



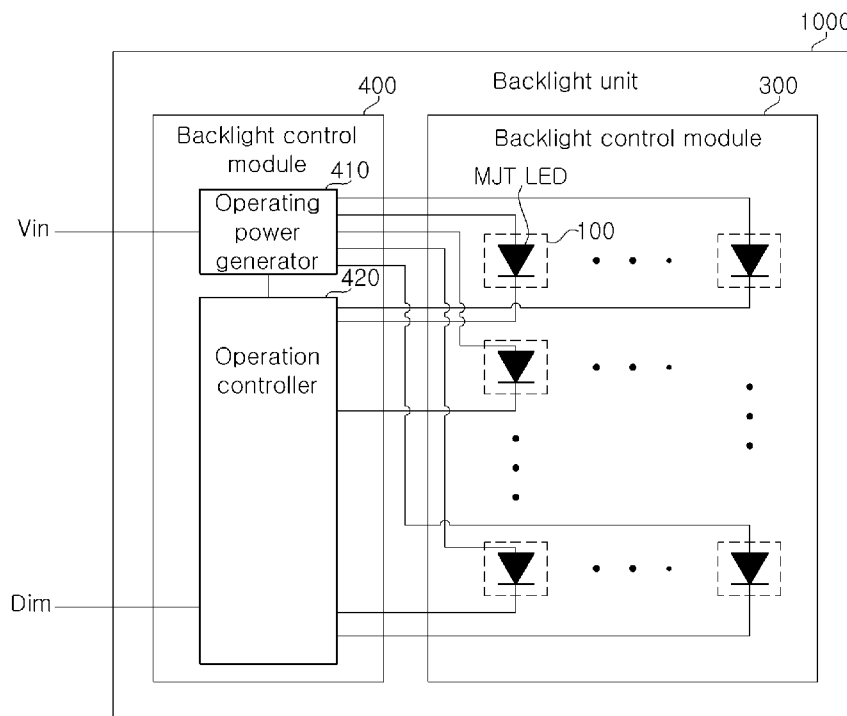
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(54) **Title:** BACKLIGHT MODULE WITH MJT LED AND BACKLIGHT UNIT INCLUDING THE SAME

(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.

Description

Title of Invention: BACKLIGHT MODULE WITH MJT LED AND BACKLIGHT UNIT INCLUDING THE SAME

Technical Field

- [1] 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.

Background Art

- [2] 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.
- [3] 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.
- [4] 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.
- [5] 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.

- [6] 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.
- [7] Figure 1 is a configuration block diagram of a typical backlight unit using LEDs in the related art. With reference to Figure 1, problems of the related art will be described in more detail. As shown in Figure 1, a typical backlight unit 1 includes a backlight control module 2 and a backlight module 5.
- [8] The backlight control module 2 includes an operating power generator 3, which generates/outputs DC power based on input voltage V_{in} input from an external power source, and an operation controller 4 controlling operation of each of a plurality of LED arrays 6a~6n 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.
- [9] The backlight module 5 includes a plurality of LED arrays 6a~6n 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 6a~6n. In Figure 1, the backlight unit 5 includes n LED arrays 6a~6n 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 6a~6n 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 6a~6n in response to an external dimming signal (Dim) to control brightness of the specific LED array.

- [10] 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.

Disclosure of Invention

Solution to Problem

- [11] 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.
- [12] 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.
- [13] 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 stability and reliability of drive circuits for controlling operation of the backlight module, and enabling reduction in manufacturing costs.
- [14] 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.
- [15] 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.
- [16] The above and other objects and advantageous effects of the present disclosure can be obtained by the following features of the present disclosure.
- [17] 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.

- [18] 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.
- [19] 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.
- [20] 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.
- [21] 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.
- [22] In one aspect, the light exit face includes a total reflection surface so as to form an apex under the central axis of the optical member.
- [23] 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.
- [24] 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.

- [25] 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.
- [26] 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.
- [27] 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.
- [28] 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.
- [29] In one aspect, each of the optical members has a light scattering pattern formed on the concave surface of the upper surface.
- [30] 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.
- [31] 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.
- [32] 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.
- [33] 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.
- [34] 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.

- [35] 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.
- [36] 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.
- [37] In one aspect, an upper center of the light exit face is formed of a flat surface or a convex curve.
- [38] 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.
- [39] In one aspect, the light incident section has a height which is 1.5 times greater than a radius of the lower entrance.
- [40] In one aspect, the material adjoining the light incident section is air.
- [41] In one aspect, the material adjoining the light exit face is air.
- [42] In one aspect, the optical members are formed of a resin or glass.
- [43] 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.
- [44] 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.
- [45] 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.

Advantageous Effects of Invention

- [46] 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.

[47] 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.

[48] 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.

[49] 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.

[50] 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 Drawings

[51] 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:

[52] Figure 1 is a configuration block diagram of a typical backlight unit including LEDs in the related art;

[53] Figure 2 is a schematic block diagram of a backlight unit employing MJT LEDs according to one exemplary embodiment of the present disclosure;

[54] Figure 3 is a schematic sectional view of an MJT LED module according to one exemplary embodiment of the present disclosure;

[55] Figure 4 is a schematic perspective view of the MJT LED according to the one exemplary embodiment of the present disclosure;

[56] Figure 5 is a schematic plan view of an MJT LED chip according to one exemplary embodiment of the present disclosure;

[57] Figure 6 is a schematic sectional view of the MJT LED chip taken along line B-B of Figure 5;

[58] Figure 7 to Figure 13 are schematic sectional views illustrating a method of fabricating an MJT LED chip according to one exemplary embodiment of the present disclosure;

[59] Figure 14 is a schematic sectional view of an MJT LED chip according to another exemplary embodiment of the present disclosure;

[60] Figure 15 to Figure 18 are schematic sectional views illustrating a method of fabricating an MJT LED chip according to another exemplary embodiment of the present

disclosure;

[61] Figure 19 shows sectional views of various modifications of an optical member according to the present disclosure;

[62] Figure 20 shows sectional views of an optical member, illustrating an MJT LED module according to a further exemplary embodiment of the present disclosure;

[63] Figure 21 is a sectional view illustrating dimensions of an MJT LED module used for simulation;

[64] Figure 22 shows graphs depicting a shape of an optical member of Figure 21;

[65] Figure 23 shows traveling directions of light beams entering the optical member of Figure 21;

[66] Figure 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;

[67] Figure 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;

[68] Figure 26 is a sectional view of an MJT LED module according to one exemplary embodiment of the present disclosure;

[69] Figures 27 (a), (b) and (c) are sectional views of the MJT LED module taken along lines a-a, b-b and c-c of Figure 26;

[70] Figure 28 is a detailed view of an optical member of the MJT LED module shown in Figure 26;

[71] Figure 29 shows a light beam angle distribution of the MJT LED module using the optical member of Figure 28;

[72] Figure 30 is a sectional view of an optical member according to another exemplary embodiment of the present disclosure;

[73] Figure 31 shows a beam angle distribution curve of an MJT LED module using the optical member of Figure 30;

[74] Figure 32a and Figure 32b show an optical member according to Comparative Example 1 and a beam angle distribution curve thereof; and

[75] Figure 33a and Figure 33b show an optical member according to Comparative Example 2 and a light beam angle distribution thereof.

Best Mode for Carrying out the Invention

[76] 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.

[77] 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.

[78] [Exemplary embodiment of the present disclosure]

[79] 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 20mA to 40mA, without being limited thereto.

[80] 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.

[81] 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.

[82] 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.

[83] Overview of backlight unit using MJT LEDs

[84] 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.

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

- [86] First, Figure 2 is a schematic block diagram of a backlight unit employing MJT LEDs according to one exemplary embodiment of the present disclosure. Referring to Figure 2, the backlight unit 1000 according to this embodiment includes a backlight control module 400 and a backlight module 300.
- [87] 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 V_{in} 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 V_{in} 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 Figure 1.
- [88] The backlight module 300 according to this disclosure may include a plurality of MJT LEDs 100 and optical members (not shown in Figure 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 Figure 2). In the embodiment shown in Figure 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 MxN 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).
- [89] Here, it should be noted that, unlike the related art shown in Figure 1, the MJT LEDs 100 within the backlight module 300 according to the embodiment of Figure 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 Figure 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.
- [90] 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).

[91] 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 Figure 1, the backlight unit 1000 according to the present disclosure as shown in Figure 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.

[92] 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 Figure 1, in the backlight unit 1000 according to the present disclosure shown in Figure 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 MxN MJT LEDs 100 as described above, the operation controller 420 includes MxN operating

current detectors and MxN 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 Figure 2. The operating current detector and the operating current controller are well known in the art and detailed descriptions thereof will thus be omitted.

[93] Overview of MJT LED and MJT LED module

[94] Figure 3 is a schematic sectional view of an MJT LED module according to one exemplary embodiment of the present disclosure, and Figure 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 Figure 3 and Figure 4.

[95] Referring to Figure 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 Figure 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.

[96] 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.

- [97] As clearly shown in Figure 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.
- [98] 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 121a for mounting the MJT LED chip 123 therein. The cavity 121a defines a light exit area of the MJT LED 100.
- [99] 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.
- [100] The MJT LED chip 123 is mounted on the bottom of the cavity 121a 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 Figure 5 to Figure 18.
- [101] 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 121a with a molding resin containing phosphors after mounting the MJT LED chip 123 in the cavity 121a. At this time, the wavelength conversion layer 125 may fill the cavity 121a 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.
- [102] 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.

- [103] 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.
- [104] 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 121a 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 121a.
- [105] 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 Figure 19 to Figure 33.
- [106] Configuration of MJT LED chip and method of manufacturing the same
- [107] 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 Figure 5 to Figure 18.
- [108] Figure 5 is a schematic plan view of an MJT LED chip according to one exemplary embodiment of the present disclosure, and Figure 6 is a schematic sectional view of the MJT LED chip taken along line B-B of Figure 5.
- [109] Referring to Figure 5 and Figure 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 60a, an insulation layer 60b, an insulation protective layer 63, and an interconnection line 65. Further, the MJT LED chip 123 may include a buffer layer 53.
- [110] 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.
- [111] 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 S1, S2 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.

- [112] 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.
- [113] The lower semiconductor layer 55 and/or the upper semiconductor layer 59 may have a single layer structure, as shown in Figure 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.
- [114] Each of the first and second light emitting cells S1, S2 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.
- [115] 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.
- [116] Although portions of the first light emitting cell S1 and the second light emitting cell S2 are shown in Figure 6, the first and second light emitting cells S1, S2 may have a similar or the same structure as that shown in Figure 5. That is, the first light emitting cell S1 and the second light emitting cell S2 may have the same gallium nitride-based semiconductor stack structure, and may have slanted side surfaces of the same structure.
- [117] The buffer layer 53 may be interposed between the light emitting cells S1, S2 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.
- [118] The transparent electrode layer 61 is placed on each of the light emitting cells S1, S2. That is, a first transparent electrode layer 61 is placed on the first light emitting cell S1 and a second transparent electrode layer 61 is placed on the second light emitting cell S2. 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 S1, S2.
- [119] In another aspect, the current blocking layer 60a may be placed on each of the light

emitting cells S1, S2. That is, the current blocking layer 60a is placed between the transparent electrode layer 61 and each of the light emitting cells S1, S2. Part of the transparent electrode layer 61 is placed on the current blocking layer 60a. The current blocking layer 60a may be placed near an edge of each of the light emitting cells S1, S2, but is not limited thereto. Alternatively, the current blocking layer 60a may be placed in a central region of each of the light emitting cells S1, S2. The current blocking layer 60a 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.

[120] The insulation layer 60b covers a portion of the side surface of the first light emitting cell S1. As shown in Figure 5 and Figure 6, the insulation layer 60b may extend to a region between the first light emitting cell S1 and the second light emitting cell S2, and may cover a portion of a side surface of the lower semiconductor layer 55 of the second light emitting cell S2. The insulation layer 60b may have the same structure and the same material as those of the current blocking layer 60a, and may include a distributed Bragg reflector, without being limited thereto. The insulation layer 60b may be formed of a different material than that of the current blocking layer 60a by a different process. Here, when the insulation layer 60b 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 60b. The insulation layer 60b may be connected to the current blocking layer 60a to form continuous layers, but is not limited thereto. In other embodiments, the insulation layer 60b may be separated from the current blocking layer 60a.

[121] The interconnection line 65 electrically connects the first light emitting cell S1 to the second light emitting cell S2. The interconnection line 65 includes a first connection section 65p and a second connection section 65n. The first connection section 65p is electrically connected to the transparent electrode layer 61 on the first light emitting cell S1, and the second connection section 65n is electrically connected to the lower semiconductor layer 55 of the second light emitting cell S2. The first connection section 65p may be placed near one edge of the first light emitting cell S1, but is not limited thereto. In other embodiments, the first connection section 65p may be placed in the central region of the first light emitting cell S1.

[122] The second connection section 65n may contact the slanted side surface of the second light emitting cell S2, particularly, the slanted side surface of the lower semiconductor layer 55 of the second light emitting cell S2. Further, as shown in Figure 5, the second connection section 65n 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 S2. The first light emitting cell S1 is

connected to the second light emitting cell S2 in series by the first and second connection sections 65p, 65n of the interconnection line 65.

- [123] 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.
- [124] Further, the current blocking layer 60a may be placed over the overlapping region between the interconnection line 65 and the transparent electrode layer 61, and the current blocking layer 60a and the insulation layer 60b may be placed over an overlapping region between the interconnection line 65 and the first light emitting cell S1. Further, the insulation layer 60b may be placed between the second light emitting cell S2 and the interconnection line 65 in other regions excluding a connection region between the interconnection line 65 and the second light emitting cell S2.
- [125] In Figure 5, the first connection section 65p and the second connection section 65n 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.
- [126] When the current blocking layer 60a and the insulation layer 60b have reflective characteristics like the distributed Bragg reflector, the current blocking layer 60a and the insulation layer 60b 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 60a and the insulation layer 60b 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 60a and the insulation layer 60b can block emission of light to the outside. Thus, there is a need for restriction of the area thereof.
- [127] 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 S1, S2 outside the region of the interconnection line 65. The insulation protective layer 63 may be formed of silicon oxide (SiO₂) or silicon nitride. The insulation protective layer 63 has an opening through which the transparent electrode layer 61 on the first light emitting cell S1 and the lower semiconductor layer of the second light emitting cell S2 are exposed, and the interconnection line 65 may be placed within the opening.
- [128] 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.

[129] According to the present embodiment, since the second connection section 65n of the interconnection line 65 electrically contacts the slanted side surface of the second light emitting cell S2, there is no need to expose the upper surface of the lower semiconductor layer 55 of the second light emitting cell S2. 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.

[130] In addition, the current blocking layer 60a and the insulation layer 60b 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.

[131] Although two light emitting cells including the first light emitting cell S1 and the second light emitting cell S2 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 S1, S2 using the interconnection lines 65.

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

[133] Referring to Figure 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.

[134] 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.

- [135] 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.
- [136] 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.
- [137] 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).
- [138] Referring to Figure 8, a plurality of light emitting cells S1, S2 separated from each other is formed by a photolithography and etching process. Each of the light emitting cells S1, S2 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 S1, S2. However, in this embodiment, the photolithography and etching process performed to partially expose the upper surface of the lower semiconductor layer 55 is omitted.
- [139] Referring to Figure 9, a current blocking layer 60a covering some region on the first light emitting cell S1 and an insulation layer 60b partially covering the side surface of the first light emitting cell S1 are formed. The insulation layer 60b may extend to cover a region between the first light emitting cell S1 and the second light emitting cell S2 while partially covering a side surface of the lower semiconductor layer 55 of the second light emitting cell S2.
- [140] The current blocking layer 60a and the insulation layer 60b may be formed by depositing an insulation material layer, followed by patterning through photolithography and etching. Alternatively, the current blocking layer 60a and the insulation layer 60b may be formed of an insulation material layer by a lift-off technique. Particularly, each

of the current blocking layer 60a and the insulation layer 60b may be a distributed Bragg reflector formed by alternately stacking layers having different indices of refraction, for example, SiO₂ and TiO₂ layers. When the insulation layer 60b 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 60b, whereby the insulation layer 60b can be formed to a smaller thickness than in the related art.

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

[142] Then, a transparent electrode layer 61 is formed on the first and second light emitting cells S1, S2. 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 60a. 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.

[143] Referring to Figure 10, 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 and the insulation layer 60b. 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 a silicon oxide or silicon nitride layer, by chemical vapor deposition.

[144] Referring to Figure 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 60b while exposing the slanted side surface of the lower semiconductor layer 55 of the second light emitting cell S2.

[145] Referring to Figure 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 65a may be deposited on the mask pattern 70. The conductive material may be deposited by plating, e-beam evaporation, sputtering, and the like.

[146] Referring to Figure 11, the mask pattern 70, together with some of the conductive material 65a, 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.

- [147] Here, a first connection section 65p of the interconnection line 65 is connected to the transparent electrode layer 61 of the first light emitting cell S1, and a second connection section 65n thereof is connected to the slanted side surface of the lower semiconductor layer 55 of the second light emitting cell S2. The first connection section 65p of the interconnection line 65 may be connected to the transparent electrode layer 60a within an upper region of the current blocking layer 60a. The interconnection line 65 is separated from the side surface of the first light emitting cell S1 by the insulation layer 60b.
- [148] In this embodiment, the current blocking layer 60a and the insulation layer 60b 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 60a.
- [149] Figure 14 is a schematic sectional view of an MJT LED chip according to another exemplary embodiment of the present disclosure.
- [150] Referring to Figure 14, the MJT LED chip according to this embodiment is generally similar to the MJT LED chip described with reference to Figures 5 and 6, and further includes a transparent conductive layer 62.
- [151] The growth substrate 51, the light emitting cells S1, S2, the buffer layer 53, the transparent electrode layer 61, the current blocking layer 60a, the insulation layer 60b, the insulation protective layer 63 and the interconnection line 65 are similar to those of the light emitting diode described with reference to Figures 5 and 6, and thus detailed descriptions thereof will be omitted.
- [152] The transparent conductive layer 62 is placed between the insulation layer 60b and the interconnection line 65. The transparent conductive layer 62 has a narrower width than the insulation layer 60b, thereby preventing a short circuit of the upper semiconductor layer 59 and the lower semiconductor layer 55 due to the transparent conductive layer 62.
- [153] 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 S2. 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 S2.
- [154] In this embodiment, since the transparent conductive layer 62 is placed between the interconnection line 65 and the insulation layer 60b, 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.

- [155] Figure 15 to Figure 18 are schematic sectional views illustrating a method of fabricating an MJT LED chip according to another exemplary embodiment of the present disclosure.
- [156] Referring to Figure 15, first, as described with reference to Figures 7 and 8, a semiconductor stack structure 56 is formed on a growth substrate 51, and a plurality of light emitting cells S1, S2 separated from each other is formed by a photolithography and etching process. Then, as described with reference to Figure 9, a current blocking layer 60a covering a region on the first light emitting cell S1 and an insulation layer 60b partially covering a side surface of the first light emitting cell S1 are formed.
- [157] As described with reference to Figure 9, each of the current blocking layer 60a and the insulation layer 60b may include a distributed Bragg reflector formed by alternately stacking layers having different indices of refraction, for example, SiO₂ and TiO₂ layers. When the insulation layer 60b 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 60b, whereby the insulation layer 60b can be formed to a smaller thickness than in the related art.
- [158] Then, a transparent electrode layer 61 is formed on the first and second light emitting cells S1, S2. As described with reference to Figure 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 60a. 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.
- [159] 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 60b 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.
- [160] Referring to Figure 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 60b. 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.

[161] Referring to Figure 17, as described with reference to Figure 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 60b is partially exposed through the opening.

[162] Referring to Figure 18, as described with reference to Figure 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.

[163] Then, referring to Figure 13, the mask pattern 70, together with some of the conductive material 65a, 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.

[164] In the embodiments described with reference to Figure 7 to Figure 13, the insulation layer 60b 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 60b including an oxide layer can be damaged by the etchant. In this case, the insulation layer 60b can fail to insulate the interconnection line 65 from the first light emitting cell S1, thereby causing a short circuit.

[165] However, in the present embodiment, since the transparent conductive layer 62 is placed on the insulation layer 60b, the insulation layer 60b 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.

[166] 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.

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

[168] Next, referring to Figure 3, Figure 4, and Figure 19 to Figure 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.

- [169] Referring to Figure 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 131a, and the upper surface 135 includes a concave surface 135a and a convex surface 135b.
- [170] The lower surface 131 is composed of a substantially circular disc-shaped plane, and has the concave section 131a 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.
- [171] Further, an inner surface of the concave section 131a has a surface 133 including side surface 133a and an upper end surface 133b. Here, the upper end surface 133b is perpendicular to a central axis C and the side surface 133a extends from the upper end surface 133b to an entrance of the concave section 131a. 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.
- [172] The concave section 131a may have a shape, a width of which gradually decreases from the entrance thereof to an upper side thereof. Specifically, the side surface 133a gradually approaches the central axis C from the entrance of the concave section 131a to the upper end surface 133b thereof. With this structure, a region for the upper end surface 133b may be formed narrower than the entrance of the concave section 131a. The side surface 133a may have a relatively gentle slope near the upper end surface 133b.
- [173] The region for the upper end surface 133b is defined within a narrower region than a region for the entrance of the concave section 131a. In addition, the region for the upper end surface 133b may be defined within a narrower region than a region surrounded by an inflection curve at which the concave surface 135a of the upper surface 135 meets the convex surface 135b thereof. Further, the region for the upper end surface 133b may be placed within a narrower region than a region for the cavity 121a(Figure 4) of the MJT LED, that is, a light exit region.
- [174] The region for the upper end surface 133b 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 133b may be minimized in consideration of misalignment between the MJT LED 100 and the optical member 130.
- [175] Further, the upper surface 135 of the optical member 130 includes the concave surface 135a and the convex surface 135b continuously extending from the concave surface 135a with reference to the central axis C. A line at which the concave surface

135a meets the convex surface 135b becomes the inflection curve. The concave surface 135a 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 135b increases the quantity of light exiting towards an outer direction of the central axis C.

- [176] The upper surface 135 and the concave section 131a have a symmetrical structure relative to the central axis C. For example, the upper surface 135 and the concave section 131a 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 131a and the upper surface 135 may have various shapes according to a desired light beam distribution.
- [177] 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.
- [178] The optical member 130 is separated from the MJT LED 100, so that an air gap is formed in the concave section 131a. 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 131a to be placed under the lower surface 131. With this structure, light traveling in the concave section 131a is prevented from being lost due to absorption by the housing 121 or the wavelength conversion layer 125.
- [179] According to this embodiment, when a perpendicular plane relative to the central axis C is formed within the concave section 131a, 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 131a does not have a relatively sharp apex, the optical member can be easily manufactured.
- [180] Figure 19 shows sectional views of various modifications of the optical member. Herein, various modifications of the concave section 131a shown in Figure 3 will be described.
- [181] In Figure 19(a), the upper end surface 133b perpendicular to the central axis C described in Figure 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.

[182] The upper end surface of Figure 19(b) is similar to that of Figure 19(a) except that the upper end surface of Figure 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.

[183] The upper end surface of Figure 19(c) is different from that of Figure 3 in that the upper end surface 133b 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.

[184] The upper end surface of Figure 19(d) is similar to that of Figure 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.

[185] Figure 20 shows sectional views of an optical member, illustrating an MJT LED module according to a further exemplary embodiment of the present disclosure.

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

[187] 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 133b 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 133b and/or the concave surface 135a having the light scattering patterns 133c, 135c, it is possible to disperse luminous flux near the central axis C of the optical member.

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

surface 133b.

- [189] Further, a material layer 139b having a different index of refraction than that of the optical member 130 may also be placed on the concave surface 135a. The index of refraction of the material layer 139b may be higher than that of the optical member, thereby allowing change of an optical path of light exiting through the concave surface 135a.
- [190] The light scattering patterns 133c, 135c of Figure 20(a) and the material layers 139a, 139b of Figure 20(b) may also be applied to the various optical members of Figure 19.
- [191] Figure 21 is a sectional view illustrating dimensions of an MJT LED module used for simulation. Here, the same reference numerals as those of Figures 3 and 4 are used (please also refer to Figures 3 and 4 for a depiction of some elements).
- [192] In the MJT LED 100, the cavity 121a has a diameter of 2.1 mm and a height of 0.6 mm. The wavelength conversion layer 125 fills the cavity 121a 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.
- [193] The optical member 130 has a height (H) of 4.7 mm and an upper surface of the optical member has a width (W1) of 15 mm. The concave surface 135a has a width (W2) of 4.3 mm. Further, the entrance of the concave section 131a placed on the lower surface 131 has a width (w1) of 2.3 mm, and the upper end surface 133b has a width (w2) of 0.5 mm. The concave section 131a has a height (h) of 1.8 mm.
- [194] Figure 22 shows graphs depicting a shape of the optical member of Figure 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 . Figure 23 shows traveling directions of light beams entering the optical member 130 from reference point P at intervals of 3° .
- [195] Referring to Figure 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.
- [196] 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 131a.
- [197] Referring to Figure 22(b), since the upper end surface 133b of the concave section 131a is perpendicular to the central axis C, R slightly increases with increasing θ_1 . An

enlarged graph in Figure 22(b) shows an increasing curve of R. On the side surface 133a of the concave section 131a, R decreases with increasing θ_1 and slightly increases near the entrance of the concave section 131a.

- [198] Referring to Figure 22(c), as θ_1 increases, θ_5/θ_1 rapidly increases near the concave surface 135a and relatively gently decreases near the convex surface 135b. In this embodiment, as shown in Figure 23, luminous flux exiting the optical member through the concave surface 135a thereof may overlap luminous flux exiting the optical member through the convex surface 135b thereof. That is, among light beams entering the optical member from reference point P, light exiting the optical member through the concave surface 135a near the inflection curve may have a higher refraction angle than light exiting the optical member through the convex surface 135b. Thus, it is possible to reduce concentration of luminous flux near the central axis C by forming the upper end surface 133b of the concave section 131a to have a planar shape and adjusting the shapes of the concave surface 135a and the convex surface 135b.
- [199] Figure 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.
- [200] As shown in Figure 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 Figure 24(b).
- [201] Figure 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.
- [202] As shown in Figure 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 Figure 25(b).
- [203] 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.

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

[205] Next, referring to Figure 26 to Figure 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.

[206] Figure 26 is a sectional view of an MJT LED module according to one exemplary embodiment of the present disclosure, and Figures 27 (a), (b) and (c) are sectional views of the MJT LED module taken along lines a-a, b-b and c-c of Figure 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, Figure 28 is a detailed view of an optical member of the MJT LED module shown in Figure 26, and Figure 29 shows a light beam angle distribution of the MJT LED module using the optical member of Figure 28.

[207] Referring to Figure 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.

[208] 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 Figure 3 and Figure 4, and detailed descriptions thereof will be omitted. Thus, the optical member 230 according to the second embodiment will be mainly described hereinafter.

[209] Referring to Figure 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 231a. The light exit face 235 is generally composed of an upwardly protruding round surface, and includes a flat surface 235a formed at an upper center thereof. The flat surface 235a 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 231a described in detail hereinafter even without the concave section at the upper center of the light exit face. The light incident section 231a has a substantially bell-shaped cross-section. That is, the light incident section 231a has a shape which gradually converges from a lower entrance thereof adjacent the MJT LED 100

towards an upper apex thereof.

- [210] Referring to Figure 27(a), the lower surface 231 of the optical member 230 has a circular shape. In addition, the light incident section 231a has a lower portion placed at a center of the lower surface 231, and the lower portion of the light incident section 231a has a circular shape. The light incident section 231a 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 Figure 27(c), the upper flat surface 235a of the optical member 230 also has a circular shape.
- [211] Referring to Figures 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 231a has a gradually decreasing diameter.
- [212] Referring to Figure 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. Figure 28 shows reference line (r) at an angle of 50° or less relative to the optical axis L.
- [213] 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 231a is greater than the shortest distance 'a' from the point (p) to the side surface of the light incident section 231a. As above, when $b > a$, the light incident section 231a 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 231a 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 231a 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.
- [214] Here, the light incident section 231a preferably has a height greater than a radius R of the lower entrance of the light incident section 231a. More preferably, the height H of the light incident section 231a is 1.5 times or more the radius R thereof. In addition, a

lower portion of the light incident section 231a 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.

[215] Figure 29 shows a light beam angle distribution of the MJT LED module using the optical member of Figure 28. Referring to Figure 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 Figure 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 231a 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.

[216] Figure 30 is a sectional view of an optical member according to another exemplary embodiment of the present disclosure. As clearly shown in Figure 30, the optical member 230 according to this embodiment has the same curved structure of the light incident section 231a as that of the optical member shown in Figure 28. Thus, the light incident section 231a 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 235b at the upper center of the light exit face.

[217] Figure 31 clearly shows a beam angle distribution curve of an MJT LED module using the optical member of Figure 30. Referring to Figure 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 Figure 31 and the light beam angle distribution of Figure 29. Thus, it can be seen that, when the light incident section 231a 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.

[218] Figures 32a and 32b show an optical member according to Comparative Example 1 and a beam angle distribution curve thereof.

[219] In the optical member of Figure 32a, 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 Figure 32b 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.

[220] Figures 33a and 33b show an optical member according to Comparative Example 2 and a light beam angle distribution thereof.

[221] In the optical member of Figure 33a, 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 Figure 33b 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.

[222] 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.

Claims

[Claim 1]

A backlight module comprising:

a printed circuit board;

a plurality of multi junction technology(MJT) light emitting diodes(LEDs) disposed on the printed circuit board; and

a plurality of optical members disposed on the MJT LEDs or on the printed circuit board so as to correspond to 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 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;

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, 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;

an insulation layer separating the interconnection line from a side surface of the first light emitting cell;

the first connection section contacting the first transparent electrode layer within an upper area of the current blocking layer; and

the second connection section contacting the slanted side surface of the second light emitting cell.

[Claim 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.

- [Claim 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.
- [Claim 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.
- [Claim 5] The backlight module according to claim 3, wherein the light exit face comprises 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.
- [Claim 6] The backlight module according to claim 3, wherein the light exit face comprises a total reflection surface so as to form an apex under a central axis of the optical member.
- [Claim 7] The backlight module according to claim 5, 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.
- [Claim 8] The backlight module according to claim 5, wherein 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.
- [Claim 9] The backlight module according to claim 1, 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 configured for light entering the optical member through the concave section to exit the optical member;
the upper surface comprising a concave surface placed at a central axis of the optical member;
the concave section of the lower surface comprising at least one of a perpendicular surface relative to the central axis and a downwardly convex surface, the at least one of the perpendicular surface relative to the central axis and the downwardly convex surface being positioned within a narrower area than an area for an entrance of the concave section.
- [Claim 10] The backlight module according to claim 9, 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.

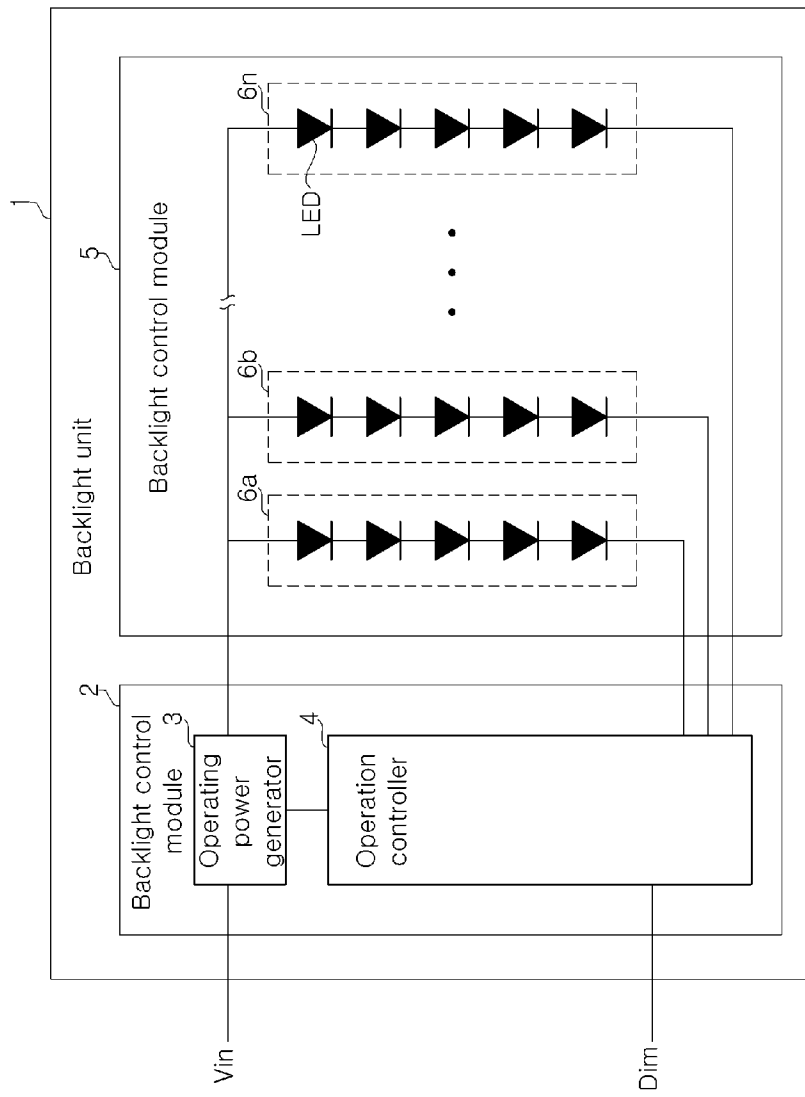
- [Claim 11] The backlight module according to claim 9, wherein the upper surface and the concave section of the optical member form a rotational body shape relative to the central axis of the optical member.
- [Claim 12] The backlight module according to claim 9, wherein each of the optical members has light scattering patterns 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.
- [Claim 13] The backlight module according to claim 9, wherein each of the optical members has a light scattering pattern on the concave surface of the upper surface.
- [Claim 14] The backlight module according to claim 9, wherein each of the optical members further comprises 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.
- [Claim 15] The backlight module according to claim 9, wherein each of the optical members further comprises a material layer having a different index of refraction than the optical member on the concave surface of the upper surface.
- [Claim 16] The backlight module according to claim 9, wherein 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.
- [Claim 17] The backlight module according to claim 16, wherein 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.
- [Claim 18] The backlight module according to claim 9, wherein each of the optical members further comprises 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.

- [Claim 19] The backlight module according to claim 1, wherein each of the optical members has an optical axis L, a light incident section, and the 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.
- [Claim 20] The backlight module according to claim 19, wherein 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.
- [Claim 21] The backlight module according to claim 19, wherein an upper center of the light exit face is formed of a flat surface or a convex curve.
- [Claim 22] The backlight module according to claim 19, wherein the light incident section comprises a lower entrance adjacent the light emitting diode and having a circular shape, and has a shape gradually converging to the apex while maintaining a circular shape.
- [Claim 23] The backlight module according to claim 22, wherein the light incident section has a height which is 1.5 times greater than a radius of the lower entrance.
- [Claim 24] The backlight module according to claim 19, wherein the material adjoining the light incident section is air.
- [Claim 25] The backlight module according to claim 19, wherein the material adjoining the light exit face is air.
- [Claim 26] The backlight module according to claim 19, wherein the optical members are formed of a resin or glass material.
- [Claim 27] A backlight unit comprising:
the backlight module according to claim 1; and
a backlight control module configured for supplying DC operating voltage to the plurality of MJT LEDs within the backlight module and configured for independently controlling operation of each of the plurality of MJT LEDs.
- [Claim 28] The backlight unit according to claim 27, 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.

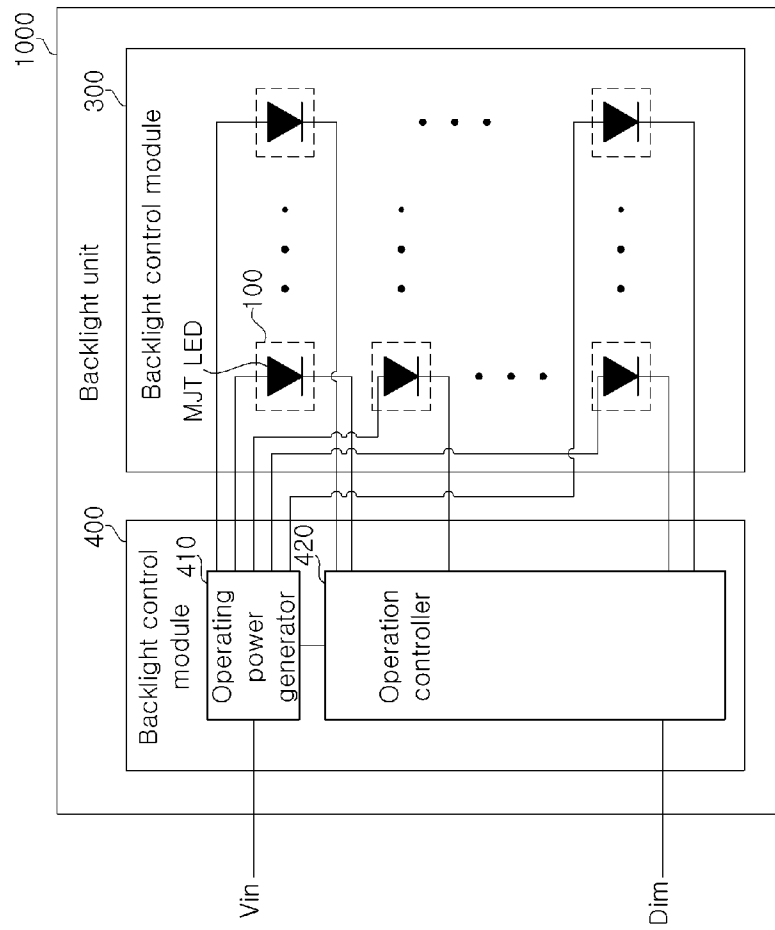
[Claim 29]

The backlight unit according to claim 27, 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.

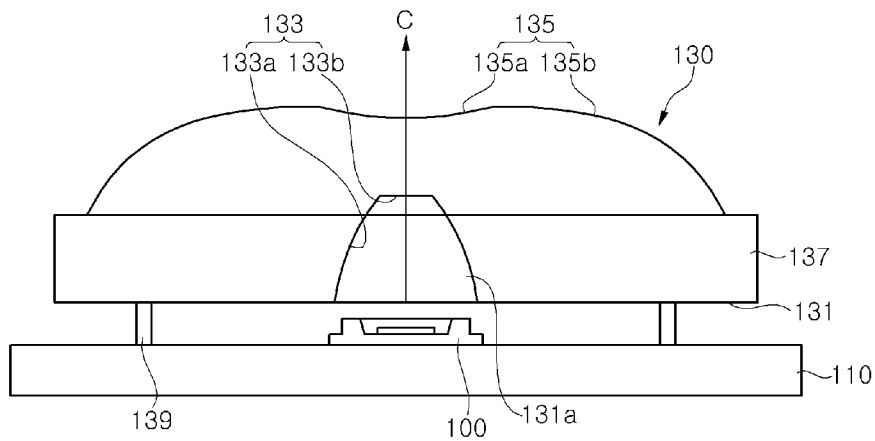
[Fig. 1]



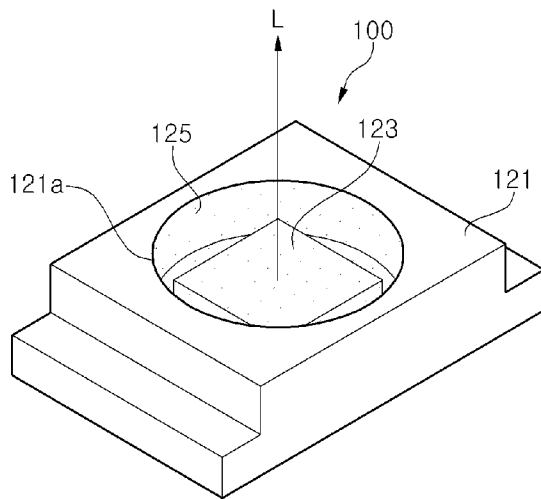
[Fig. 2]



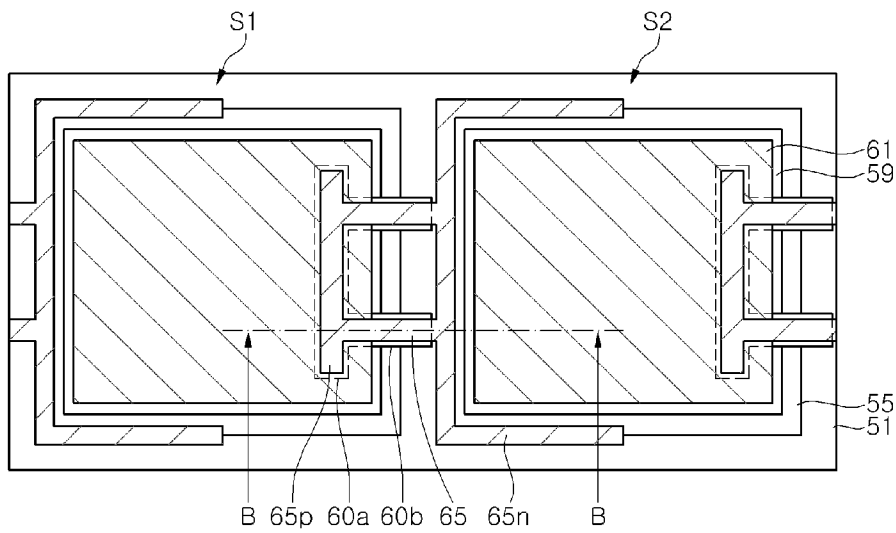
[Fig. 3]



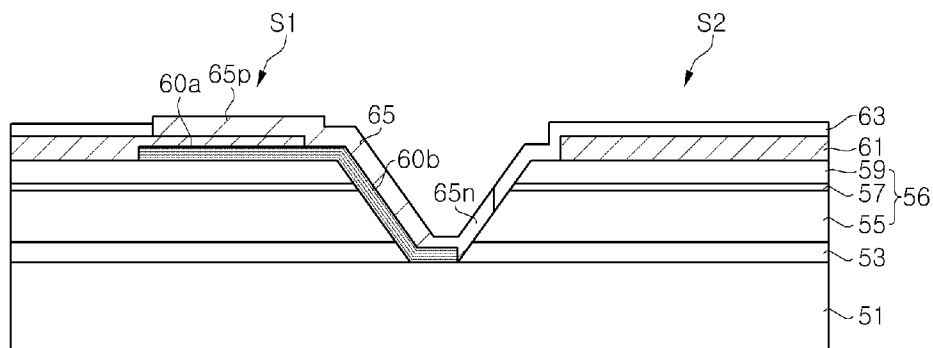
[Fig. 4]



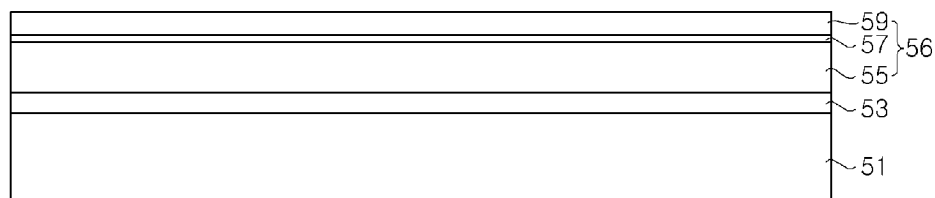
[Fig. 5]



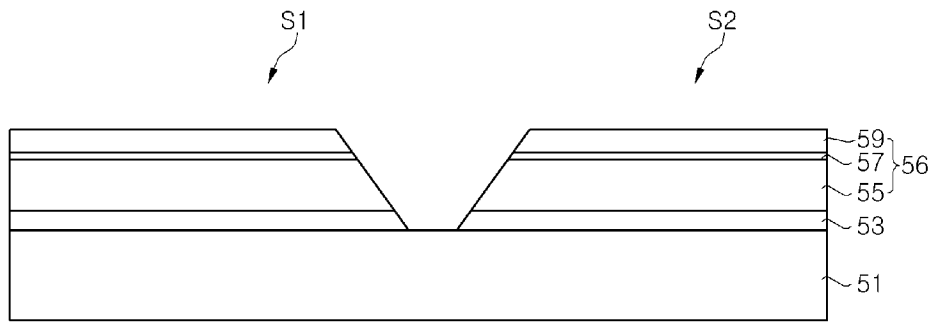
[Fig. 6]



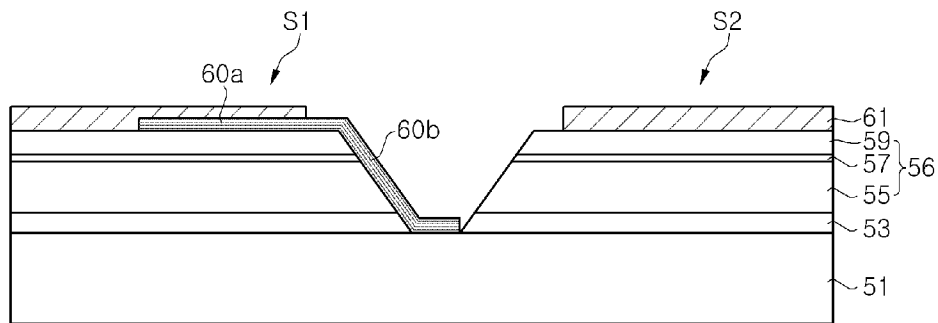
[Fig. 7]



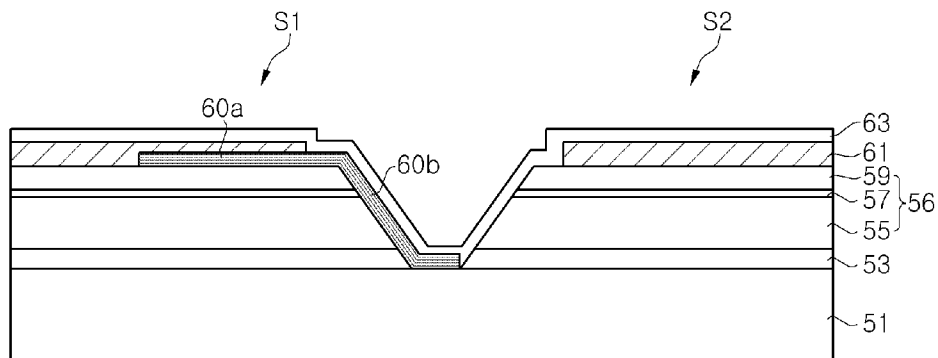
[Fig. 8]



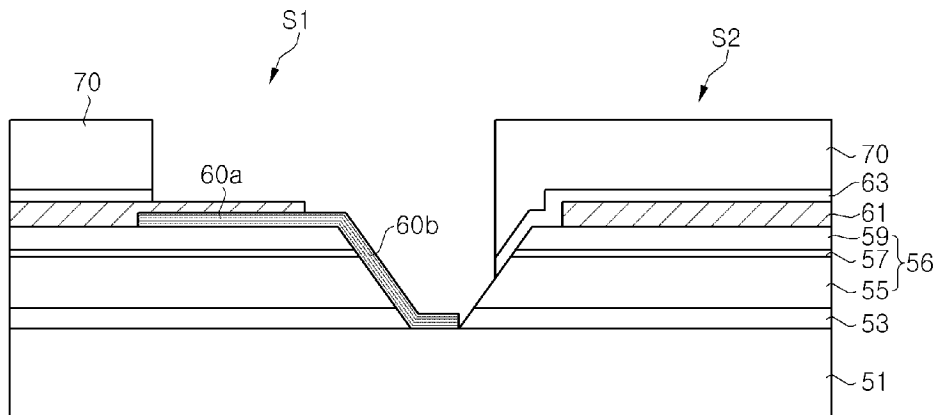
[Fig. 9]



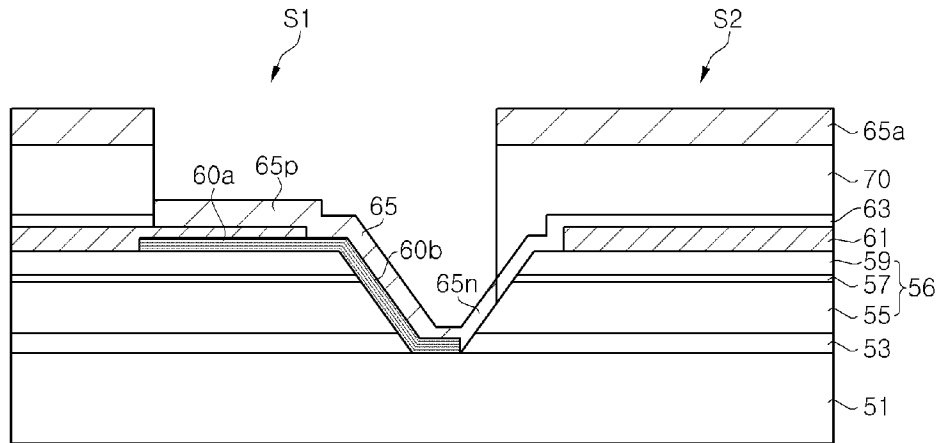
[Fig. 10]



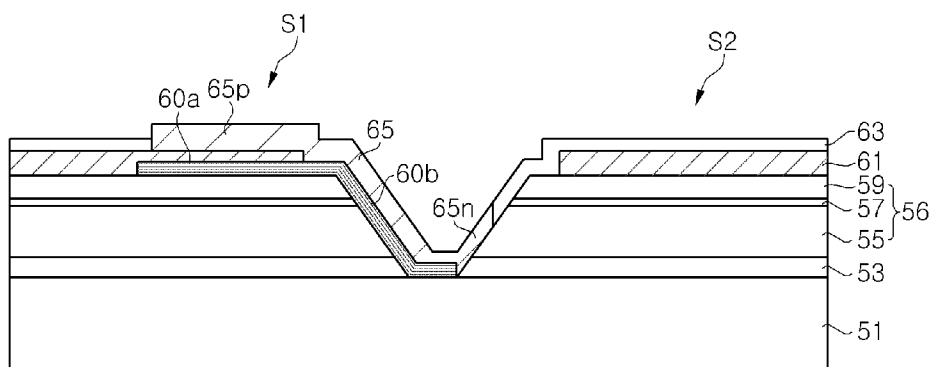
[Fig. 11]



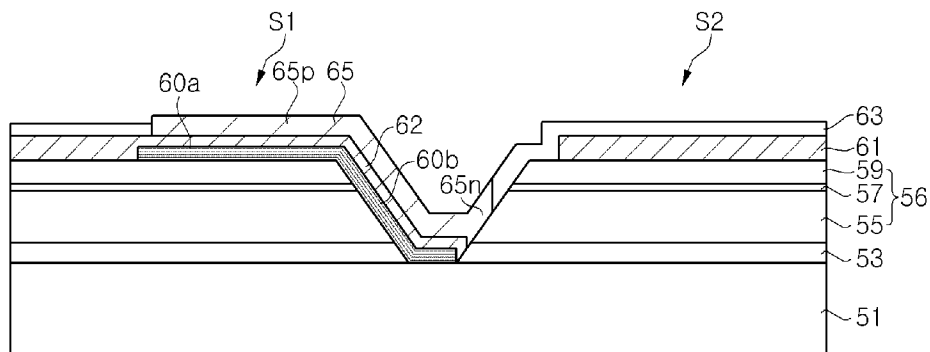
[Fig. 12]



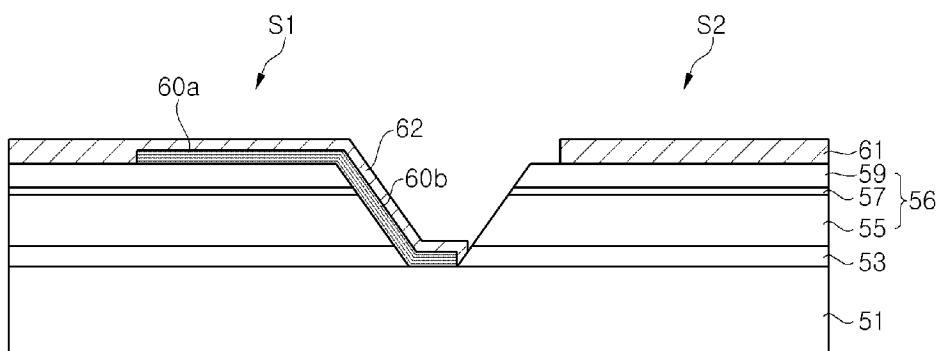
[Fig. 13]



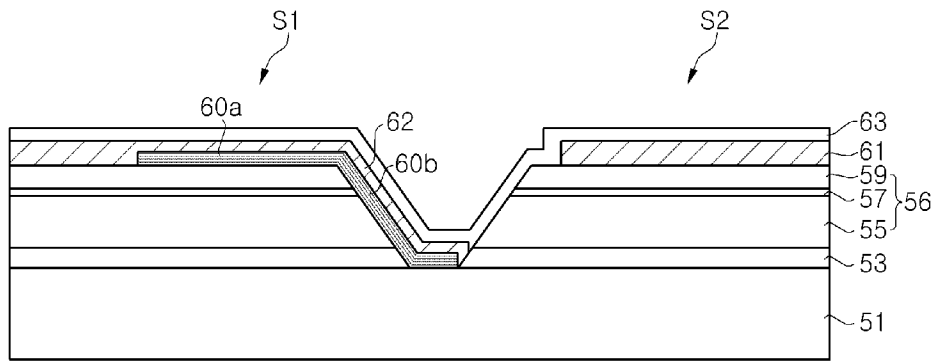
[Fig. 14]



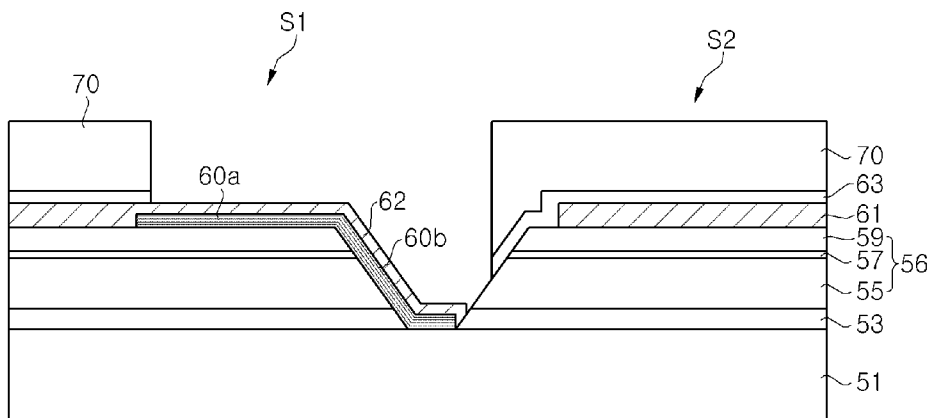
[Fig. 15]



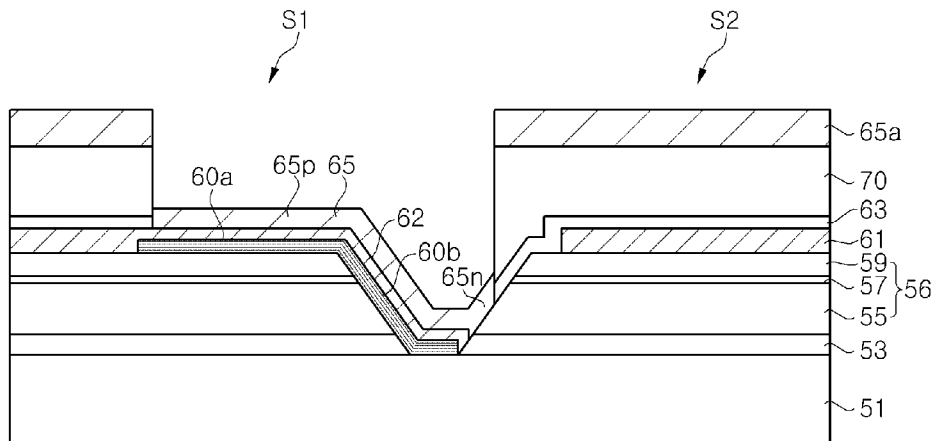
[Fig. 16]



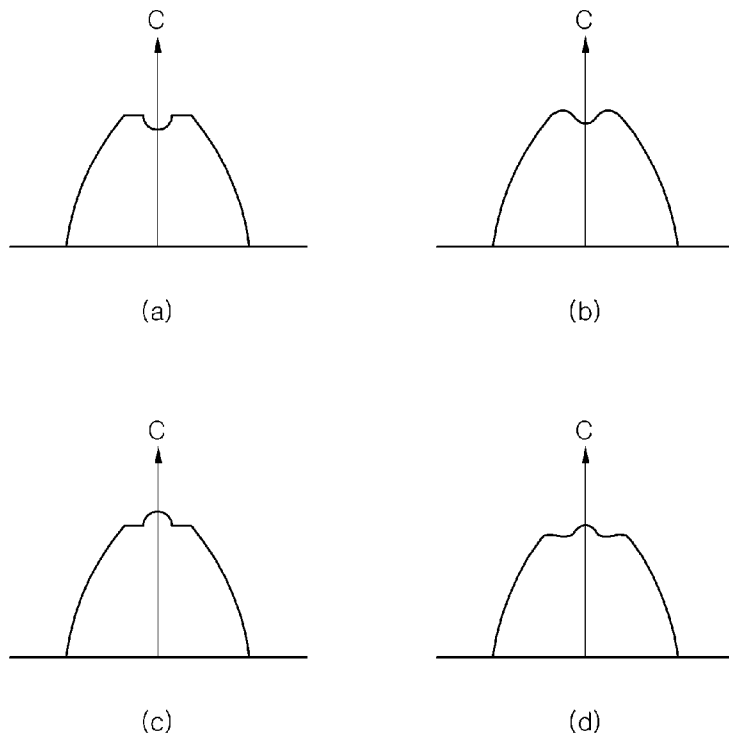
[Fig. 17]



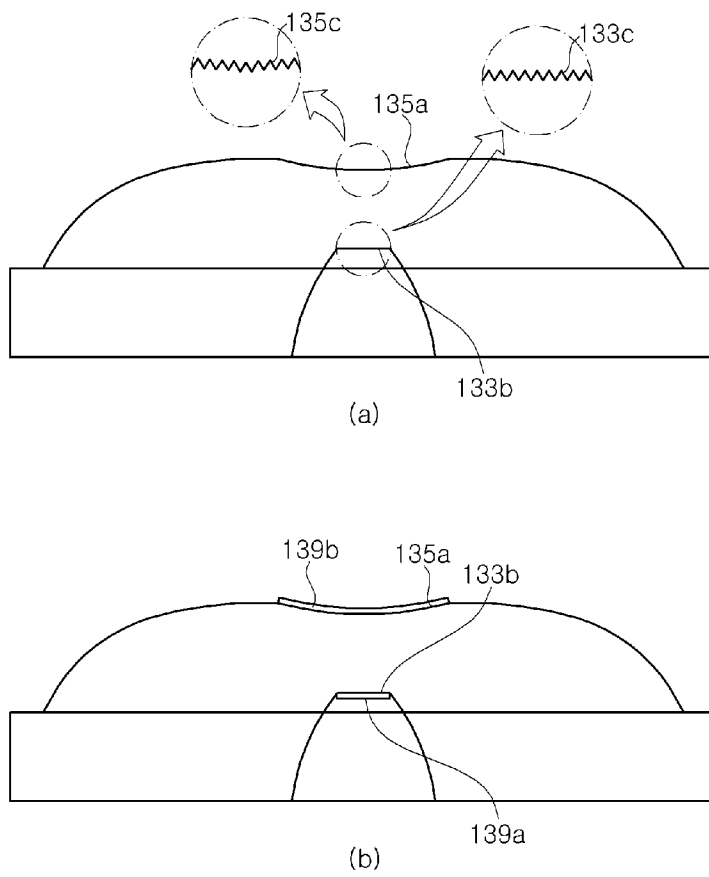
[Fig. 18]



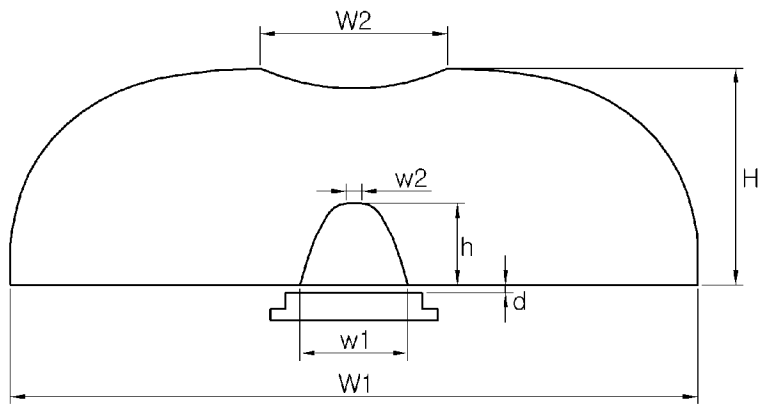
[Fig. 19]



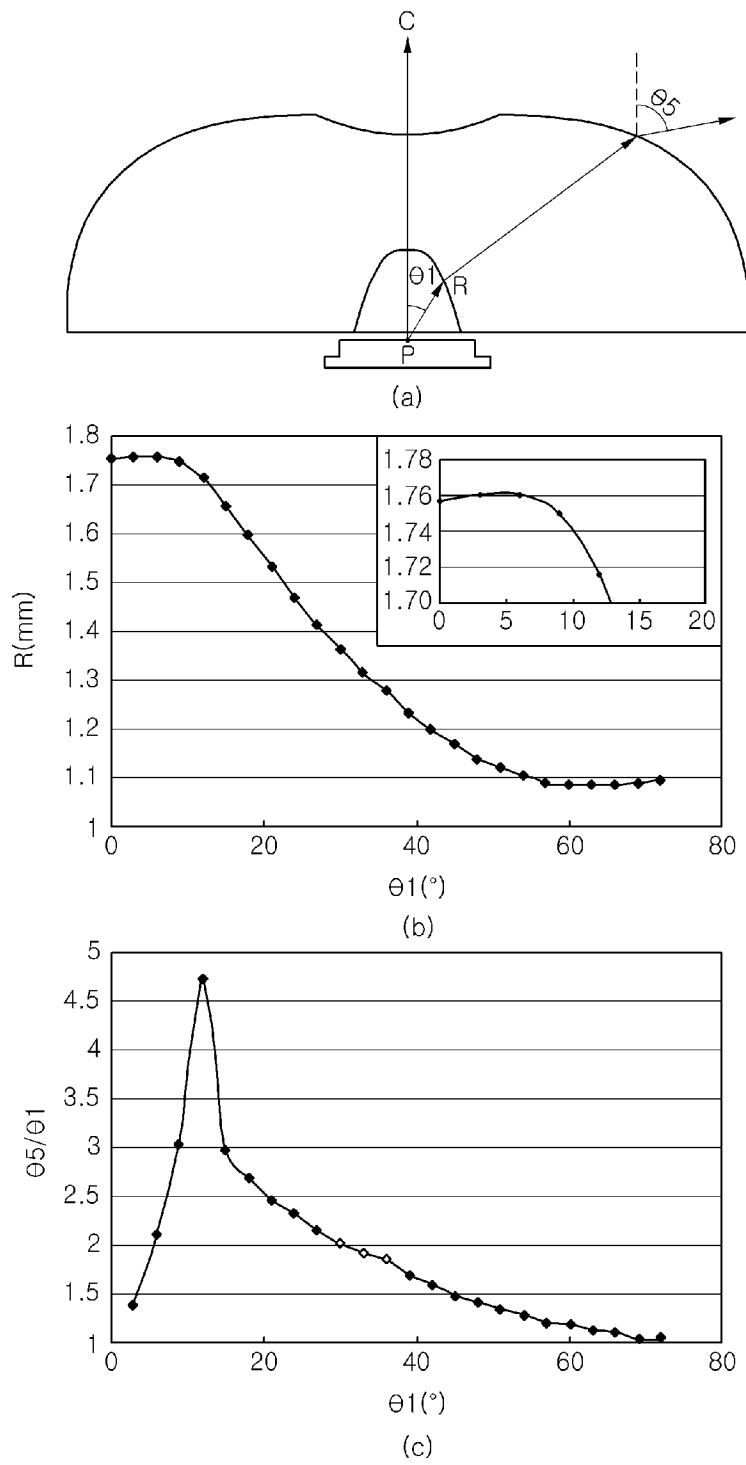
[Fig. 20]



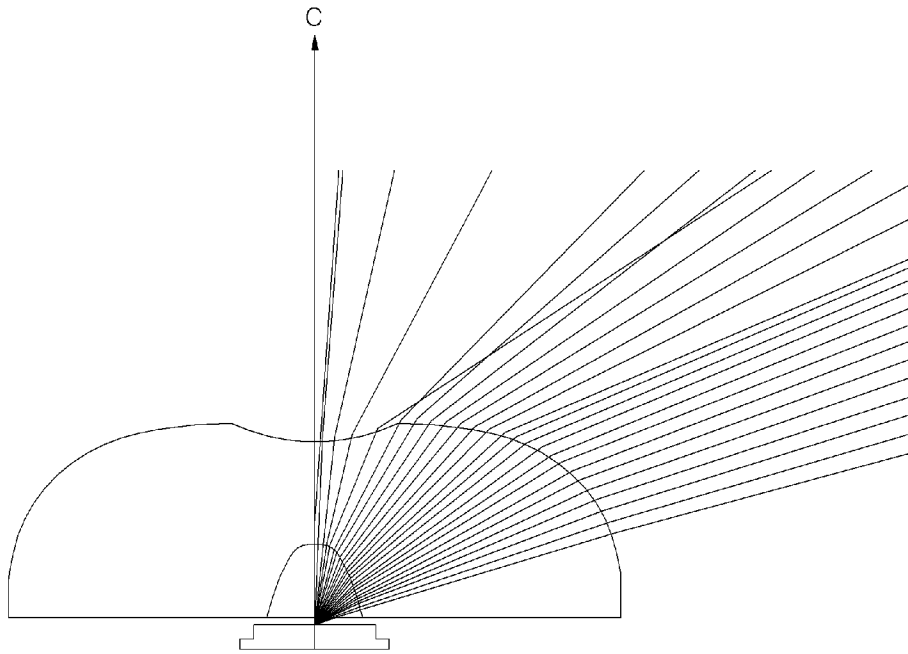
[Fig. 21]



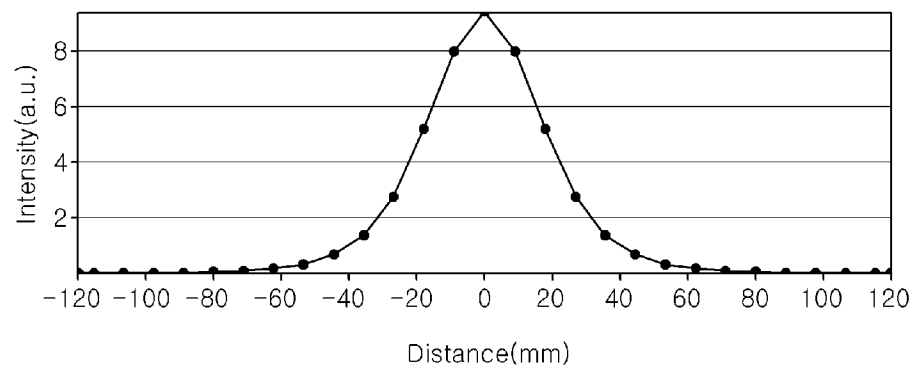
[Fig. 22]



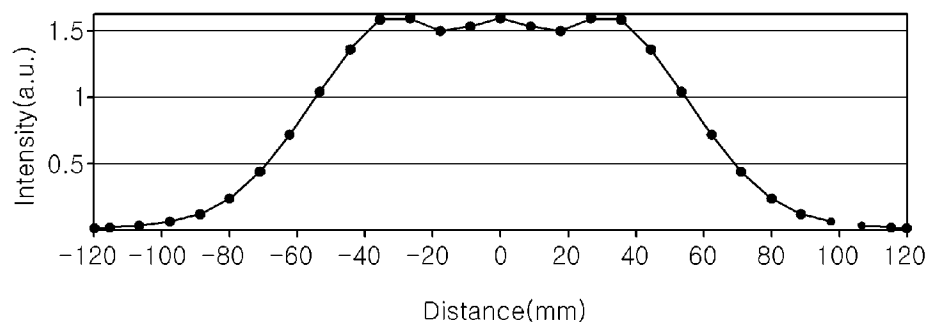
[Fig. 23]



[Fig. 24]

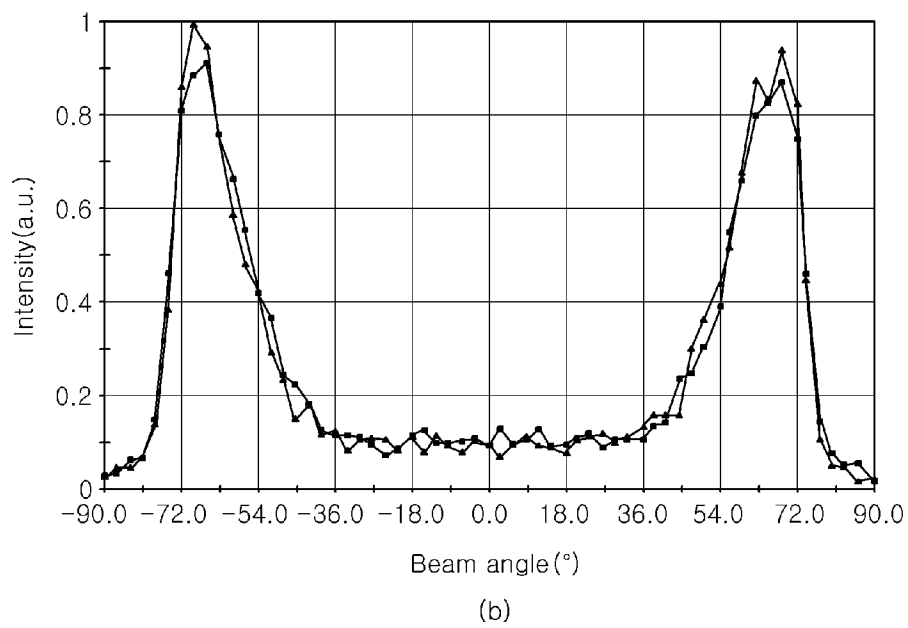
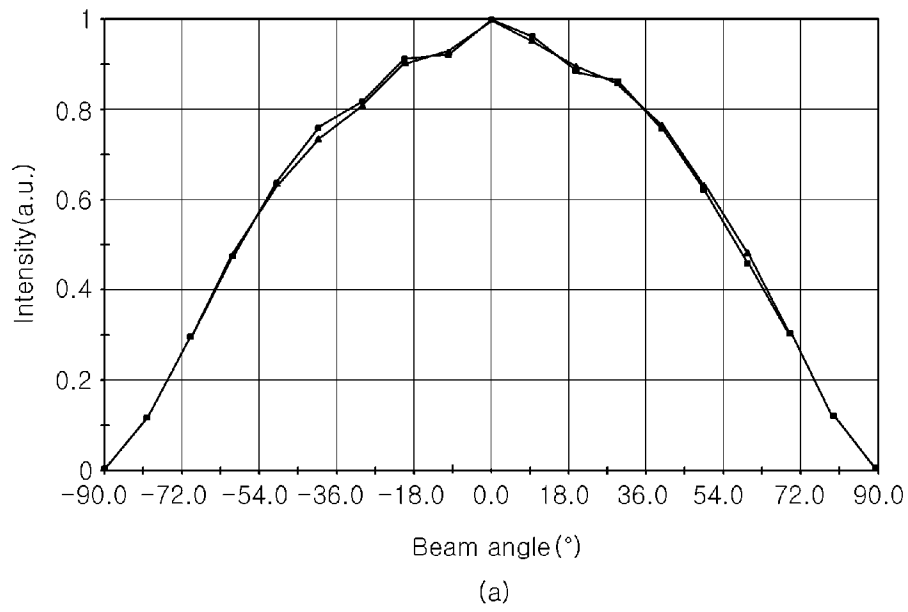


(a)

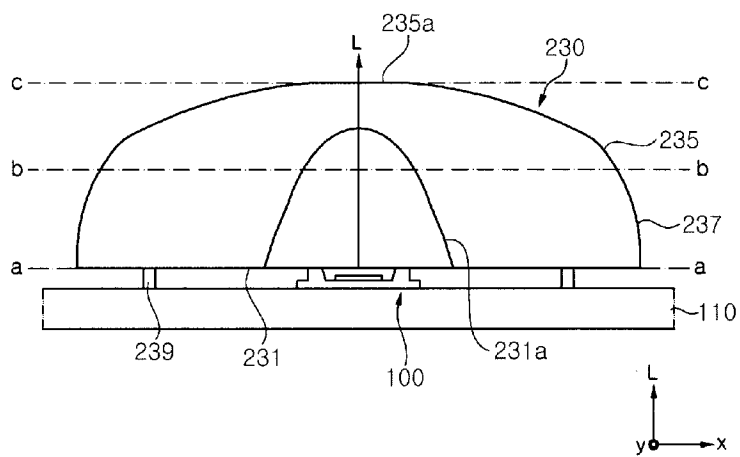


(b)

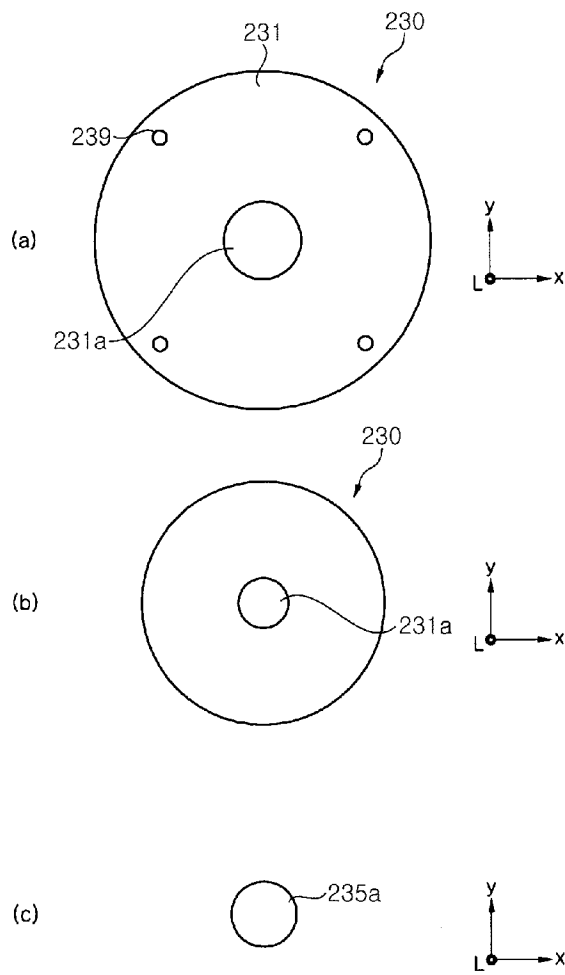
[Fig. 25]



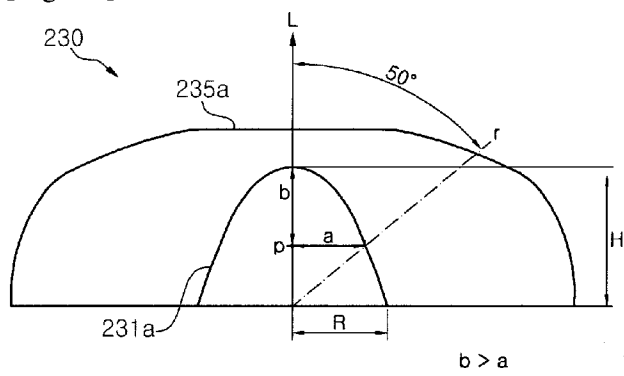
[Fig. 26]



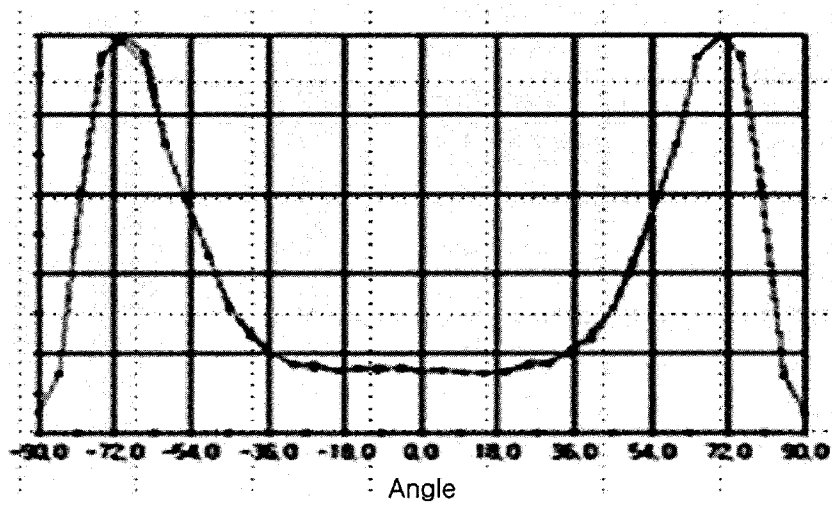
[Fig. 27]



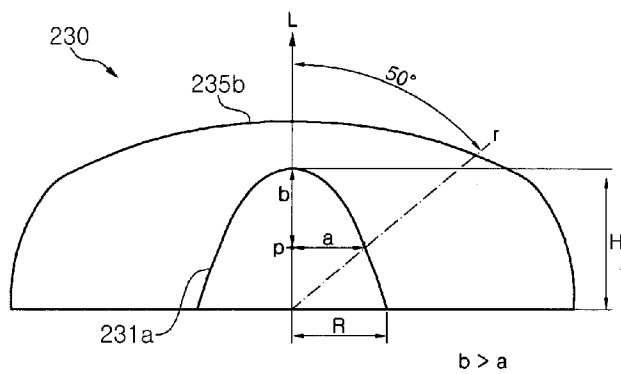
[Fig. 28]



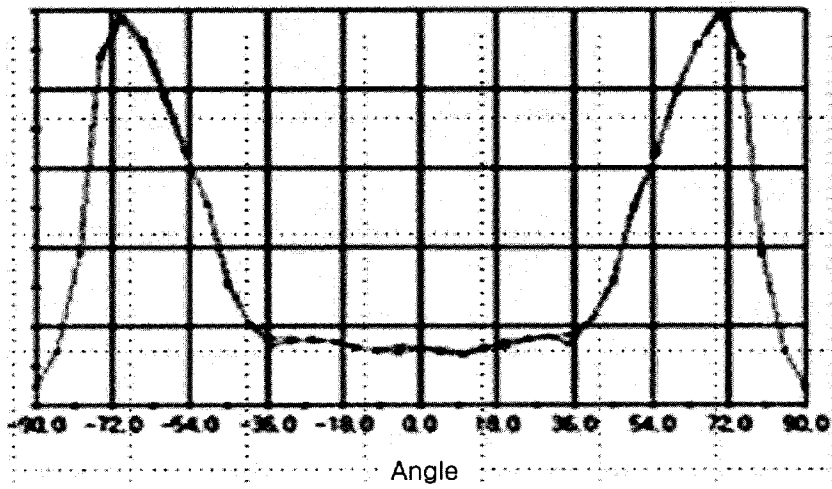
[Fig. 29]



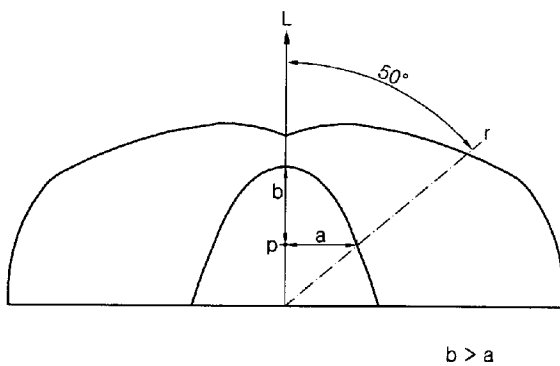
[Fig. 30]



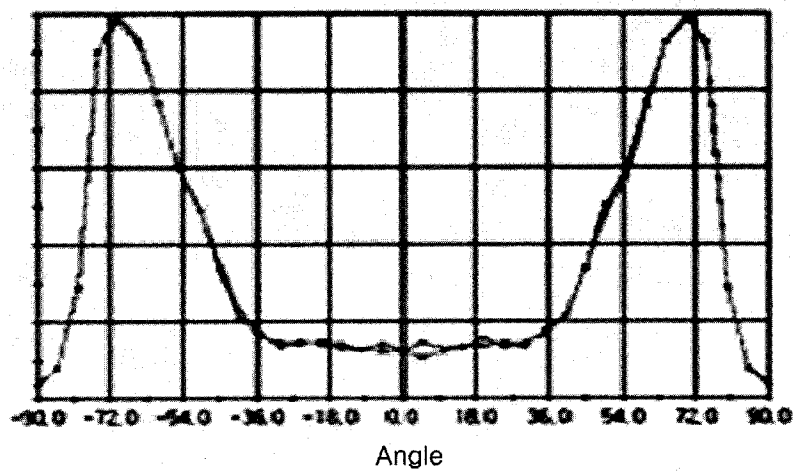
[Fig. 31]



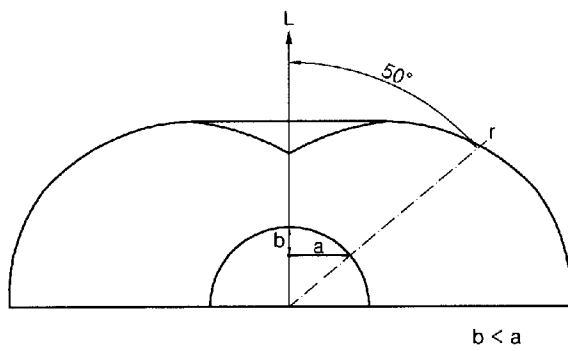
[Fig. 32a]



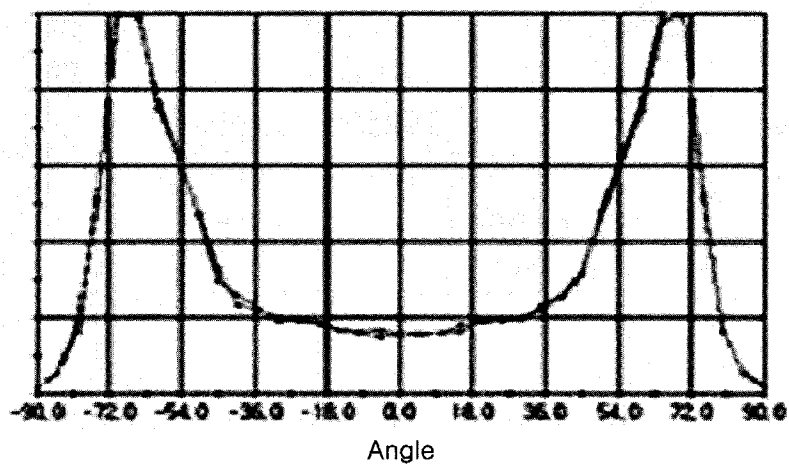
[Fig. 32b]



[Fig. 33a]



[Fig. 33b]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2014/006745**A. CLASSIFICATION OF SUBJECT MATTER****F21S 2/00(2006.01)i, H01L 33/00(2010.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F21S 2/00; F21S 8/02; H01L 33/00; H01L 33/54; H01L 33/58; F21Y 101/02; H01L 33/48

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: LED, MJT, cell, electrode, layer, line, connection, insulation

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-022489 A (ASAHI RUBBER INC.) 03 February 2014 See abstract; paragraphs 22-28; and figure 1.	1-29
A	JP 2012-243641 A (PANASONIC CORP.) 10 December 2012 See abstract; figure 1; and claim 1.	1-29
A	JP 2014-026933 A (PANASONIC CORP.) 06 February 2014 See paragraphs 28-31; and figures 4, 5.	1-29
A	US 2011-0175122 A1 (HYE YOUNG KIM) 21 July 2011 See paragraphs 47-51; and figures 1, 2.	1-29
A	US 2013-0020589 A1 (CHIH-KUANG YU et al.) 24 January 2013 See paragraphs 79-83; and figure 37.	1-29



Further documents are listed in the continuation of Box C.



See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

05 December 2014 (05.12.2014)

Date of mailing of the international search report

05 December 2014 (05.12.2014)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2014/006745

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2014-022489 A	03/02/2014	None	
JP 2012-243641 A	10/12/2012	None	
JP 2014-026933 A	06/02/2014	None	
US 2011-0175122 A1	21/07/2011	CN 102130272 A	20/07/2011
		CN 102130272 B	30/04/2014
		EP 2348552 A2	27/07/2011
		EP 2348552 A3	04/07/2012
		KR 10-1091304 B1	07/12/2011
		KR 10-2011-0085421 A	27/07/2011
		TW 201126767 A	01/08/2011
		US 8395170 B2	12/03/2013
US 2013-0020589 A1	24/01/2013	US 2014-084244 A1	27/03/2014
		US 8604491 B2	10/12/2013