LED module according to one exemplary embodiment of the present disclosure;

FIGS. **27** (*a*), (*b*) and (*c*) are sectional views of the MJT LED module taken along lines a-a, b-b and c-c of FIG. **26**;

FIG. **28** is a detailed view of an optical member of the MJT LED module shown in FIG. **26**;

FIG. **29** shows a light beam angle distribution of the MJT LED module using the optical member of FIG. **28**;

FIG. **30** is a sectional view of an optical member according to another exemplary embodiment of the present disclosure;

FIG. **31** shows a beam angle distribution curve of an MJT LED module using the optical member of FIG. **30**;

FIG. **32**A and FIG. **32**B show an optical member according to Comparative Example 1 and a beam angle distribution curve thereof;

FIG. **33**A and FIG. **33**B show an optical member according to Comparative Example 2 and a light beam angle distribution thereof; and

FIG. **34** is a sectional view of an optical member according to another exemplary embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE DISCLOSURE

The present disclosure will be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the disclosure are illustrated. These embodiments will be described such that the disclosure can be easily understood by a person having ordinary knowledge in the art. Here, although various embodiments are disclosed herein, it should be understood that these embodiments are not intended to be exclusive. For example, individual structures, elements or features of a particular embodiment are not limited to that particular embodiment and can be applied to other embodiments without departing from the spirit and scope of the disclosure. In addition, it should be understood that locations or arrangement of individual components in each of the embodiments may be changed without departing from the spirit and scope of the present disclosure. Therefore, the following embodiments are not to be construed as limiting the disclosure, and the present disclosure should be limited only by the claims and equivalents thereof. Like components will be denoted by like reference numerals, and lengths, areas, thicknesses and shapes of the components are not drawn to scale throughout the accompanying drawings.

Now, exemplary embodiments of the disclosure will be described in detail with reference to the accompanying drawings so as to be easily realized by a person having ordinary knowledge in the art.

As used herein, the term "MJT LED chip" means a single LED chip, in which a plurality of light emitting cells is connected to each other via interconnection lines. The MJT LED chip may include N light emitting cells (N is an integer of 2 or more), in which N may be set in various ways as needed. Further, each of the light emitting cells may have a forward voltage in the range from 3V to 3.6V, but is not limited thereto. Accordingly, a forward voltage of a certain MJT LED chip (or MJT LED) is proportional to the number of light emitting cells included in the corresponding MJT LED chip. Since the number of light emitting cells included in the MJT LED chip may be set in various ways as needed, the MJT LED chip according to the present disclosure may be configured to have an operating voltage of 6V to 36V depending upon a specification of an operating power generator (for example, a DC converter) used in a backlight unit, but is not limited thereto. Further, operating current of the MJT LED chip is much smaller than a typical single-cell LED, and may range, for example, from 20 mA to 40 mA, without being limited thereto.

In addition, the term "MJT LED" refers to a light emitting device or an LED package, on which the MJT LED chip according to the present disclosure is mounted.

Further, the term "MJT LED module" refers to a component in which a single MJT LED and a single optical member corresponding to the MJT LED are coupled to each other. The corresponding optical member may be directly placed on the MJT LED, or may be placed on a printed circuit board on which the MJT LED is mounted. Regardless of displacement of the optical member, the case wherein a single MJT LED and a single optical member corresponding thereto are coupled to each other will be referred to as the MJT LED module.

Further, the term "backlight module" means a lighting module, in which a plurality of MJT LEDs is disposed on a printed circuit board and optical members are provided corresponding to the respective MJT LEDs. Thus, the term "backlight module" may mean a lighting module in which plural MJT LED modules are mounted on a printed circuit board in a predetermined manner. In one aspect, a backlight module according to one exemplary embodiment of the disclosure may be a direct type backlight module. However, it should be understood that the present disclosure is not limited thereto. In other embodiments, the backlight module according to the present disclosure may be used as a light source for surface lighting. Accordingly, it will be apparent to those skilled in the art that any component including the subject matter of the backlight module according to the present disclosure falls within the scope of the present disclosure, despite the name of the component.

Overview of Backlight Unit Using MJT LEDs

Before detailed descriptions of the backlight unit according to the present disclosure are given, several technical features of the present disclosure will be described. The present disclosure is based on characteristics of an MJT LED in order to solve the aforementioned problems in the related art. That is, in order to solve the problems due to low voltage and high current operation characteristics of a typical single-cell LED in the related art, the present disclosure has been created based on high voltage and low current operation characteristics of the MJT LED (for example, an operating voltage of 6 V to 36 V and an operating current of 20 mA to 40 mA), and provides a backlight module using such an MJT LED. As described above, unlike a typical single-cell LED, the MJT LED may include any number of light emitting cells and may have various forward voltages depending upon the number of light emitting cells included therein. In addition, since the MJT LED includes a plurality of light emitting cells, it is possible to illuminate a wider area than the typical single-cell LED, and since the MJT LED is constituted by a single MJT LED chip, design and application of an optical member therefor can be easily achieved. Thus, when using such an MJT LED, one divided area among a plurality of divided areas in a liquid crystal panel can be covered by one MJT LED module (that is, one MJT LED and one optical member). As a result, the number of LEDs required for the backlight module is reduced as compared with the typical single-cell LED. Consequently, according to the present disclosure, a plurality of MJT LED modules is used to constitute a backlight module and a backlight unit is configured to allow independent control of each of the MJT LEDs constituting the backlight module, thereby achieving the above and other objects of the present disclosure.

Now, referring to FIG. **2** to FIG. **4**, a backlight unit **1000** according to one exemplary embodiment of the disclosure will be described in more detail.

First, FIG. **2** is a schematic block diagram of a backlight unit employing MJT LEDs according to one exemplary embodiment of the present disclosure. Referring to FIG. **2**, the backlight unit **1000** according to this embodiment includes a backlight control module **400** and a backlight module **300**.

More specifically, the backlight control module **400** according to this disclosure includes an operating power generator **410**, which generates/outputs DC power based on input voltage Vin input from an external power source, and an operation controller **420** controlling operation of each of a plurality of MJT LEDs **100** constituting the backlight module **300** (on/off control and dimming control). The operating power generator **410** generally generates stable DC voltage such as 12V, 24V, 48V, and the like, as operating power and supplies the DC voltage to the plurality of MJT LEDs **100** constituting the backlight module **300**. Here, the input voltage Vin supplied to the operating power generator **410** may be a commercially available alternating voltage of 220V or 110V. The operating power generator **410** may have substantially the same configuration as the typical operating power generator **410** as shown in FIG. **1**.

The backlight module **300** according to this disclosure may include a plurality of MJT LEDs **100** and optical members (not shown in FIG. **2**) corresponding to the respective MJT LEDs **100** and disposed in a regular arrangement (for example, in a matrix arrangement) on a printed circuit board (not shown in FIG. **2**). In the embodiment shown in FIG. **2**, it is assumed that M MJT LEDs **100** are disposed in a longitudinal direction and N MJT LEDs **100** are disposed in a transverse direction to form an M×N matrix arrangement within the backlight module **300**. In addition, an MJT LED placed at a left side uppermost portion of the backlight module will be referred to as a 1-1st MJT LED (**100_11**) and an MJT LED placed at a right side lowermost portion thereof will be referred to as an M-Nth MJT LED (100_MN).

Here, it should be noted that, unlike the related art shown in FIG. **1**, the MJT LEDs **100** within the backlight module **300** according to the embodiment of FIG. **2** are independently connected to the operating power generator **410** and the operation controller **420** instead of being connected to each other in series, in parallel, or in series/parallel. That is, in the embodiment shown in FIG. **2**, an anode terminal of each MJT LED **100** is independently connected to the operating power generator **410** and a cathode terminal of each MJT LED **100** is independently connected to the operation controller **420**.

With this configuration, the operation controller **420** according to this disclosure may independently control operation of each of the plurality of MJT LEDs **100** constituting the backlight module **300**. More specifically, the operation controller **420** according to this disclosure may control a dimming level of a specific MJT LED among the plurality of MJT LEDs **100** in response to a dimming signal (Dim).

In one embodiment, the operation controller **420** according to the present disclosure includes a PWM (Pulse Width Modulation) controller (not shown) and may perform dimming control through pulse width modulation control with respect to operating power supplied to a specific MJT LED, which is a dimming control target, among the MJT LEDs **100**. Particularly, unlike the typical backlight unit in the related art as shown in FIG. **1**, the backlight unit **1000** according to the present disclosure as shown in FIG. **2** includes the plurality of MJT LEDs **100**, each of which is connected to the operating power generator **410** to independently receive operating power, thereby enabling dimming control in such a pulse width modulation manner. For example, when there is a need for dimming control of the 1-1st MJT LED (**100_11**), the operation controller **420** performs pulse width modulation of the generated operating power at a predetermined duty ratio (for example, 60%) in response to a dimming signal (Dim), and supplies the modified operating power to the 1-1st MJT LED (**100_11**) to perform dimming control of the 1-1st MJT LED (**100_11**). At this time, operating power, which is not subjected to pulse width modulation and has a duty ratio of 100%, will be supplied to other MJT LEDs except for the 1-1st MJT LED (**100_11**). Alternatively, operating power, which is subjected to pulse width modulation at a normal duty ratio (a duty ratio of, for example, 80% when no separate dimming control is provided), is provided to the other MJT LEDs except for the 1-1st MJT LED (**100_11**). Consequently, the backlight unit **1000** according to the present disclosure allows local dimming with respect to only the 1-1st MJT LED (**100_11**). Of course, it will be apparent to those skilled in the art that it is possible to perform simultaneous dimming control with respect to the plurality of MJT LEDs at the same dimming level and/or at different dimming levels for the respective MJT LEDs through PWM control. The PWM controller for PWM control of the operating power is well known in the art, and thus, a detailed description thereof will be omitted.

In another embodiment, the operation controller **420** according to the present disclosure includes an operating current detector (not shown) and an operating current controller (not shown), and may perform dimming control by controlling the operating current supplied to a specific MJT LED, which is a dimming control target, among the MJT LEDs **100**. Particularly, unlike the typical backlight unit shown in FIG. **1**, in the backlight unit **1000** according to the present disclosure shown in FIG. **2**, each of the plural MJT LEDs **100** is independently connected to the operation controller **420**, thereby enabling dimming control by control of the operating current of each of the MJT LEDs. Here, the operating current detector and the operating current controller included in the operation controller **420** correspond one to one to each of the MJT LEDs **100**. Accordingly, when the backlight module **300** is composed of M×N MJT LEDs **100** as described above, the operation controller **420** includes M×N operating current detectors and M×N operating current controllers. For example, when there is a need for dimming control with respect to an M-Nth MJT LED (100_MN), the operation controller **420** detects operating current flowing through the M-Nth MJT LED (**100**_MN) using the operating current detector, and changes the operating current flowing through the M-Nth MJT LED (**100**_MN) (for example, to 100% of a maximum operating current) in response to a dimming signal (Dim), thereby performing dimming control with respect to the M-Nth MJT LED (**100**_MN). Here, since normal operating current (a preset standard operating current, for example, 80% of the maximum operating current, when there is no separate dimming control) flows through other MJT LEDs except for the M-Nth MJT LED (**100**_MN), local dimming can be performed with respect only to the M-Nth MJT LED (**100**_MN). It will be apparent to those skilled in the art that dimming control of the plurality of MJT LEDs can be performed to the same dimming level through simultaneous control of the operating current with respect to the plurality of MJT LEDs and/or to different dimming levels for the respective MJT LEDs. In such an embodiment, since there is no need for independent supply of operating power to the MJT LEDs **100**, the anode terminal of each of the MJT LEDs **100** may be connected in parallel to one operating power line connected to the operating power generator **410**, unlike the embodiment shown in FIG. **2**. The operating current detector and the operating current controller are well known in the art and detailed descriptions thereof will thus be omitted.

Overview of MJT LED and MJT LED Module

FIG. **3** is a schematic sectional view of an MJT LED module according to one exemplary embodiment of the present disclosure, and FIG. **4** is a schematic perspective view of the MJT LED according to the one exemplary embodiment of the present disclosure. Now, detailed configurations of an MJT LED **100** and an MJT LED module according to embodiments of the present disclosure will be described with reference to FIG. **3** and FIG. **4**.

Referring to FIG. **3**, the MJT LED module includes an MJT LED **100** and an optical member **130**. When the MJT LED **100** is mounted on a printed circuit board **110**, the corresponding optical member **130** is mounted on the printed circuit board **110** at a place corresponding to the position of the MJT LED **100**. As described above, in other embodiments, the optical member **130** may be directly connected to the MJT LED **100**. Although the printed circuit board **110** is partially shown in FIG. **3**, a plurality of MJT LEDs **100** and the optical members **130** corresponding thereto are disposed on a single printed circuit board **110** in various arrangements such as a matrix arrangement or a honeycomb arrangement to form the backlight module **300** as described above.

The printed circuit board **110** is formed on an upper surface thereof with conductive land patterns to which terminals of the MJT LED **100** are bonded. Further, the printed circuit board **110** may include a reflective layer on the upper surface thereof. The printed circuit board **110** may be a MCPCB (Metal-Core PCB) based on a metal having good thermal conductivity. Alternatively, the printed circuit board **110** may be formed of an insulating substrate material such as FR4. Although not shown, the printed circuit board **110** may be provided at a lower side thereof with a heat sink to dissipate heat from the MJT LED **100**.

As clearly shown in FIG. **4**, the MJT LED **100** may include a housing **121**, an MJT LED chip **123** mounted on the housing **121**, and a wavelength conversion layer **125** covering the MJT LED chip **123**. The MJT LED **100** further includes lead terminals (not shown) supported by the housing **121**.

The housing **121** forms a package body and may be formed by injection molding of a plastic resin such as PA, PPA, and the like. In this case, the housing **121** may be formed in a state of supporting the lead terminals by an injection molding process, and may have a cavity **121***a* for mounting the MJT LED chip **123** therein. The cavity **121***a* defines a light exit area of the MJT LED **100**.

The lead terminals are separated from each other within the housing **121** and extend outside of the housing **121** to be bonded to the land patterns on the printed circuit board **110**.

The MJT LED chip **123** is mounted on the bottom of the cavity **121***a* and electrically connected to the lead terminals. The MJT LED chip **123** may be a gallium nitride-based MJT LED which emits UV light or blue light. A detailed configuration of the MJT LED chip **123** according to the present disclosure and a method of manufacturing the same will be described below with reference to FIG. **5** to FIG. **18**.

The wavelength conversion layer **125** covers the MJT LED chip **123**. In one embodiment, the wavelength conversion layer **125** may be formed by filling the cavity **121***a* with a molding resin containing phosphors after mounting the MJT LED chip **123** in the cavity **121***a*. At this time, the wavelength conversion layer **125** may fill the cavity **121***a* of the housing **121** and have a substantially flat or convex upper surface. Further, a molding resin having a shape of the optical member may be formed on the wavelength conversion layer **125**.

In another embodiment, the MJT LED chip **123**, which has a coating layer of the phosphors formed by conformal coating, may be mounted on the housing **121**. Specifically, the coating layer of the phosphors may be formed on the MJT LED chip **123** by conformal coating and the MJT LED chip **123** having the conformal coating layer may be mounted on the housing **121**. The MJT LED chip **123** having the conformal coating layer may be molded with a transparent resin. In addition, the molding resin may have the shape of the optical member and thus may act as a primary optical member.

The wavelength conversion layer **125** converts—wavelengths of light emitted from the MJT LED chip **123** to provide light of mixed colors, for example, white light.

The MJT LED **100** is designed to have a light beam distribution of a mirror symmetry structure, particularly, a light beam distribution of a rotational symmetry structure. At this time, an axis of the MJT LED directed towards the center of the light beam distribution is defined as an optical axis L. That is, the MJT LED **100** is designed to have a light beam distribution which is bilaterally symmetrical with respect to the optical axis L. Generally, the cavity **121***a* of the housing **121** may have a mirror symmetry structure, and the optical axis L may be defined as a straight line passing through the center of the cavity **121***a*.

The optical member **130** includes a light incident face through which light emitted from the MJT LED **100** enters the optical member and a light exit face through which the light exits the optical member at a wider light beam distribution than that of the MJT LED **100**, thereby enabling uniform distribution of the light emitted from MJT LED **100**. The optical member **130** according to the present disclosure will be described below with reference to FIG. **19** to FIG. **33**.

Configuration of MJT LED Chip and Method of Manufacturing the Same

Next, the configuration of the MJT LED chip **123** mounted on the MJT LED according to the present disclosure and a method of manufacturing the same will be described in more detail with reference to FIG. **5** to FIG. **18**.

FIG. **5** is a schematic plan view of an MJT LED chip according to one exemplary embodiment of the present disclosure, and FIG. **6** is a schematic sectional view of the MJT LED chip taken along line B-B of FIG. **5**.

Referring to FIG. **5** and FIG. **6**, the MJT LED chip **123** includes a growth substrate **51**, light emitting cells **S1**, **S2**, a transparent electrode layer **61**, a current blocking layer **60***a*, an insulation layer **60***b*, an insulation protective layer **63**, and an interconnection line **65**. Further, the MJT LED chip **123** may include a buffer layer **53**.

The growth substrate **51** may be an insulation or conductive substrate, and may include, for example, a sapphire substrate, a gallium nitride substrate, a silicon carbide (SiC) substrate, or a silicon substrate. In addition, the growth substrate **51** may have a convex-concave pattern (not shown) on an upper surface thereof as in a patterned sapphire substrate.

A first light emitting cell **S1** and a second light emitting cell **S2** are separated from each other on a single growth substrate **51**. Each of the first and second light emitting cells S**1**, S**2** has a stack structure **56**, which includes a lower semiconductor layer **55**, an upper semiconductor layer **59** placed on a region of the lower semiconductor layer, and an active layer **57** interposed between the lower semiconductor layer and the upper semiconductor layer. Here, the upper and lower semiconductor layers may be an n-type semiconductor layer and a p-type semiconductor layer, respectively, or vice versa.

Each of the lower semiconductor layer **55**, the active layer **57** and the upper semiconductor layer **59** may be formed of a gallium nitride-based semiconductor material, that is, (Al, In, Ga)N. The compositional elements and ratio of the active layer **57** are determined depending upon desired wavelengths of light, for example, UV light or blue light, and the lower semiconductor layer **55** and the upper semiconductor layer **59** are formed of a material having a greater band gap than the active layer **57**.

The lower semiconductor layer **55** and/or the upper semiconductor layer **59** may have a single layer structure, as shown in FIG. **5**. Alternatively, these semiconductor layers may have a multilayer structure. Further, the active layer **57** may have a single quantum-well structure or a multi-quantum well structure.

Each of the first and second light emitting cells S**1**, S**2** may have a slanted side surface, an inclination of which may range, for example, from 15° to 80° relative to an upper surface of the growth substrate **51**.

The active layer **57** and the upper semiconductor layer **59** are placed on the lower semiconductor layer **55**. An upper surface of the lower semiconductor layer **55** may be completely covered by the active layer **57** such that only a side surface thereof is exposed.

Although portions of the first light emitting cell S**1** and the second light emitting cell S**2** are shown in FIG. **6**, the first and second light emitting cells S**1**, S**2** may have a similar or the same structure as that shown in FIG. **5**. That is, the first light emitting cell S**1** and the second light emitting cell S**2** may have the same gallium nitride-based semiconductor stack structure, and may have slanted side surfaces of the same structure.

The buffer layer **53** may be interposed between the light emitting cells S**1**, S**2** and the growth substrate **51**. The buffer layer **53** relieves lattice mismatch between the growth substrate **51** and the lower semiconductor layer **55** formed thereon.

The transparent electrode layer **61** is placed on each of the light emitting cells S**1**, S**2**. That is, a first transparent electrode layer **61** is placed on the first light emitting cell S**1** and a second transparent electrode layer **61** is placed on the second light emitting cell S**2**. The transparent electrode layer **61** may be placed on the upper semiconductor layer **59** to be connected to the upper semiconductor layer **59**, and may have a narrower area than the upper semiconductor layer **59**. That is, the transparent electrode layer **61** may be recessed from an edge of the upper semiconductor layer **59**. With this structure, it is possible to prevent current crowding at the edge of the transparent electrode layer **61** through the side surfaces of the light emitting cells S**1**, S**2**.

In another aspect, the current blocking layer **60***a* may be placed on each of the light emitting cells S**1**, S**2**. That is, the current blocking layer **60***a* is placed between the transparent electrode layer **61** and each of the light emitting cells S**1**, S**2**. Part of the transparent electrode layer **61** is placed on the current blocking layer **60***a*. The current blocking layer **60***a* may be placed near an edge of each of the light emitting cells S**1**, S**2**, but is not limited thereto. Alternatively, the current blocking layer **60***a* may be placed in a central region of each of the light emitting cells S**1**, S**2**. The current blocking layer **60***a* is formed of an insulation material and, particularly, may include a distributed Bragg reflector in which layers having different indices of refraction are alternately stacked one above another.

The insulation layer **60***b* covers a portion of the side surface of the first light emitting cell S**1**. As shown in FIG. **5** and FIG. **6**, the insulation layer **60***b* may extend to a region between the first light emitting cell S**1** and the second light emitting cell S**2**, and may cover a portion of a side surface of the lower semiconductor layer **55** of the second light emitting cell S**2**. The insulation layer **60***b* may have the same structure and the same material as those of the current blocking layer **60***a*, and may include a distributed Bragg reflector, without being limited thereto. The insulation layer **60***b* may be formed of a different material than that of the current blocking layer **60***a* by a different process. Here, when the insulation layer **60***b* is a distributed Bragg reflector formed by stacking multiple layers, it is possible to efficiently suppress generation of defects such as pinholes in the insulation layer **60***b*. The insulation layer **60***b* may be connected to the current blocking layer **60***a* to form continuous layers, but is not limited thereto. In other embodiments, the insulation layer **60***b* may be separated from the current blocking layer **60***a*.

The interconnection line **65** electrically connects the first light emitting cell S**1** to the second light emitting cell S**2**. The interconnection line **65** includes a first connection section **65***p* and a second connection section **65***n*. The first connection section **65***p* is electrically connected to the transparent electrode layer **61** on the first light emitting cell S**1**, and the second connection section **65***n* is electrically connected to the lower semiconductor layer **55** of the second light emitting cell S**2**. The first connection section **65***p* may be placed near one edge of the first light emitting cell S**1**, but is not limited thereto. In other embodiments, the first connection section **65***p* may be placed in the central region of the first light emitting cell S**1**.

The second connection section **65***n* may contact the slanted side surface of the second light emitting cell S**2**, particularly, the slanted side surface of the lower semiconductor layer **55** of the second light emitting cell S**2**. Further, as shown in FIG. **5**, the second connection section **65***n* may electrically contact the slanted side surface of the lower semiconductor layer **55** while extending to both sides along the circumference of the second light emitting cell S**2**. The first light emitting cell S**1** is connected to the second light emitting cell S**2** in series by the first and second connection sections **65***p*, **65***n* of the interconnection line **65**.

The interconnection line **65** may contact the transparent electrode layer **61** over an overlapping region with the transparent electrode layer **61**. In the related art, a portion of the insulation layer is placed between the transparent electrode layer and the interconnection line. On the contrary, according to the present disclosure, the interconnection line **65** may directly contact the transparent electrode layer **61** without any insulation material interposed therebetween.

Further, the current blocking layer **60***a* may be placed over the overlapping region between the interconnection line **65** and the transparent electrode layer **61**, and the current blocking layer **60***a* and the insulation layer **60***b* may be placed over an overlapping region between the interconnection line **65** and the first light emitting cell S**1**. Further, the insulation layer **60***b* may be placed between the second light emitting cell S**2** and the interconnection line **65** in other regions excluding a connection region between the interconnection line **65** and the second light emitting cell S**2**.

In FIG. **5**, the first connection section **65***p* and the second connection section **65***n* of the interconnection line **65** are connected to each other through two paths. However, it should be understood that the first and second connection sections may be connected to each other via a single path.

When the current blocking layer **60***a* and the insulation layer **60***b* have reflective characteristics like the distributed Bragg reflector, the current blocking layer **60***a* and the insulation layer **60***b* are preferably placed substantially in the same region as the region for the interconnection line **65** within a region having an area of two times or less the area of the interconnection line **65**. The current blocking layer **60***a* and the insulation layer **60***b* block light emitted from the active layer **57** from being absorbed into the interconnection line **65**. However, when occupying an excessively large area, the current blocking layer **60***a* and the insulation layer **60***b* can block emission of light to the outside. Thus, there is a need for restriction of the area thereof.

The insulation protective layer **63** may be placed outside the region of the interconnection line **65**. The insulation protective layer **63** covers the first and second light emitting cells S**1**, S**2** outside the region of the interconnection line **65**. The insulation protective layer **63** may be formed of silicon oxide (SiO_2) or silicon nitride. The insulation protective layer **63** has an opening through which the transparent electrode layer **61** on the first light emitting cell S**1** and the lower semiconductor layer of the second light emitting cell S**2** are exposed, and the interconnection line **65** may be placed within the opening.

A side surface of the insulation protective layer **63** and a side surface of the interconnection line **65** may face each other, and may contact each other. Alternatively, the side surface of the insulation protective layer **63** and the side surface of the interconnection line **65** may be separated from each other while facing each other.

According to the present embodiment, since the second connection section **65***n* of the interconnection line **65** electrically contacts the slanted side surface of the second light emitting cell S**2**, there is no need to expose the upper surface of the lower semiconductor layer **55** of the second light emitting cell S**2**. Accordingly, there is no need for partial removal of the second semiconductor layer **59** and the active layer **57**, thereby increasing an effective light emitting area of the MJT LED chip **123**.

In addition, the current blocking layer **60***a* and the insulation layer **60***b* may be formed of the same material and have the same structure, and thus may be formed at the same time by the same process. Further, since the interconnection line **65** is placed within the opening of the insulation protective layer **63**, the insulation protective layer **63** and the interconnection line **65** may be formed using the same mask pattern.

Although two light emitting cells including the first light emitting cell S**1** and the second light emitting cell S**2** are illustrated in this embodiment, it should be understood that the present disclosure is not limited thereto. That is, a greater number of light emitting cells may be electrically connected to each other via the interconnection lines **65**. For example, the interconnection lines **65** may electrically connect the lower semiconductor layers **55** and the transparent electrode layers **61** of adjacent light emitting cells to each other to form a series array of light emitting cells. A plurality of such arrays may be formed and connected in inverse-parallel to each other to be operated by an AC power source connected thereto. In addition, a bridge rectifier (not shown) may be connected to the series array of light emitting cells to allow the light emitting cells to be operated by the AC power source. The bridge rectifier may be formed by bridging the light emitting cells having the same structure as that of the light emitting cells S**1**, S**2** using the interconnection lines **65**.

FIG. **7** to FIG. **13** are schematic sectional views illustrating a method of fabricating an MJT LED chip according to one exemplary embodiment of the present disclosure.

Referring to FIG. **7**, a semiconductor stack structure **56** including a lower semiconductor layer **55**, an active layer **57** and an upper semiconductor layer **59** is formed on a growth substrate **51**. In addition, a buffer layer **53** may be formed on the growth substrate **51** before formation of the lower semiconductor layer **55**.

The growth substrate **51** may be formed of a material selected from among sapphire (Al_2O_3), silicon carbide (SiC), zinc oxide (ZnO), silicon (Si), gallium arsenic (GaAs), gallium phosphide (GaP), lithium alumina ($LiAl_2O_3$), boron nitride (BN), aluminum nitride (AlN), and gallium nitride (GaN), without being limited thereto. That is, the material for the growth substrate **51** may be selected in various ways depending upon materials of semiconductor layers to be formed on the growth substrate **51**. Further, the growth substrate **51** may have a convex-concave pattern on an upper surface thereof as in a patterned sapphire substrate.

The buffer layer **53** is formed to relieve lattice mismatch between the growth substrate **51** and the semiconductor layer **55** formed thereon, and may be formed of, for example, gallium nitride (GaN) or aluminum nitride (AlN). When the growth substrate **51** is a conductive substrate, the buffer layer **53** is preferably formed of an insulation layer or a semi-insulating layer. For example, the buffer layer **53** may be formed of AlN or semi-insulating GaN.

Each of the lower semiconductor layer **55**, the active layer **57** and the upper semiconductor layer **59** may be formed of a gallium nitride-based semiconductor material, for example, (Al, In, Ga)N. The lower and upper semiconductor layers **55**, **59** and the active layer **57** may be intermittently or continuously formed by metal organic chemical vapor deposition (MOCVD), molecular beam epitaxy, hydride vapor phase epitaxy (HVPE), and the like.

Here, the lower and upper semiconductor layers may be n-type and p-type semiconductor layers, or vice versa. Among the gallium nitride-based compound semiconductor layers, an n-type semiconductor layer may be formed by doping an n-type impurity, for example, silicon (Si), and a p-type semiconductor layer may be formed by doping a p-type impurity, for example, magnesium (Mg).

Referring to FIG. **8**, a plurality of light emitting cells S**1**, S**2** separated from each other is formed by a photolithography and etching process. Each of the light emitting cells S**1**, S**2** is formed to have a slanted side surface. In a typical method of manufacturing an MJT LED chip, an additional photolithography and etching process is performed to partially expose an upper surface of the lower semiconductor layer **55** of each of the light emitting cells S**1**, S**2**. However, in this embodiment, the photolithography and etching process performed to partially expose the upper surface of the lower semiconductor layer **55** is omitted.

Referring to FIG. **9**, a current blocking layer **60***a* covering some region on the first light emitting cell S**1** and an insulation layer **60***b* partially covering the side surface of the first light emitting cell S**1** are formed. The insulation layer **60***b* may extend to cover a region between the first light emitting cell S**1** and the second light emitting cell S**2** while partially covering a side surface of the lower semiconductor layer **55** of the second light emitting cell S**2**.

The current blocking layer **60**a and the insulation layer **60**b may be formed by depositing an insulation material layer, followed by patterning through photolithography and etching. Alternatively, the current blocking layer **60**a and the insulation layer **60**b may be formed of an insulation material layer by a lift-off technique. Particularly, each of the current blocking layer **60**a and the insulation layer **60**b may be a distributed Bragg reflector formed by alternately stacking layers having different indices of refraction, for example, SiO_2 and TiO_2 layers. When the insulation layer **60**b is a distributed Bragg reflector formed by stacking multiple layers, it is possible to efficiently suppress generation of defects such as pinholes in the insulation layer **60**b, whereby the insulation layer **60**b can be formed to a smaller thickness than in the related art.

As shown in FIG. **9**, the current blocking layer **60**a and the insulation layer **60**b may be connected to each other. However, it should be understood that the present disclosure is not limited thereto.

Then, a transparent electrode layer **61** is formed on the first and second light emitting cells S**1**, S**2**. The transparent electrode layer **61** may be formed of an indium tin oxide (ITO) layer, a conductive oxide layer such as a zinc oxide layer, or a metal layer such as Ni/Au. The transparent electrode layer **61** is connected to the upper semiconductor layer **59** and is partially placed on the current blocking layer **60**a. The transparent electrode layer **61** may be formed by a lift-off process, without being limited thereto. Alternatively, the transparent electrode layer **61** may be formed by a photolithography and etching process.

Referring to FIG. **10**, an insulation protective layer **63** is formed to cover the first and second light emitting cells S**1**, S**2**. The insulation protective layer **63** covers the transparent electrode layer **61** and the insulation layer **60**b. In addition, the insulation protective layer **63** may cover an overall area of the first and second light emitting cells S**1**, S**2**. The insulation protective layer **63** may be formed of an insulation material layer, such as a silicon oxide or silicon nitride layer, by chemical vapor deposition.

Referring to FIG. **11**, a mask pattern **70** having an opening is formed on the insulation protective layer **63**. The opening of the mask pattern **70** corresponds to a region for an interconnection line. Then, some region of the insulation protective layer **63** is removed by etching through the mask pattern **70**. As a result, an opening is formed on the insulation protective layer **63** to expose some of the transparent electrode layer **61** and the insulation layer **60**b while exposing the slanted side surface of the lower semiconductor layer **55** of the second light emitting cell S**2**.

Referring to FIG. **12**, with the mask pattern **70** remaining on the insulation protective layer **63**, a conductive material is deposited to form the interconnection line **65** within the opening of the mask pattern **70**. Here, some of the conductive material **65**a may be deposited on the mask pattern **70**. The conductive material may be deposited by plating, e-beam evaporation, sputtering, and the like.

Referring to FIG. **11**, the mask pattern **70**, together with some of the conductive material **65**a, is removed from the mask pattern **70**. As a result, the interconnection line **65** electrically connecting the first and second light emitting cells S**1**, S**2** to each other is completed.

Here, a first connection section **65**p of the interconnection line **65** is connected to the transparent electrode layer **61** of the first light emitting cell S**1**, and a second connection section **65**n thereof is connected to the slanted side surface of the lower semiconductor layer **55** of the second light emitting cell S**2**. The first connection section **65**p of the interconnection line **65** may be connected to the transparent electrode layer **60**a within an upper region of the current blocking layer **60**a. The interconnection line **65** is separated from the side surface of the first light emitting cell S**1** by the insulation layer **60**b.

In this embodiment, the current blocking layer **60**a and the insulation layer **60**b are formed by the same process. As a result, the insulation protective layer **63** and the interconnection line **65** may be formed using the same mask pattern **70**, whereby the MJT LED chip can be manufactured by the same number of exposure processes while adding the current blocking layer **60**a.

FIG. **14** is a schematic sectional view of an MJT LED chip according to another exemplary embodiment of the present disclosure.

Referring to FIG. **14**, the MJT LED chip according to this embodiment is generally similar to the MJT LED chip described with reference to FIGS. **5** and **6**, and further includes a transparent conductive layer **62**.

The growth substrate **51**, the light emitting cells S**1**, S**2**, the buffer layer **53**, the transparent electrode layer **61**, the current blocking layer **60**a, the insulation layer **60**b, the insulation protective layer **63** and the interconnection line **65** are similar to those of the light emitting diode described with reference to FIGS. **5** and **6**, and thus detailed descriptions thereof will be omitted.

The transparent conductive layer **62** is placed between the insulation layer **60**b and the interconnection line **65**. The transparent conductive layer **62** has a narrower width than the insulation layer **60**b, thereby preventing a short circuit of the upper semiconductor layer **59** and the lower semiconductor layer **55** due to the transparent conductive layer **62**.

On the other hand, the transparent conductive layer **62** is connected to a first transparent electrode layer **61**, and may electrically connect the first transparent electrode layer **61** to the second light emitting cell S**2**. For example, the transparent conductive layer **62** may be connected at one end thereof to the lower semiconductor layer **55** of the second light emitting cell. In addition, when two or more light emitting cells are connected thereto, a second transparent conductive layer **62** may extend from a second transparent electrode layer **61** on the second light emitting cell S**2**.

In this embodiment, since the transparent conductive layer **62** is placed between the interconnection line **65** and the insulation layer **60**b, current can flow through the transparent conductive layer **62** even in the case where the interconnection line **65** is disconnected, thereby improving electric stability of the MJT LED chip.

FIG. **15** to FIG. **18** are schematic sectional views illustrating a method of fabricating an MJT LED chip according to another exemplary embodiment of the present disclosure.

Referring to FIG. **15**, first, as described with reference to FIGS. **7** and **8**, a semiconductor stack structure **56** is formed on a growth substrate **51**, and a plurality of light emitting cells S**1**, S**2** separated from each other is formed by a photolithography and etching process. Then, as described with reference to FIG. **9**, a current blocking layer **60**a covering a region on the first light emitting cell S**1** and an insulation layer **60**b partially covering a side surface of the first light emitting cell S**1** are formed.

As described with reference to FIG. **9**, each of the current blocking layer **60**a and the insulation layer **60**b may include a distributed Bragg reflector formed by alternately stacking layers having different indices of refraction, for example, SiO_2 and TiO_2 layers. When the insulation layer **60**b include the distributed Bragg reflector formed by stacking multiple layers, it is possible to efficiently suppress generation of defects such as pinholes in the insulation layer **60**_b_, whereby the insulation layer **60**_b_ can be formed to a smaller thickness than in the related art.

Then, a transparent electrode layer **61** is formed on the first and second light emitting cells **S1**, **S2**. As described with reference to FIG. **9**, the transparent electrode layer **61** may be formed of an indium tin oxide (ITO) layer, a conductive oxide layer such as a zinc oxide layer, or a metal layer such as Ni/Au. The transparent electrode layer **61** is connected to the upper semiconductor layer **59** and is partially placed on the current blocking layer **60**_a_. The transparent electrode layer **61** may be formed by a lift-off process, without being limited thereto. Alternatively, the transparent electrode layer **61** may be formed by a photolithography and etching process.

During formation of the transparent electrode layer **61**, a transparent conductive layer **62** is formed. The transparent conductive layer **62** may be formed together with the transparent electrode layer **61** using the same material and the same process. The transparent conductive layer **62** is formed on the insulation layer **60**_b_ and may be connected to the transparent electrode layer **61**. Further, the transparent conductive layer **62** may be electrically connected at one end thereof to the slanted side surface of the lower semiconductor layer **55** of the second light emitting cell **S2**.

Referring to FIG. **16**, an insulation protective layer **63** is formed to cover the first and second light emitting cells **S1**, **S2**. The insulation protective layer **63** covers the transparent electrode layer **61**, the transparent conductive layer **62**, and the insulation layer **60**_b_. In addition, the insulation protective layer **63** may cover an overall area of the first and second light emitting cells **S1**, **S2**. The insulation protective layer **63** may be formed of an insulation material layer, such as silicon oxide or silicon nitride, by chemical vapor deposition.

Referring to FIG. **17**, as described with reference to FIG. **11**, a mask pattern **70** having an opening is formed on the insulation protective layer **63**. The opening of the mask pattern **70** corresponds to a region for an interconnection line. Then, a portion of the insulation protective layer **63** is removed by etching through the mask pattern **70**. As a result, an opening is formed on the insulation protective layer **63** to expose some of the transparent electrode layer **61** and the transparent conductive layer **62**, while exposing the slanted side surface of the lower semiconductor layer **55** of the second light emitting cell **S2**. Further, the insulation layer **60**_b_ is partially exposed through the opening.

Referring to FIG. **18**, as described with reference to FIG. **12**, with the mask pattern **70** remaining on the insulation protective layer **63**, a conductive material is deposited to form an interconnection line **65** within the opening of the mask pattern **70**.

Then, referring to FIG. **13**, the mask pattern **70**, together with some of the conductive material **65**_a_, is removed from the mask pattern **70**. As a result, the interconnection line **65** electrically connecting the first and second light emitting cells **S1**, **S2** to each other is completed.

In the embodiments described with reference to FIG. **7** to FIG. **13**, the insulation layer **60**_b_ can be damaged during etching of the insulation protective layer **63**. For example, when the insulation protective layer **63** is subjected to etching using an etchant, which contains, for example, hydrofluoric acid, the insulation layer **60**_b_ including an oxide layer can be damaged by the etchant. In this case, the insulation layer **60**_b_ can fail to insulate the interconnection line **65** from the first light emitting cell **S1**, thereby causing a short circuit.

However, in the present embodiment, since the transparent conductive layer **62** is placed on the insulation layer **60**_b_, the insulation layer **60**_b_ under the transparent conductive layer **62** can be protected from etching damage. As a result, it is possible to prevent a short circuit due to the interconnection line **65**.

In this embodiment, the transparent electrode layer **61** and the transparent conductive layer **62** may be formed by the same process. Accordingly, the MJT LED chip can be manufactured by the same number of exposing processes while adding the transparent conductive layer **62**.

Structure of optical member according to first embodiment and MJT LED module including the same

Next, referring to FIG. **3**, FIG. **4**, and FIG. **19** to FIG. **25**, detailed structures and functions of an optical member according to a first embodiment and an MJT LED module including the same will be described.

Referring to FIG. **3** again, the optical member **130** according to the first embodiment may include a lower surface **131** and an upper surface **135**, and may further include a flange **137** and legs **139**. The lower surface **131** includes a concave section **131**_a_, and the upper surface **135** includes a concave surface **135**_a_ and a convex surface **135**_b_.

The lower surface **131** is composed of a substantially circular disc-shaped plane, and has the concave section **131**_a_ placed at a central portion thereof. The lower surface **131** is not required to be a flat surface, and may have various convex-concave patterns.

Further, an inner surface of the concave section **131**_a_ has a surface **133** including side surface **133**_a_ and an upper end surface **133**_b_. Here, the upper end surface **133**_b_ is perpendicular to a central axis C and the side surface **133**_a_ extends from the upper end surface **133**_b_ to an entrance of the concave section **131**_a_. Herein, when aligned to coincide with the optical axis L of the MJT LED **100**, the central axis C is defined as a central axis of the optical member **130**, which becomes a center of a beam distribution of light exiting the optical member **130**.

The concave section **131**_a_ may have a shape, a width of which gradually decreases from the entrance thereof to an upper side thereof. Specifically, the side surface **133**_a_ gradually approaches the central axis C from the entrance of the concave section **131**_a_ to the upper end surface **133**_b_ thereof. With this structure, a region for the upper end surface **133**_b_ may be formed narrower than the entrance of the concave section **131**_a_. The side surface **133**_a_ may have a relatively gentle slope near the upper end surface **133**_b_.

The region for the upper end surface **133**_b_ is defined within a narrower region than a region for the entrance of the concave section **131**_a_. In addition, the region for the upper end surface **133**_b_ may be defined within a narrower region than a region surrounded by an inflection curve at which the concave surface **135**_a_ of the upper surface **135** meets the convex surface **135**_b_ thereof. Further, the region for the upper end surface **133**_b_ may be placed within a narrower region than a region for the cavity **121**_a_ (FIG. **4**) of the MJT LED, that is, a light exit region.

The region for the upper end surface **133**_b_ reduces variation of the beam distribution of light exiting the optical member **130** through the upper surface **135** thereof even in the case of misalignment between the optical axis L of the MJT LED and the central axis C of the optical member **130**. Thus, the region for the upper end surface **133**_b_ may be minimized in consideration of misalignment between the MJT LED **100** and the optical member **130**.

Further, the upper surface **135** of the optical member **130** includes the concave surface **135**_a_ and the convex surface

135*b* continuously extending from the concave surface **135***a* with reference to the central axis C. A line at which the concave surface **135***a* meets the convex surface **135***b* becomes the inflection curve. The concave surface **135***a* disperses light exiting near the central axis C of the optical member **130** through refraction of the light at a relatively large angle. Further, the convex surface **135***b* increases the quantity of light exiting towards an outer direction of the central axis C.

The upper surface **135** and the concave section **131***a* have a symmetrical structure relative to the central axis C. For example, the upper surface **135** and the concave section **131***a* have a mirror symmetry structure relative to a plane passing through the central axis C and may have a rotational body shape relative to the central axis C. In addition, the concave section **131***a* and the upper surface **135** may have various shapes according to a desired light beam distribution.

In another aspect, the flange **137** connects the upper surface **135** to the lower surface **131** and defines an outer size of the optical member. A side surface of the flange **137** and the lower surface **131** may be formed with convex-concave patterns. The legs **139** of the optical member **130** are coupled to the printed circuit board **110** to support the lower surface **131** while separating the lower surface **131** from the printed circuit board **110**. Coupling of the legs **139** to the printed circuit board **110** may be performed by bonding a distal end of each of the legs **139** to the printed circuit board **110** using an adhesive or by fitting each of the legs **139** into a corresponding hole formed in the printed circuit board **110**.

The optical member **130** is separated from the MJT LED **100**, so that an air gap is formed in the concave section **131***a*. The housing **121** of the MJT LED **100** is placed below the lower surface **131**, and the wavelength conversion layer **125** of the MJT LED **100** is separated from the concave section **131***a* to be placed under the lower surface **131**. With this structure, light traveling in the concave section **131***a* is prevented from being lost due to absorption by the housing **121** or the wavelength conversion layer **125**.

According to this embodiment, when a perpendicular plane relative to the central axis C is formed within the concave section **131***a*, it is possible to reduce variation of the beam distribution of light exiting the optical member **130** even upon misalignment between the MJT LED **100** and the optical member **130**. Furthermore, since the concave section **131***a* does not have a relatively sharp apex, the optical member can be easily manufactured.

FIG. **19** shows sectional views of various modifications of the optical member. Herein, various modifications of the concave section **131***a* shown in FIG. **3** will be described.

In FIG. **19**(*a*), the upper end surface **133***b* perpendicular to the central axis C described in FIG. **3** has a downwardly protruding surface formed at a portion thereof near the central axis C. With this downwardly protruding surface, the optical member can achieve primary control of light entering the portion of the optical member near the central axis C thereof.

The upper end surface of FIG. **19**(*b*) is similar to that of FIG. **19**(*a*) except that the upper end surface of FIG. **19**(*b*) has upwardly protruding surfaces formed at portions thereof perpendicular to the central axis C of the optical member. Since the upper end surface is combined with the upwardly protruding surfaces and the downwardly protruding surface, the optical member can reduce variation in light beam distribution due to misalignment between the MJT LED and the optical member.

The upper end surface of FIG. **19**(*c*) is different from that of FIG. **3** in that the upper end surface **133***b* is formed with an upwardly protruding surface at a portion thereof near the central axis C of the optical member. With this upwardly protruding surface, the optical member can achieve further dispersion of light entering the portion of the optical member near the central axis C thereof.

The upper end surface of FIG. **19**(*d*) is similar to that of FIG. **19**(*c*) except that the upper end surface has downwardly protruding surfaces at portions thereof perpendicular to the central axis C of the optical member. Since the upper end surface is combined with the upwardly protruding surfaces and the downwardly protruding surface, the optical member can reduce variation in light beam distribution due to misalignment between the MJT LED and the optical member.

FIG. **20** shows sectional views of an optical member, illustrating an MJT LED module according to a further exemplary embodiment of the present disclosure.

Referring to FIG. **20**(*a*), the upper end surface **133***b* may be formed with a light scattering pattern **133***c*. The light scattering pattern **133***c* may be a convex-concave pattern. In addition, the concave surface **135***a* may also be formed with a light scattering pattern **135***c*. The light scattering pattern **135***c* may also be a convex-concave pattern.

Generally, a relatively large luminous flux is concentrated near the central axis C of the optical member. Furthermore, according to embodiments of the present disclosure, since the upper end surface **133***b* is perpendicular to the central axis C, more luminous flux can be concentrated near the central axis C. Accordingly, with the structure of the upper end surface **133***b* and/or the concave surface **135***a* having the light scattering patterns **133***c*, **135***c*, it is possible to disperse luminous flux near the central axis C of the optical member.

Referring to FIG. **20**(*b*), a material layer **139***a* having a different index of refraction than that of the optical member **130** may be placed on the upper end surface **133***b*. The index of refraction of the material layer **139***a* may be higher than that of the optical member, thereby allowing change of an optical path of light incident on the upper end surface **133***b*.

Further, a material layer **139***b* having a different index of refraction than that of the optical member **130** may also be placed on the concave surface **135***a*. The index of refraction of the material layer **139***b* may be higher than that of the optical member, thereby allowing change of an optical path of light exiting through the concave surface **135***a*.

The light scattering patterns **133***c*, **135***c* of FIG. **20**(*a*) and the material layers **139***a*, **139***b* of FIG. **20**(*b*) may also be applied to the various optical members of FIG. **19**.

FIG. **21** is a sectional view illustrating dimensions of an MJT LED module used for simulation. Here, the same reference numerals as those of FIGS. **3** and **4** are used (please also refer to FIGS. **3** and **4** for a depiction of some elements).

In the MJT LED **100**, the cavity **121***a* has a diameter of 2.1 mm and a height of 0.6 mm. The wavelength conversion layer **125** fills the cavity **121***a* and has a flat surface. A distance (d) between the MJT LED **100** and the lower surface **131** of the optical member **130** is 0.18 mm and the MJT LED **100** and the optical member **130** are arranged such that the optical axis L of the MJT LED **100** is aligned with the central axis C of the optical member.

The optical member **130** has a height (H) of 4.7 mm and an upper surface of the optical member has a width (W**1**) of 15 mm. The concave surface **135***a* has a width (W**2**) of 4.3 mm. Further, the entrance of the concave section **131***a* placed on the lower surface **131** has a width (w**1**) of 2.3 mm, and the upper end surface **133***b* has a width (w**2**) of 0.5 mm. The concave section **131***a* has a height (h) of 1.8 mm.

FIG. **22** shows graphs depicting a shape of the optical member of FIG. **21**. Here, (a) is a sectional view of the optical member illustrating reference point P, distance R, angle of incidence θ**1**, and exit angle θ**5**; (b) shows variation of distance R according to angle of incidence θ**1**; and (c) shows variation of θ**5**/θ**1** according to angle of incidence θ**1**. FIG. **23** shows traveling directions of light beams entering the optical member **130** from reference point P at intervals of 3°.

Referring to FIG. **22**(*a*), reference point P indicates a light exit point of the MJT LED **100** placed on the optical axis L. Properly, reference point P is set to be placed on an outer surface of the wavelength conversion layer **125** in order to exclude external factors, such as light scattering by the phosphors in the MJT LED **100** and the like.

θ**1** indicates an angle of incidence of light entering the optical member **130** from the reference point P, and θ**5** indicates an exit angle of light exiting the optical member **130** through the upper surface **135** thereof. R indicates a distance from reference point P to the inner surface of the concave section **131***a*.

Referring to FIG. **22**(*b*), since the upper end surface **133***b* of the concave section **131***a* is perpendicular to the central axis C, R slightly increases with increasing θ1. An enlarged graph in FIG. **22**(*b*) shows an increasing curve of R. On the side surface **133***a* of the concave section **131***a*, R decreases with increasing θ1 and slightly increases near the entrance of the concave section **131***a*.

Referring to FIG. **22**(*c*), as θ1 increases, θ**5**/θ**1** rapidly increases near the concave surface **135***a* and relatively gently decreases near the convex surface **135***b*. In this embodiment, as shown in FIG. **23**, luminous flux exiting the optical member through the concave surface **135***a* thereof may overlap luminous flux exiting the optical member through the convex surface **135***b* thereof. That is, among light beams entering the optical member from reference point P, light exiting the optical member through the concave surface **135***a* near the inflection curve may have a higher refraction angle than light exiting the optical member through the convex surface **135***b*. Thus, it is possible to reduce concentration of luminous flux near the central axis C by forming the upper end surface **133***b* of the concave section **131***a* to have a planar shape and adjusting the shapes of the concave surface **135***a* and the convex surface **135***b*.

FIG. **24** shows graphs depicting illuminance distribution, in which (a) is a graph depicting illuminance distribution of an MJT LED, and (b) is a graph showing illuminance distribution of the MJT LED module using an optical member. Illuminance distribution is represented as a magnitude of luminous flux density of light entering a screen separated a distance of 25 mm from a reference point.

As shown in FIG. **24**(*a*), the MJT LED **100** provides a bilaterally symmetric illumination distribution with reference to the optical axis (C), and has a luminous flux density which is very high at the center thereof and rapidly decreases towards the periphery thereof. When the optical member **130** is applied to the MJT LED **100**, the MJT LED **100** can provide a substantially uniform luminous flux density within a radius of 40 mm, as shown in FIG. **24**(*b*).

FIG. **25** shows graphs depicting light beam distributions, in which (a) is a graph depicting a light beam distribution of an MJT LED, and (b) is a graph depicting a light beam distribution of the MJT LED module using an optical member. The light beam distribution shows light intensity at a place separated a distance of 5 m from reference point P according to a beam angle, and beam distributions in orthogonal directions are shown to overlap each other in one graph.

As shown in FIG. **25**(*a*), the intensity of light emitted from the MJT LED **100** is high at a beam angle of 0°, that is, at the center thereof, and gradually decreases with increasing beam angle. When the optical member is applied to the MJT LED **100**, the intensity of light emitted from the MJT LED **100** is relatively low at a beam angle of 0° and is relatively high near a beam angle of 70°, as shown in FIG. **25**(*b*).

Accordingly, when the optical member **130** is applied to the MJT LED **100**, it is possible to achieve uniform backlighting of a relatively wide area through change of the light beam distribution of the MJT LED, which has high light intensity at the center thereof.

Structure of optical member according to second embodiment and MJT LED module including the same

Next, referring to FIG. **26** to FIG. **33**, detailed structures and functions of an optical member according to a second embodiment and an MJT LED module including the same will be described.

FIG. **26** is a sectional view of an MJT LED module according to one exemplary embodiment of the present disclosure, and FIGS. **27** (*a*), (*b*) and (*c*) are sectional views of the MJT LED module taken along lines a-a, b-b and c-c of FIG. **26**. Here, line a-a corresponds to a line on a lower surface of the optical member, line c-c corresponds to a line on an upper surface of the optical member, and line b-b corresponds to a cutting line at the middle of the height of a diffusion lens between line a-a and line c-c. Further, FIG. **28** is a detailed view of an optical member of the MJT LED module shown in FIG. **26**, and FIG. **29** shows a light beam angle distribution of the MJT LED module using the optical member of FIG. **28**.

Referring to FIG. **26**, the MJT LED module includes an MJT LED **100** and an optical member **230** disposed on the MJT LED **100** and formed of a resin or glass material. Although the printed circuit board **110** is partially shown to show a single MJT LED module in this embodiment, a plurality of MJT LED modules is regularly arranged on a single printed circuit board **110** to form the backlight module **300** as described above.

First, the MJT LED **100** and the printed circuit board **110** are the same as those of the first embodiment described above with reference to FIG. **3** and FIG. **4**, and detailed descriptions thereof will be omitted. Thus, the optical member **230** according to the second embodiment will be mainly described hereinafter.

Referring to FIG. **26**, the optical member **230** includes a lower surface **231** and a light exit face **235** at the opposite side thereof, and may further include legs **239**. The lower surface **231** includes a concave light incident section **231***a*. The light exit face **235** is generally composed of an upwardly protruding round surface, and includes a flat surface **235***a* formed at an upper center thereof. The flat surface **235***a* is placed corresponding to a concave section of an optical member such as aspects of the optical member shown in the first embodiment, and the optical member **230** according to the present embodiment can disperse light near the optical axis by the structure of a light incident section **231***a* described in detail hereinafter even without the concave section at the upper center of the light exit face. The light incident section **231***a* has a substantially bell-shaped cross-section. That is, the light incident section **231***a* has a shape which gradually converges from a lower entrance thereof adjacent the MJT LED **100** towards an upper apex thereof.

Referring to FIG. **27**(*a*), the lower surface **231** of the optical member **230** has a circular shape. In addition, the light incident section **231***a* has a lower portion placed at a center of the lower surface **231**, and the lower portion of the light incident section **231***a* has a circular shape. The light incident section **231***a* maintains a circular shape from the lower entrance immediately before the upper apex thereof, and has a gradually decreasing diameter in an upward direction. Referring to FIG. **27**(*c*), the upper flat surface **235***a* of the optical member **230** also has a circular shape.

Referring to FIGS. **27** (*a*), (*b*) and (*c*) in order, the optical member **230** includes the lower surface **231** having a circular shape, and has a gradually decreasing diameter in the upward direction. The optical member **230** may have a greater variation in diameter of a circular outer circumference at an upper portion of a side surface thereof than that of the circular outer circumference at a lower portion of the side surface thereof. The circular shape of the light incident section **231***a* has a gradually decreasing diameter.

Referring to FIG. **28**, an optical axis L corresponding to the central axis of the optical member **230** is shown. To obtain a uniform light distribution using the optical member **230**, it is necessary to have a light intensity peak at an angle of 60° or more from the optical axis L. To obtain such optical characteristics, it is important to achieve effective dispersion of light at an angle of 50° or less from the optical axis L. FIG. **28** shows reference line (r) at an angle of 50° or less relative to the optical axis L.

To achieve effective dispersion of light at an angle of 50° or less from the optical axis L, within the range between the optical axis L and the reference line (r), that is, at an angle of 50° or less from the optical axis L, the shortest distance 'b' from a certain point (p) on the optical axis L to the apex of the light incident section **231***a* is greater than the shortest distance 'a' from the point (p) to the side surface of the light incident section **231***a*. As above, when b>a, the light incident section **231***a* can contribute to wide dispersion of light traveling within an angle of 50° or less from the optical axis L to an angle of 60° or more from the optical axis L. In contrast, when b<a, the light incident section **231***a* fails to contribution to wide dispersion of light traveling within an angle of 50° or less from the optical axis L. As such, it is necessary to form a separate concave section for wide dispersion of light at the upper center of the light exit face in the related art. In other words, the optical member **230** according to the present disclosure employs the curved structure of the light incident section **231***a* satisfying the condition of b>a within an angle of 50° or less from the optical axis L and thus the concave section at the upper center of the light exit face can be omitted.

Here, the light incident section **231***a* preferably has a height greater than a radius R of the lower entrance of the light incident section **231***a*. More preferably, the height H of the light incident section **231***a* is 1.5 times or more the radius R thereof. In addition, a lower portion of the light incident section **231***a* adjoins air which has a lower index of refraction than the resin or glass material, and an upper portion of the light exit face also adjoins air which has a lower index of refraction than the resin or glass material.

FIG. **29** shows a light beam angle distribution of the MJT LED module using the optical member of FIG. **28**. Referring to FIG. **29**, it can be seen that a light intensity peak is formed at about 72° from the optical axis L and light is widely distributed. From the result of FIG. **29**, it can be seen that the optical member **230** according to the present disclosure can uniformly disperse light at an angle of 60° or less from the optical axis L through the curved structure of the light incident section **231***a* satisfying the condition of b>a at an angle of 50° or less from the optical axis L even without the concave section at the upper center of the light exit face, thereby achieving uniform distribution of light.

FIG. **30** is a sectional view of an optical member according to another exemplary embodiment of the present disclosure. As clearly shown in FIG. **30**, the optical member **230** according to this embodiment has the same curved structure of the light incident section **231***a* as that of the optical member shown in FIG. **28**. Thus, the light incident section **231***a* of the optical member according to this embodiment satisfies the condition of b>a at an angle of 50° or less from the optical axis L. Here, unlike the optical member according to the above embodiment, which has the flat surface formed at the upper center of the light exit face, the optical member **230** according to this embodiment has a convexly round surface **235***b* at the upper center of the light exit face.

FIG. **31** clearly shows a beam angle distribution curve of an MJT LED module using the optical member of FIG. **30**. Referring to FIG. **31**, it can be seen that a light intensity peak is formed at about 72° from the optical axis L and light is widely distributed. In addition, there is no significant difference between the light beam angle distribution of FIG. **31** and the light beam angle distribution of FIG. **29**. Thus, it can be seen that, when the light incident section **231***a* satisfies the condition of b>a at an angle of 50° or less from the optical axis L, there is no significant difference in light beam angle distribution, regardless of whether the light exit face has the flat surface or the convex surface at the upper center thereof.

FIGS. **32**A and **32**B show an optical member according to Comparative Example 1 and a beam angle distribution curve thereof.

In the optical member of FIG. **32**A, at an angle of 50° or less from the optical axis L, the shortest distance 'b' from a certain point on the optical axis to an apex of a light incident section is greater than the shortest distance 'a' from the same point to a side surface of the light incident section, and the light exit face has a concave section formed at an upper center thereof. In FIG. **32**B showing a beam angle distribution curve under these conditions, it can be seen that there is no substantial difference in light beam angle distribution between the above embodiments and this comparative example. This result means that, under the condition of b>a, the concave section formed at the upper center of the light exit face provides substantially no function in change of the light beam angle distribution.

FIGS. **33**A and B show an optical member according to Comparative Example 2 and a light beam angle distribution thereof.

In the optical member of FIG. **33**A, at an angle of 50° or less from the optical axis L, the shortest distance 'b' from a certain point on the optical axis to an apex of a light incident section is smaller than the shortest distance 'a' from the same point to a side surface of the light incident section, and the light exit face has a concave section formed at an upper center thereof. In FIG. **33**B showing a beam angle distribution curve under these conditions, it can be seen that there is no substantial difference between the light beam angle distribution of Comparative Example 1 and that of the above embodiments. This result means that, under the condition of b<a, the concave section formed at the upper center of the light exit face contributes to wide dispersion of light at an angle of 50° or less from the optical axis L.

FIG. **34** is a sectional view of an optical member according to another exemplary embodiment of the present disclosure. As shown in FIG. **34**, the light exit face **135** includes a total reflection surface **135***c* so as to form an apex **135***d* under the central axis C of the optical member. Light can be dispersed laterally based on the light axis C, by total refection of light in the total reflection surface **135***c*.

Although the present disclosure has been illustrated with reference to some exemplary embodiments in conjunction with the drawings, it should be understood that some features of a certain embodiment may also be applied to other embodiments without departing from the spirit and scope of the disclosure. Further, it should be understood that these embodiments are provided by way of illustration only, and that various modifications and changes can be made without departing from the spirit and scope of the present disclosure.

What is claimed is:

1. A backlight module comprising:
a printed circuit board (PCB);
a plurality of multi junction technology (MJT) light emitting diodes (LEDs) disposed on the PCB; and
a plurality of optical members respectively disposed over each of the MJT LEDs, each optical member comprising:
a light incident face through which light emitted from the corresponding MJT LED enters the optical member; and
a light exit face through which light exits the optical member at a wider beam angle than that of the corresponding MJT LED,
wherein each of the MJT LEDs comprises:
a first light emitting cell and a second light emitting cell separated from each other on a growth substrate, the second light emitting cell having a slanted side surface; and
an interconnection line electrically connecting the first light emitting cell to the second light emitting cell in series, the interconnection line comprising a first connection section for electrical connection to the first light emitting cell and a second connection section for electrical connection to the second light emitting cell,
wherein each of the optical members further comprises:
a lower surface having a concave section configured for light emitted from the MJT LED to enter the optical member; and
an upper surface comprising a concave surface on a central axis of the optical member, the concave surface having a total internal reflection surface so as to form an apex on the central axis of the optical member, and
wherein the concave section of the lower surface comprises:
a first concave surface on the central axis;
a second concave surface having a diameter greater than the first concave surface; and
a downwardly protruding surface surrounding the first concave surface of the concave section and connecting the first concave surface to the second concave surface, the downwardly protruding surface comprising a portion disposed closer to the PCB than a portion of the second concave surface.

2. The backlight module according to claim **1**, wherein each of the MJT LEDs comprises first to N-th light emitting cells, wherein N is a natural number of 2 or more, and the N-th light emitting cell is electrically connected to a (N−1)th light emitting cell in the same structure as a connection structure between the first light emitting cell and a second light emitting cell.

3. The backlight module according to claim **2**, wherein the first to N-th light emitting cells are connected to each other in series and configured to operate at an operating voltage of 2.5V to 4 V, each of the MJT LEDs being configured to operate at an operating voltage of at least 10 V or more.

4. The backlight module according to claim **2**, wherein each of the MJT LEDs comprises three light emitting cells each configured to operate at an operating voltage of 3V to 3.6V, and is operated at an operating voltage of 12V to 14V.

5. The backlight module according to claim **1**, wherein the light incident face comprises an opening formed near the central axis of the optical member, the opening having a height which is 1.5 times or more than a width thereof.

6. The backlight module according to claim **1**, wherein the upper surface and the concave section of the optical member form a mirror symmetry structure relative to a plane passing through the central axis of the optical member.

7. The backlight module according to claim **1**, wherein the upper surface and the concave section of the optical member form a rotational body shape relative to the central axis of the optical member.

8. The backlight module according to claim **1**, wherein each of the optical members is formed of a material, the index of refraction of which is higher than that of a material adjoining the light incident section and that of a material adjoining the light exit face.

9. The backlight module according to claim **8**, wherein the material adjoining the light incident face is air.

10. The backlight module according to claim **8**, wherein the material adjoining the light exit face is air.

11. The backlight module according to claim **8**, wherein the optical members are formed of a resin or glass material.

12. A backlight unit comprising:
a backlight module comprising:
a printed circuit board (PCB);
a plurality of multi junction technology (MJT) light emitting diodes (LEDs) disposed on the printed circuit board; and
a plurality of optical members respectively disposed over each of the MJT LEDs and each optical member including a light incident face through which light emitted from the corresponding MJT LED enters the optical member and a light exit face through which light exits the optical member at a wider beam angle than that of the corresponding MJT LED,
wherein the light incident surface comprises:
a first concave surface on a central axis;
a second concave surface having a diameter greater than the first concave surface; and
a downwardly protruding surface surrounding the first concave surface, the downwardly protruding surface comprising a portion disposed closer to the PCB than a portion of the second concave surface,
wherein each of the MJT LEDs comprises:
a first light emitting cell and a second light emitting cell separated from each other on a growth substrate, the second light emitting cell having a slanted side surface; and
an interconnection line electrically connecting the first light emitting cell to the second light emitting cell in series, the interconnection line comprising a first connection section for electrical connection to the

first light emitting cell and a second connection section for electrical connection to the second light emitting cell, and

wherein each of the light emitting cells is configured to operate at an operating voltage of 2.5V to 4 V, and each of the MJT LEDs is configured to operate at an operating voltage of at least 10V or more; and

a backlight control module comprising:

an operating power generator configured for supplying DC operating voltage to the MJT LEDs within the backlight module; and

an operation controller configured for independently controlling a dimming operation of the MJT LEDs,

wherein the DC operating voltage supplied by the operating power generator is equal to or less than 48V.

13. The backlight unit according to claim **12**, wherein the backlight control module is configured to supply the DC operating voltage to each of the plurality of MJT LEDs within the backlight module, and is configured to perform pulse width modulation control with respect to the DC operating voltage supplied to at least one MJT LED among the plurality of MJT LEDs in response to a dimming signal to perform dimming control of the at least one MJT LED.

14. The backlight unit according to claim **12**, wherein the backlight control module is configured for independent detection and control of operating current of each of the plurality of MJT LEDs within the backlight module, and configured to control operating current of at least one MJT LED among the plurality of MJT LEDs in response to a dimming signal to perform dimming control of the at least one MJT LED.

15. The backlight unit according to claim **12**, wherein:

each of the optical members comprises:

a lower surface having a concave section configured for light emitted from the MJT LED to enter the optical member; and

an upper surface comprising a concave surface on a central axis of the optical member, the concave surface having a total internal reflection surface so as to form an apex on the central axis of the optical member; and

the concave section of the lower surface comprises:

a concave surface on the central axis; and

a downwardly protruding surface surrounding the concave surface of the concave section.

16. The backlight unit according to claim **12**, wherein each of the MJT LEDs comprises an anode terminal and a cathode terminal, and the operation controller is directly connected to a cathode terminal of each of the MJT LEDs.

17. The backlight unit according to claim **12**, wherein each of the MJT LEDs is configured to operate at an operating current of 20mA to 40mA.

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