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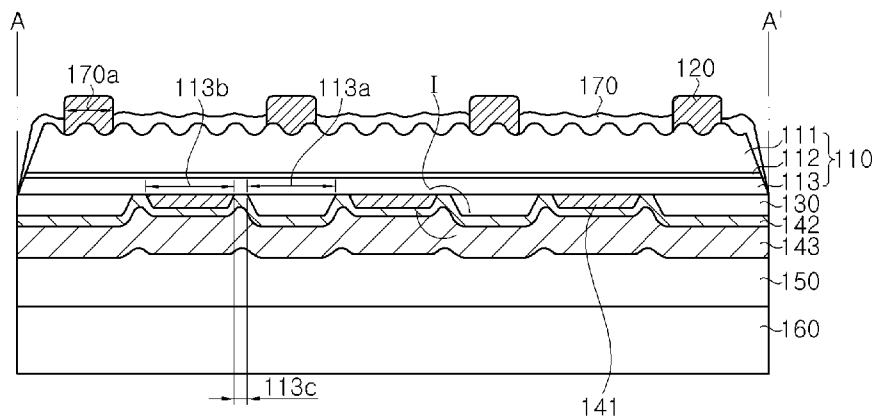
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(54) Title: LIGHT EMITTING DIODE WITH HIGH EFFICIENCY



(57) Abstract: A light emitting diode includes: a light emitting structure including a second semiconductor layer and a first semiconductor layer; a first electrode electrically connected to the first semiconductor layer; a current blocking layer disposed on a lower surface of the light emitting structure; and a second electrode electrically connected to the second semiconductor layer, wherein the second electrode includes a first reflective metal layer adjoining the second semiconductor layer and a second reflective metal layer covering a lower surface of the current blocking layer and a lower surface of the first reflective metal layer while adjoining a portion of the second semiconductor layer, and wherein contact resistance between the second reflective metal layer and the second semiconductor layer is higher than contact resistance between the first reflective metal layer and the second semiconductor layer.



Description

Title of Invention: LIGHT EMITTING DIODE WITH HIGH EFFICIENCY

Technical Field

- [1] The present invention relates to a light emitting diode and, more particularly, to a light emitting diode that includes a reflective metal layer and thus has improved light extraction efficiency.

Background Art

- [2] A light emitting diode (LED) is a solid state device configured to convert electrical energy into light. Light emitting diodes are broadly applied to various light sources for backlight units, lighting apparatuses, signal boards, large displays, and the like. With increasing use of LEDs for lighting and expansion of application ranges to high current and high output devices, there is a need for development of an electrode technology for improvement in reliability of electrodes electrically connecting an external structure such as a module to semiconductor layers of an LED while improving light extraction efficiency of the LED.

Disclosure of Invention

Technical Problem

- [3] It is an aspect of the present invention to provide a light emitting diode that has improved light extraction efficiency by preventing a barrier metal layer from absorbing light.
- [4] It is another aspect of the present invention to provide a light emitting diode that includes regions having different electrical junction characteristics one another on a lower surface of a second conductive type semiconductor layer in order to improve current spreading efficiency.
- [5] It is a further aspect of the present invention to provide a light emitting diode that can prevent delamination of an electrode connected to a second conductive type semiconductor layer in order to improve reliability.

Solution to Problem

- [6] An exemplary embodiment of the present invention provides a light emitting diode including: a light emitting structure including a second conductive type semiconductor layer, an active layer disposed on an upper surface of the second conductive type semiconductor layer and a first conductive semiconductor layer disposed on an upper surface of the active layer, at least one first electrode electrically connected to the first conductive type semiconductor layer, a current blocking layer disposed on a lower surface of the light emitting structure; and a second electrode electrically connected to

the second conductive type semiconductor layer, wherein the second electrode includes a first reflective metal layer adjoining the second conductive type semiconductor layer, and a second reflective metal layer covering a lower surface of the current blocking layer and a lower surface of the first reflective metal layer while adjoining a portion of the second conductive type semiconductor layer, and wherein contact resistance between the second reflective metal layer and the second conductive type semiconductor layer may be higher than contact resistance between the first reflective metal layer and the second conductive type semiconductor layer.

- [7] Another exemplary embodiment of the present invention provides a light emitting diode including: a light emitting structure including a second conductive type semiconductor layer, an active layer disposed on an upper surface of the second conductive type semiconductor layer, and a first conductive semiconductor layer disposed on an upper surface of the active layer, at least one first electrode disposed on an upper surface of the light emitting structure and electrically connected to the first conductive type semiconductor layer, a current blocking layer disposed on a lower surface of the light emitting structure, and a second electrode disposed on a lower surface of the light emitting structure and electrically connected to the second conductive type semiconductor layer, wherein the second electrode includes a first reflective metal layer adjoining the second conductive type semiconductor layer, and a second reflective metal layer covering a lower surface of the current blocking layer and a lower surface of the first reflective metal layer, and bonding strength between the current blocking layer and the second reflective metal layer is greater than bonding strength between the current blocking layer and the first reflective metal layer.

Advantageous Effects of Invention

- [8] According to exemplary embodiments, a lower surface of a second conductive type semiconductor layer of a light emitting diode includes regions having different electrical junction characteristics, thereby improving current spreading efficiency. With this structure, the light emitting diode can reduce forward voltage and increase output voltage. Further, the light emitting diode can prevent delamination of a second electrode by securing high bonding strength between a current blocking layer and a second reflective metal layer, thereby improving reliability.

Brief Description of Drawings

- [9] FIG. 1 is plan views of a light emitting diode according to one exemplary embodiment of the present invention.
- [10] FIG. 2 is a cross-sectional view of the light emitting diode according to the exemplary embodiment of the present invention.
- [11] FIG. 3 is an enlarged view of part I of FIG. 2.

- [12] FIG. 4 shows graphs comparing performance of the light emitting diode according to the exemplary embodiment of the present invention with that of a typical light emitting diode.
- [13] FIG. 5 is a sectional view of a light emitting diode according to another exemplary embodiment of the present invention.
- [14] FIG. 6 is a sectional view of a light emitting diode according to a further exemplary embodiment of the present invention.
- [15] FIG. 7 is an exploded perspective view of one embodiment of a lighting apparatus to which a light emitting diode according to one exemplary embodiment of the present invention is applied.
- [16] FIG. 8 is a sectional view of one embodiment of a display to which a light emitting diode according to one exemplary embodiment of the present invention is applied.
- [17] FIG. 9 is a sectional view of one embodiment of a display to which a light emitting diode according to one exemplary embodiment of the present invention is applied.
- [18] FIG. 10 is a sectional view of one embodiment of a headlight to which a light emitting diode according to one exemplary embodiment of the present invention is applied.

Best Mode for Carrying out the Invention

- [19] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings. The following embodiments are provided by way of example so as to fully convey the spirit of the present invention to those skilled in the art to which the present invention pertains. Accordingly, the present invention is not limited to the embodiments disclosed herein and can also be implemented in different forms. In the drawings, widths, lengths, thicknesses, and the like of elements can be exaggerated for clarity and descriptive purposes. When an element or layer is referred to as being "disposed above" or "disposed on" another element or layer, it may be directly "disposed above" or "disposed on" the other element or layer or intervening elements or layers can be present. Throughout the specification, like reference numerals denote like elements having the same or similar functions.
- [20] A light emitting diode according to one exemplary embodiment of the present invention includes: a light emitting structure including a second conductive type semiconductor layer, an active layer disposed on an upper surface of the second conductive type semiconductor layer, and a first conductive semiconductor layer disposed on an upper surface of the active layer; at least one first electrode electrically connected to the first conductive type semiconductor layer; a current blocking layer disposed on a lower surface of the light emitting structure; and a second electrode electrically connected to the second conductive type semiconductor layer, wherein the second

electrode includes a first reflective metal layer adjoining the second conductive type semiconductor layer and a second reflective metal layer covering a lower surface of the current blocking layer and a lower surface of the first reflective metal layer while adjoining a portion of the second conductive type semiconductor layer, and wherein contact resistance between the second reflective metal layer and the second conductive type semiconductor layer is higher than contact resistance between the first reflective metal layer and the second conductive type semiconductor layer.

[21] The first reflective metal layer may be spaced apart from the current blocking layer.

[22] The second reflective metal layer may include an Al layer, and the Al layer may adjoin the current blocking layer, the first reflective metal layer and the second conductive type semiconductor layer.

[23] The light emitting diode may further include a barrier metal layer disposed on a lower surface of the second reflective metal layer, and the barrier metal layer may include Ni.

[24] The current blocking layer may include a first region adjoining the second conductive type semiconductor layer, the first reflective metal layer may include a second region adjoining the second conductive type semiconductor layer, the second reflective metal layer may include a third region adjoining the second conductive type semiconductor layer, and the first region, the second region and the third region may have different electrical junction characteristics.

[25] The third region and the second reflective metal layer may form Schottky junction therebetween.

[26] The third region may have a smaller area than the second region.

[27] A portion of the second reflective metal layer may cover a side surface of the current blocking layer.

[28] The side surface of the current blocking layer may include an inclined surface.

[29] The second reflective metal layer may include a protrusion protruding beyond a side surface of the light emitting structure.

[30] The light emitting diode may further include an insulation layer disposed on an upper surface and a side surface of the light emitting structure.

[31] A portion of the current blocking layer may be placed on an upper surface of the protrusion.

[32] The insulation layer and the current blocking layer may adjoin each other.

[33] The insulation layer and the current blocking layer may be formed of the same material.

[34] In some exemplary embodiments, the first electrode may include an electrode pad and an upper extension, and the upper extension may include a region overlapping the current blocking layer. Further, the current blocking layer may have a greater width

than the upper extension such that portions of the current blocking layer are placed beyond both sides of the upper extension in a width direction in a view showing the upper extension overlapping the current blocking layer. Particularly, each of portions of the current blocking layer placed beyond both sides of the upper extension in the width direction may have the same or greater width than the upper extension. With the structure wherein the width of the current blocking layer is three times or more the width of the upper extension, the light emitting diode can achieve current spreading over a wide area thereof, thereby improving light output.

- [35] A light emitting diode according to another exemplary embodiment of the present invention includes: a light emitting structure including a second conductive type semiconductor layer, an active layer disposed on an upper surface of the second conductive type semiconductor layer, and a first conductive semiconductor layer disposed on an upper surface of the active layer; at least one first electrode disposed on an upper surface of the light emitting structure and electrically connected to the first conductive type semiconductor layer; a current blocking layer disposed on a lower surface of the light emitting structure; and a second electrode disposed on a lower surface of the light emitting structure and electrically connected to the second conductive type semiconductor layer, wherein the second electrode includes a first reflective metal layer adjoining the second conductive type semiconductor layer, and a second reflective metal layer covering a lower surface of the current blocking layer and a lower surface of the first reflective metal layer, and wherein bonding strength between the current blocking layer and the second reflective metal layer is greater than bonding strength between the current blocking layer and the first reflective metal layer.
- [36] The second reflective metal layer may include Al.
- [37] A portion of the second reflective metal layer may cover a side surface of the current blocking layer, and may separate the current blocking layer from the first reflective metal layer.
- [38] FIG. 1 to FIG. 4 are plan views, a cross-sectional view and graphs illustrating a light emitting diode according to one exemplary embodiment of the present invention. FIG. 1a is a top plan view of the light emitting diode and FIG. 1b is a top plan view of a lower structure of a second reflective metal layer of the light emitting diode described below. FIG. 2 is a cross-sectional view taken along line A-A' of FIG. 1 and FIG. 3 is an enlarged view of part I of FIG. 2. FIG. 4a shows a graph comparing forward voltage of the light emitting diode according to the exemplary embodiment with that of a typical light emitting diode and FIG. 4b shows a graph comparing output power of the light emitting diode according to the exemplary embodiment with that of the typical light emitting diode.
- [39] Referring to FIG. 1 to FIG. 3, the light emitting diode according to this exemplary

embodiment includes a light emitting structure 110, a first electrode 120, a current blocking layer 130, and a second electrode 140, and may further include an insulation layer 170 and a substrate 160.

- [40] The light emitting structure 110 may include a second conductive type semiconductor layer 113, an active layer 112 disposed on an upper surface of the second conductive type semiconductor layer 113, and a first conductive type semiconductor layer 111 disposed on an upper surface of the active layer 112. The first conductive type semiconductor layer 111, the active layer 112 and the second conductive type semiconductor layer 113 may include a III-V based compound semiconductor, for example, a nitride-based semiconductor such as (Al, Ga, In)N. The first conductive type semiconductor layer 111 may include an n-type dopant (for example, Si) and the second conductive type semiconductor layer 113 may include a p-type dopant (for example, Mg), or vice versa. The active layer 112 may include a multi-quantum well (MQW) structure and may have a compositional ratio determined to emit light having a desired peak wavelength. Particularly, the active layer 112 may include an InGaN well layer to emit blue light or near ultraviolet light.
- [41] The light emitting structure 110 may be formed by sequentially stacking the first conductive type semiconductor layer 111, the active layer 112, and the second conductive type semiconductor layer 113 on a growth substrate (not shown). The growth substrate may be selected from any substrates so long as the substrate allows growth of the first conductive type semiconductor layer 111, the active layer 112, and the second conductive type semiconductor layer 113 thereon, and may include, for example, a sapphire substrate, a silicon carbide substrate, a gallium nitride substrate, an aluminum nitride substrate, a silicon substrate, and the like. Specifically, in this exemplary embodiment, the growth substrate may be a patterned sapphire substrate (PSS). The growth substrate may be removed from the light emitting structure, whereby an upper surface of the light emitting structure 110 can have a shape corresponding to the pattern of the substrate. Specifically, when the growth substrate includes a rounded pattern, the upper surface of the light emitting structure 110 may also include a rounded shape.
- [42] A side surface of the light emitting structure 110 may include an inclined surface. Referring to FIG. 2, the inclined surface may have an angle of 90° or less, for example, 60°, with respect to a lower surface of the first conductive type semiconductor layer 111. The inclined surface of the light emitting structure 110 serves to improve emission of light generated in the light emitting structure 110. The inclined surface may be formed by a dicing process for individually dividing light emitting diodes, or may be formed by a separate etching process.
- [43] The first electrode 120 may be disposed on an upper surface of the light emitting

structure 110. The number of the first electrodes 120 may be at least one and the first electrode 120 may be electrically connected to the first conductive type semiconductor layer 111. The first electrode 120 may be a single layer or multilayer structure of Ni, Al, Au, Cr, and the like. The first electrode 120 may be formed by depositing a metallic material to the upper surface of the light emitting structure 110, followed by patterning.

- [44] A lower surface of the first electrode 120 adjoins an upper surface of the first conductive type semiconductor layer 111. In a structure wherein the upper surface of the first conductive type semiconductor layer 111 includes a pattern, an upper surface of the first electrode 120 may include a shape corresponding to the pattern of the upper surface of the first conductive type semiconductor layer 111. For example, in a structure wherein the upper surface of the first conductive type semiconductor layer 111 includes a rounded pattern, the upper surface of the first electrode 120 placed on the rounded pattern may also include a rounded shape. With this structure, when a wire is coupled to the first electrode 120, the wire can be stably bonded to the first electrode 120 via the shape of the upper surface of the first electrode 120.
- [45] The first electrode 120 may include at least one bonding pad 121 and an upper extension 122.
- [46] The bonding pad 121 serves to guide electric current applied to the light emitting structure 110 to flow outside. In this exemplary embodiment, the bonding pad 121 may be placed near one side of the light emitting structure 110. Specifically, the first conductive type semiconductor layer 111 includes a first side surface 111a and a second side surface 111b placed opposite the first side surface 111a, and the bonding pad 121 may be placed near the first side surface 111a. Although the first electrode is illustrated as including two bonding pads 121 in this exemplary embodiment, it should be understood that other implementations are also possible and the first electrode 120 may include one bonding pad or three or more bonding pads.
- [47] The upper extension 122 may extend from the bonding pad 121. The upper extension 122 serves to prevent current crowding near the bonding pad 121 upon application of current to the light emitting diode. Specifically, a portion of the upper extension 122 may be placed along four sides of the first conductive type semiconductor layer 111. Furthermore, the other portion of the upper extension 122 may be placed between the bonding pads 121 and a portion of the upper extension 122 near the second side surface 111b.
- [48] The current blocking layer 130 may be placed on a lower surface of the light emitting structure 110. The current blocking layer 130 may at least partially overlap the first electrode 120 in a vertical direction. The current blocking layer 130 may include a first region 113a adjoining the second conductive type semiconductor layer 113. The

current blocking layer 130 may serve to prevent electric current applied to the light emitting diode from crowding on the semiconductor layer near the first electrode 120, thereby preventing deterioration in current spreading efficiency. The first region 113a may overlap the first electrode 120 in the vertical direction. This structure can more effectively prevent current crowding. Particularly, the current blocking layer 130 may be formed to have a greater width than the upper extension 122 in order to improve light output through efficient spreading of electric current. Particularly, in a view showing the current blocking layer 130 overlapping the upper extension 122, each of portions of the current blocking layer 130 placed beyond both sides of the upper extension 122 in a width direction may have a greater width than the upper extension 122. Accordingly, the width of the current blocking layer 130 may be greater than three times the width of the upper extension 122 in order to achieve significant improvement in light output. For example, when the upper extension 122 of the first electrode 120 has a width of 15 μm , the width of the current blocking layer 130 may exceed about 45 μm and the upper extension 122 may be placed on an upper side of a central region of the current blocking layer 130. However, since an excessively large width of the current blocking layer 130 can cause increase in forward voltage, it is desirable that the width of the current blocking layer 130 be adjusted to be four times or less the width of an upper extension 121. Adjustment of the widths of the upper extension 122 and the current blocking layer 130 disposed under the upper extension may be applied to an overall region of the upper extension 122, or may be applied to some region thereof. Particularly, width adjustment may be applied to the upper extension 122 and the current blocking layer 130 placed inside the light emitting diode rather than along an edge of the light emitting diode, like the upper extension 121 that connects a portion of the upper extension 122 placed near the second side surface 111b to the bonding pads 121.

[49] The current blocking layer 130 may exhibit insulating properties and may include an insulating material. For example, the current blocking layer 130 may include SiO_x or SiN_x , or may include a distributed Bragg reflector (DBR) in which materials layers having different indices of refraction are stacked one above another. That is, the current blocking layer 130 may exhibit transmittance or reflectivity with respect to light having a certain wavelength. The current blocking layer 130 may be composed of a single layer or multiple layers formed through chemical vapor deposition (CVD) or the like.

[50] The current blocking layer 130 may include at least one opening 130a that exposes the second conductive type semiconductor layer 113. Referring to FIG. 1b, the opening 130a may have a rectangular shape or a circular shape, without being limited thereto. The opening 130a may be formed using a mask, or through deposition of the current blocking layer 130, followed by etching, without being limited thereto.

- [51] A side surface of the current blocking layer 130 may include an inclined surface. Referring to FIG. 2 and FIG. 3, an angle defined between a lower surface of the current blocking layer 130 and the side surface of the current blocking layer 130 may be greater than 90° and less than 180° . In the structure wherein the side surface of the current blocking layer 130 includes the inclined surface, a portion of a second reflective metal layer 141, which covers the side surface of the current blocking layer 130, is placed along the inclined side surface of the current blocking layer 130 and can more effectively reflect light generated by the active layer 112 towards an upper side of the light emitting structure 110. In addition, this structure can increase a junction area between the current blocking layer 130 and the second reflective metal layer 141, thereby improving mechanical reliability of the light emitting diode.
- [52] The second electrode 140 may be placed on the lower surface of the light emitting structure 110. The second electrode 140 may be electrically connected to the second conductive type semiconductor layer 113. The second electrode 140 may include a first reflective metal layer 141, a second reflective metal layer 142, and a barrier metal layer 143.
- [53] The first reflective metal layer 141 may adjoin the second conductive type semiconductor layer 113. In addition, the first reflective metal layer 141 may form ohmic contact with the second conductive type semiconductor layer 113. The first reflective metal layer 141 includes a second region 113b that forms ohmic contact with the second conductive type semiconductor layer 113 through the opening 130a. The first reflective metal layer 141 may be spaced apart from the current blocking layer 130.
- [54] The first reflective metal layer 141 may include a metal or an alloy capable of reflecting light emitted from the light emitting structure 110. For example, the first reflective metal layer 141 may include Ag, Ag alloy, Ni/Ag, NiZn/Ag, TiO/Ag, or Ni/Ag/Ni/Ti layers, and may be formed through deposition and patterning. Particularly, when the second conductive type semiconductor layer 113 is a p-type semiconductor layer, the Ni layer forms ohmic contact with the second conductive type semiconductor layer 113. Since the Ni layer deteriorates reflectivity of Ag due to low reflectivity with respect to light generated from the light emitting structure 110, the Ni layer may have a thin thickness. The first reflective metal layer 141 may be formed by e-beam evaporation, vacuum deposition, sputtering or metal organic chemical vapor deposition (MOCVD).
- [55] The second reflective metal layer 142 may cover the current blocking layer 130 and the first reflective metal layer 141. Specifically, the second reflective metal layer 142 may be placed to cover a lower surface and side surfaces of the current blocking layer 130 and a lower surface and side surfaces of the first reflective metal layer 141. The second reflective metal layer 142 may adjoin the current blocking layer 130 and the

first reflective metal layer 141. Furthermore, the second reflective metal layer 142 may adjoin a portion of the second conductive type semiconductor layer 113 through the opening 130a. Specifically, the second reflective metal layer 142 may include a third region 113c formed by separation between the first reflective metal layer 141 and the current blocking layer 130 and exposing a lower surface of the second conductive type semiconductor layer 113.

- [56] The second reflective metal layer 142 may be placed between the current blocking layer 130 and the barrier metal layer 143 described below and/or between the first reflective metal layer 141 and the barrier metal layer 143.
- [57] The second reflective metal layer 142 may include a metal having different reflectivity than the metal of the first reflective metal layer 141. Specifically, when the first reflective metal layer 141 includes Ag, the second reflective metal layer 142 may include Al. Ag has a reflectivity of about 98.9% and Al has a reflectivity of about 90.3%.
- [58] Referring to FIG. 1 to FIG. 3, the first region 113a, the second region 113b and the third region 113c may have different electrical junction characteristics, and may exhibit different reflection characteristics. Specifically, the first region 113a, the second region 113b and the third region 113c may have different contact resistances due to the different electrical junction characteristics thereof.
- [59] Contact resistance of the third region 113c, that is, the second reflective metal layer 142 and the second conductive type semiconductor layer 113, may be higher than the contact resistance of the second region 113b, that is, the first reflective metal layer 141 and the second conductive type semiconductor layer 113. With this structure, the second reflective metal layer 142 can serve to reflect light while reducing forward voltage through current spreading.
- [60] The second reflective metal layer 142 may be formed of a metal having higher work function than the first reflective metal layer 141. Specifically, the second reflective metal layer 142 may form Schottky junction with the second conductive type semiconductor layer 113. Increase in area of the first region 113a in which the current blocking layer 130 adjoins the second conductive type semiconductor layer 113 can cause deterioration in light extraction efficiency through decrease in a reflective area of the second electrode 140. Conversely, decrease in area of the first region 113a can cause deterioration in current spreading efficiency of the light emitting diode. In the structure wherein the second reflective metal layer 142 forms Schottky junction with the third region 113c, most current can be applied to the second electrode 140 through the second region 113b which forms ohmic contact. Further, since the third region 113c can also reflect light generated in the light emitting structure 110, this structure can improve current spreading and light extraction efficiency while minimizing the

area of the current blocking layer 130.

- [61] Furthermore, with the structure wherein the second reflective metal layer 142 includes Al, the light emitting diode may be configured to have ohmic contact between the second reflective metal layer 142 and the second conductive type semiconductor layer 113. In this structure, however, in order to form ohmic contact between the second reflective metal layer 142 and the second conductive type semiconductor layer 113, it is necessary to perform heat treatment at a high temperature of 700°C or more. As a result, there can be a problem of damage to the light emitting structure 110 due to heat. However, in exemplary embodiments of the invention, the second reflective metal layer 142 forms Schottky junction with the second conductive type semiconductor layer 113 instead of ohmic contact so long as the second reflective metal layer 142 has light reflection characteristics. As a result, the exemplary embodiments can omit heat treatment with respect to the first reflective metal layer 142 while maximizing reflection of light by the second electrode 140 when the light is generated in the light emitting structure 110. That is, as compared with the structure wherein the second reflective metal layer 142 is omitted, an effective area of the second electrode 140 capable of reflecting light can be increased, thereby improving light extraction efficiency.
- [62] The third region 113c may have a smaller area than the second region 113b. Accordingly, since the third region 113c forming Schottky junction with the second conductive type semiconductor layer 113 has a small area, overall resistance of the light emitting diode can be reduced, thereby further reducing forward voltage (Vf).
- [63] In the structure wherein the current blocking layer 130 includes a distributed Bragg reflector (DBR), the current blocking layer 130 can reflect light in a wide wavelength band. Particularly, when the active layer 112 emits light such as near UV light, the light can be reflected by the distributed Bragg reflector (DBR), thereby improving light extraction efficiency. On the other hand, the second reflective metal layer 142 disposed under the current blocking layer 130 reflects light passing through the current blocking layer 130, thereby improving light extraction efficiency. Particularly, in the structure wherein the current blocking layer 130 is the distributed Bragg reflector (DBR), the second reflective metal layer 142 and the current blocking layer 130 can reflect light in a substantially overall wavelength band emitted from the active layer 112. For example, when light emitted from the active layer 112 is near UV light, it is possible to maintain high reflectivity through the current blocking layer 130 and the second reflective metal layer 142. Furthermore, combination of the second reflective metal layer 142 and the current blocking layer 130 can maintain high reflectivity with respect to light entering the current blocking layer 130 at various angles of incidence.
- [64] Bonding strength between the second reflective metal layer 142 and the current

blocking layer 130 may be greater than the bonding strength between the first reflective metal layer 141 and the current blocking layer 130. Specifically, in the structure wherein the first reflective metal layer 141 includes Ag and the second reflective metal layer 142 includes Al, bonding strength between Al of the second reflective metal layer 142 and the current blocking layer 130 may be greater than Ag of the first reflective metal layer 141 and the current blocking layer 130. A portion of the second reflective metal layer 142 may cover the lower surface and the side surfaces of the current blocking layer 130. In this structure, light passing through the lower surface and the side surfaces of the current blocking layer 130 can be reflected by the second reflective metal layer 142. Furthermore, since the current blocking layer 130 adjoins the second reflective metal layer 142 instead of the first reflective metal layer 141 exhibiting low bonding strength with respect to the current blocking layer 130, the light emitting diode has improved reliability by solving the problem of delamination of the second electrode 140 from the current blocking layer 130.

- [65] The second reflective metal layer 142 may be formed by e-beam evaporation, vacuum deposition, sputtering or metal organic chemical vapor deposition (MOCVD).
- [66] The barrier metal layer 143 may be placed on the lower surface of the second reflective metal layer 142. The barrier metal layer 143 may be spaced apart from the first reflective metal layer 141 and the current blocking layer 130 by the second reflective metal layer 142. In a structure wherein the barrier metal layer 143 adjoins the current blocking layer 130, light passing through the current blocking layer 130 can be absorbed into the barrier metal layer 143. However, since the second reflective metal layer 142 having higher reflectivity than the barrier metal layer 143 is disposed between the current blocking layer 130 and the barrier metal layer 143, it is possible to prevent light loss caused by absorption of light by the barrier metal layer 143.
- [67] The barrier metal layer 143 serves to prevent diffusion of Ag of the first reflective metal layer 141 to the outside of the first reflective metal layer. The barrier metal layer 143 may be formed of Ni, Cr, Ti, Pt, Au or combinations thereof. For example, referring to FIG. 3, the barrier metal layer 143 may include a structure wherein a Ni layer 143a and a Ti layer 143b are repeatedly stacked one above another. Since the barrier metal layer 143, particularly, the Ni layer 143a, exhibits high reflectivity with respect to light emitted from the active layer 112, there is a need to prevent light emitted from the active layer 112 from entering the Ni layer 143a. To this end, according to exemplary embodiments, the second reflective metal layer 142 is disposed between the current blocking layer 130 and the barrier metal layer 143 while adjoining the second conductive type semiconductor layer 113 so as to prevent direct contact between the Ni layer 143a and the second conductive type semiconductor layer 113. The barrier metal layer 143 may be formed by e-beam evaporation, vacuum deposition,

sputtering or metal organic chemical vapor deposition (MOCVD).

- [68] The light emitting diode according to this exemplary embodiment may further include the insulation layer 170. The insulation layer 170 may be disposed on an upper surface and side surfaces of the light emitting structure 110. The insulation layer 170 serves to protect the light emitting structure 110 from external impact and contaminants. The insulation layer 170 may include at least one opening 170a that exposes the first electrode 120. The first electrode 120 may be exposed through the opening 170a to be connected to a wire and the like. The insulation layer 170 may include SiO_x or SiN_x , without being limited thereto. The insulation layer 170 may be formed of the same material as the current blocking layer 130.
- [69] The light emitting diode according to this exemplary embodiment may further include the substrate 160. The substrate 160 may be disposed on a lower surface of the barrier metal layer 143. The substrate 160 may serve to protect the barrier metal layer 143. In addition, the substrate 160 may serve to hold the light emitting structure 110 upon separation of a substrate (not shown) from the light emitting structure 110. The substrate 160 may include a conductive metal such as Cu. Referring to FIG. 2, the substrate 160 may be disposed on the lower surface of the barrier metal layer 143 via a bonding material 150. The bonding material 150 may include bonding metals such as AuSn.
- [70] Referring to FIG. 4, the light emitting diode according to the present invention has better properties in terms of forward voltage V_f and output power than a typical light emitting diode. Specifically, the light emitting diode according to the present invention was used as an inventive example and a typical light emitting diode having the same structure as the light emitting diode according to the present invention excluding the second reflective metal layer 142 was used as a comparative example. Both light emitting diodes had a size of $1,000\ \mu\text{m} \times 1,000\ \mu\text{m}$, the first reflective metal layer 141 was composed of Ni/Ag/Ni/Ti layers ($3\text{\AA}/2,000\text{\AA}/200\text{\AA}/3000\text{\AA}$), the current blocking layer 130 was composed of SiO_2 ($8,000\text{\AA}$), the barrier metal layer 143 was composed of Ti/Ni layers (14 layers, $1.4\ \mu\text{m}$) and Au ($50\text{\AA}$), and the second reflective metal layer 142 of the light emitting diode of the inventive example was composed of Al ($2,000\text{\AA}$).
- [71] Referring to FIG. 4a, since the light emitting diode of the inventive example had a forward voltage of 3.041V and the light emitting diode of the comparative example had a forward voltage of 3.104V, it can be seen that the light emitting diode according to the present invention has reduced forward voltage. Referring to FIG. 4b, since the light emitting diode of the inventive example had an output power of 621.6 mW and since the light emitting diode of the comparative example had had an output power of 615.7 mW, it can be seen that the light emitting diode according to the present invention has increased output power. This result shows that the second reflective

metal layer 142 can serve to improve light extraction efficiency of the light emitting diode.

[72] On the other hand, with the width of the upper extension 122 fixed to 15 μm , the forward voltage V_f and the light output were measured while changing the width of the current blocking layer 130 to 23 μm , 30 μm , 50 μm and 70 μm . With reference to a value obtained by setting the width of the current blocking layer to 23 μm , light output increased and forward voltage slightly increased with increasing width of the current blocking layer 130. Particularly, when the current blocking layer 130 had a width of 50 μm , the forward voltage V_f insignificantly increased by less than 1% and the light output significantly increased by about 3.2%.

[73] FIG. 5 is a sectional view of a light emitting diode according to another exemplary embodiment of the present invention. The light emitting diode of FIG. 5 is similar to the light emitting diode described with reference to FIG. 1 to FIG. 3 except that an upper surface of the first conductive type semiconductor layer 111 includes a roughened surface R. The roughened surface R serves to prevent light generated in the light emitting structure 110 from returning back to the interior of the light emitting diode through reflection by the upper surface of the first conductive type semiconductor layer 111, thereby improving light extraction efficiency of the light emitting diode. Specifically, a portion of the upper surface of the first conductive type semiconductor layer 111, which does not adjoin the first electrode 120, may include the roughened surface R. In a structure wherein a portion of the upper surface of the light emitting structure 110 having the first electrode 120 disposed thereon, that is, a portion of the upper surface of the first conductive type semiconductor layer 111 adjoining the lower surface of the first electrode 120, includes the roughened surface R, the material of the first electrode 120 can be diffused to an excessively deep portion in the light emitting structure 110 along the roughened surface R. As a result, the light emitting diode can have reduced internal quantum efficiency, thereby deteriorating reliability of the light emitting diode.

[74] FIG. 6 is a sectional view of a light emitting diode according to a further exemplary embodiment of the present invention. The light emitting diode of FIG. 6 is similar to the light emitting diode described with reference to FIG. 1 to FIG. 3 except that side surfaces of the second reflective metal layer 142 protrude beyond the side surfaces of the light emitting structure 110. Specifically, the second reflective metal layer 142 may include a protrusion P protruding beyond the side surfaces of the light emitting structure 110. An upper surface of the second reflective metal layer 142 may have a wider area than the lower surface of the light emitting structure 110. In this structure, some of light emitted through the side surfaces of the light emitting structure 110 can be reflected towards an upper portion of the light emitting diode by the second re-

flective metal layer 142. Accordingly, the light emitting diodes can have improved light extraction efficiency.

- [75] Referring to FIG. 6, a portion of the current blocking layer 130 may be placed on an upper surface of the protrusion P. With this structure, the upper surface of the protrusion P can be protected from external impact and contaminants. In addition, the insulation layer 170 may adjoin the current blocking layer 130. Specifically, a portion of the insulation layer 170 may adjoin the current blocking layer 130 disposed on the upper surface of the protrusion P. In this structure, a distance from a side surface of the insulation layer 170 or a side surface of the current blocking layer 130 to the light emitting structure 110 can be increased, thereby preventing external contaminants from entering the light emitting diode while more effectively protecting the light emitting structure 110 from external impact. The insulation layer 170 and the current blocking layer 130 may be formed of the same material. For example, when the current blocking layer 130 is formed of SiO₂, the insulation layer 170 may also be formed of SiO₂. In this structure, high bonding strength can be generated between the insulation layer 170 and the current blocking layer 130, thereby preventing delamination of the insulation layer 170 or the current blocking layer 130 while more effectively preventing external contaminants from entering the light emitting diode.
- [76] FIG. 7 is an exploded perspective view of one embodiment of a lighting apparatus to which a light emitting diode according to one exemplary embodiment of the invention is applied.
- [77] Referring to FIG. 7, the lighting apparatus according to this embodiment includes a diffusive cover 1010, a light emitting diode module 1020, and a body 1030. The body 1030 may receive the light emitting diode module 1020 and the diffusive cover 1010 may be disposed on the body 1030 to cover an upper side of the light emitting diode module 1020.
- [78] The body 1030 may have any shape so long as the body can supply electric power to the light emitting diode module 1020 while receiving and supporting the light emitting diode module 1020. For example, as shown in the drawing, the body 1030 may include a body case 1031, a power supply 1033, a power supply case 1035, and a power source connection section 1037.
- [79] The power supply 1033 is received in the power supply case 1035 to be electrically connected to the light emitting diode module 1020, and may include at least one IC chip. The IC chip may regulate, change or control electric power supplied to the light emitting diode module 1020. The power supply case 1035 may receive and support the power supply 1033. The power supply case 1035 having the power supply 1033 secured therein may be disposed within the body case 1031. The power source connection section 1037 is disposed at a lower end of the power supply case 1035 and

coupled thereto. Accordingly, the power source connection section 1037 is electrically connected to the power supply 1033 within the power supply case 1035 and may serve as a passage through which power can be supplied from an external power source to the power supply 1033.

[80] The light emitting diode module 1020 includes a substrate 1023 and a light emitting diode 1021 disposed on the substrate 1023. The light emitting diode module 1020 may be disposed at an upper portion of the body case 1031 and electrically connected to the power supply 1033.

[81] As the substrate 1023, any substrate capable of supporting the light emitting diode 1021 may be used without limitation. For example, the substrate 1023 may include a printed circuit board having interconnects formed thereon. The substrate 1023 may have a shape corresponding to a securing portion formed at the upper portion of the body case 1031 so as to be stably secured to the body case 1031. The light emitting diode 1021 may include at least one of the light emitting diodes according to the embodiments described above.

[82] The diffusive cover 1010 is disposed on the light emitting diode 1021 and may be secured to the body case 1031 to cover the light emitting diode 1021. The diffusive cover 1010 may be formed of a light-transmitting material and light orientation of the lighting apparatus may be adjusted through regulation of the shape and optical transmissivity of the diffusive cover 1010. As such, the diffusive cover 1010 may be modified in various shapes depending on usage and applications of the lighting apparatus.

[83] FIG. 8 is a sectional view of one embodiment of a display to which a light emitting diode according to one exemplary embodiment of the invention is applied.

[84] The display according to this embodiment includes a display panel 2110, a backlight unit BLU1 supplying light to the display panel 2110, and a panel guide 2100 supporting a lower edge of the display panel 2110.

[85] The display panel 2110 is not particularly limited and may be, for example, a liquid crystal panel including a liquid crystal layer. Gate driving PCBs may be further disposed at the edge of the display panel 2110 to supply driving signals to a gate line. Here, the gate driving PCBs 2112 and 2113 may be formed on a thin film transistor substrate instead of being formed on separate PCBs.

[86] The backlight unit BLU1 includes a light source module, which includes at least one substrate 2150 and a plurality of light emitting diodes 2160. The backlight unit BLU1 may further include a bottom cover 2180, a reflective sheet 2170, a diffusive plate 2131, and optical sheets 2130.

[87] The bottom cover 2180 may be open at an upper side thereof to receive the substrate 2150, the light emitting diodes 2160, the reflective sheet 2170, the diffusive plate

2131, and the optical sheets 2130. In addition, the bottom cover 2180 may be coupled to the panel guide 2100. The substrate 2150 may be disposed under the reflective sheet 2170 to be surrounded by the reflective sheet 2170. Alternatively, when a reflective material is coated onto a surface thereof, the substrate 2150 may be disposed on the reflective sheet 2170. Further, a plurality of substrates 2150 may be arranged parallel to one other. However, it should be understood that other implementations are also possible and the light source module may include a single substrate.

[88] The light emitting diodes 2160 may include at least one of the light emitting diodes according to the embodiments described above. The light emitting diodes 2160 may be regularly arranged in a predetermined pattern on the substrate 2150. In addition, a lens 2210 is disposed on each of the light emitting diodes 2160 to improve uniformity of light emitted from the plurality of light emitting diodes 2160.

[89] The diffusive plate 2131 and the optical sheets 2130 are disposed on the light emitting devices 2160. Light emitted from the light emitting devices 2160 may be supplied in the form of sheet light to the display panel 2110 through the diffusive plate 2131 and the optical sheets 2130.

[90] In this way, the light emitting diodes according to the embodiments may be applied to direct type displays like the display according to this embodiment.

[91] FIG. 9 is a sectional view of one embodiment of a display to which a light emitting diode according to one exemplary embodiment of the invention is applied.

[92] The display according to this embodiment includes a display panel 3210 on which an image is displayed, and a backlight unit BLU2 disposed at a rear side of the display panel 3210 and emitting light thereto. Further, the display includes a frame 240 supporting the display panel 3210 and receiving the backlight unit BLU2, and covers 3240, 3280 surrounding the display panel 3210.

[93] The display panel 3210 is not particularly limited and may be, for example, a liquid crystal panel including a liquid crystal layer. A gate driving PCB may be further disposed at an edge of the display panel 3210 to supply driving signals to a gate line. Here, the gate driving PCB may be formed on a thin film transistor substrate instead of being formed on a separate PCB. The display panel 3210 is secured by the covers 3240, 3280 disposed at upper and lower sides thereof, and the cover 3280 disposed at the lower side of the display panel 3210 may be coupled to the backlight unit BLU2.

[94] The backlight unit BLU2 supplying light to the display panel 3210 includes a lower cover 3270 partially open at an upper side thereof, a light source module disposed at one side inside the lower cover 3270, and a light guide plate 3250 disposed parallel to the light source module and converting spot light into sheet light. In addition, the backlight unit BLU2 according to this embodiment may further include optical sheets 3230 disposed on the light guide plate 3250 to spread and collect light, and a reflective

sheet 3260 disposed at a lower side of the light guide plate 3250 and reflecting light traveling in a downward direction of the light guide plate 3250 towards the display panel 3210.

- [95] The light source module includes a substrate 3220 and a plurality of light emitting diodes 3110 arranged at constant intervals on one surface of the substrate 3220. As the substrate 3220, any substrate capable of supporting the light emitting diodes 3110 and being electrically connected thereto may be used without limitation. For example, the substrate 3220 may include a printed circuit board. The light emitting diodes 3110 may include at least one of the light emitting diodes according to the exemplary embodiments described above. Light emitted from the light source module enters the light guide plate 3250 and is supplied to the display panel 3210 through the optical sheets 3230. The light guide plate 3250 and the optical sheets 3230 convert spot light emitted from the light emitting diodes 3110 into sheet light.
- [96] In this way, the light emitting diodes according to the embodiments may be applied to edge type displays like the display according to this embodiment.
- [97] FIG. 10 is a sectional view of one embodiment of a headlight to which a light emitting diode according to one exemplary embodiment of the invention is applied.
- [98] Referring to FIG. 10, the headlight according to this embodiment includes a lamp body 4070, a substrate 4020, a light emitting diode 4010, and a cover lens 4050. The headlight may further include a heat dissipation unit 4030, a support rack 4060, and a connection member 4040.
- [99] The substrate 4020 is secured by the support rack 4060 and disposed above the lamp body 4070. As the substrate 4020, any member capable of supporting the light emitting diode 4010 may be used without limitation. For example, the substrate 4020 may include a substrate having a conductive pattern, such as a printed circuit board. The light emitting diode 4010 is disposed on the substrate 4020 and may be supported and secured by the substrate 4020. In addition, the light emitting diode 4010 may be electrically connected to an external power source through the conductive pattern of the substrate 4020. Further, the light emitting diode 4010 may include at least one of the light emitting diodes according to the exemplary embodiments described above.
- [100] The cover lens 4050 is disposed on a path of light emitted from the light emitting diode 4010. For example, as shown in the drawing, the cover lens 4050 may be spaced apart from the light emitting diode 4010 by the connection member 4040 and may be disposed in a direction of supplying light emitted from the light emitting diode 4010. By the cover lens 4050, an orientation angle and/or a color of light emitted by the headlight can be adjusted. On the other hand, the connection member 4040 is disposed to secure the cover lens 4050 to the substrate 4020 while surrounding the light emitting diode 4010, and thus may act as a light guide that provides a luminous path 4045. The

connection member 4040 may be formed of a light reflective material or coated therewith. On the other hand, the heat dissipation unit 4030 may include heat dissipation fins 4031 and/or a heat dissipation fan 4033, and dissipates heat generated upon operation of the light emitting diode 4010.

[101] In this way, the light emitting diodes according to the exemplary embodiment may be applied to headlights, particularly, headlights for vehicles, like the headlight according to this embodiment.

Claims

- [Claim 1] A light emitting diode comprising:
a light emitting structure comprising a second conductive type semiconductor layer, an active layer disposed on an upper surface of the second conductive type semiconductor layer, and a first conductive semiconductor layer disposed on an upper surface of the active layer;
at least one first electrode electrically connected to the first conductive type semiconductor layer;
a current blocking layer disposed on a lower surface of the light emitting structure; and
a second electrode electrically connected to the second conductive type semiconductor layer,
wherein the second electrode comprises:
a first reflective metal layer adjoining the second conductive type semiconductor layer; and
a second reflective metal layer covering a lower surface of the current blocking layer and a lower surface of the first reflective metal layer while adjoining a portion of the second conductive type semiconductor layer, and
wherein contact resistance between the second reflective metal layer and the second conductive type semiconductor layer is higher than contact resistance between the first reflective metal layer and the second conductive type semiconductor layer.
- [Claim 2] The light emitting diode according to claim 1, wherein the first reflective metal layer is spaced apart from the current blocking layer.
- [Claim 3] The light emitting diode according to claim 1, wherein the second reflective metal layer comprises an Al layer, the Al layer adjoining the current blocking layer, the first reflective metal layer and the second conductive type semiconductor layer.
- [Claim 4] The light emitting diode according to claim 3, further comprising:
a barrier metal layer disposed on a lower surface of the second reflective metal layer,
wherein the barrier metal layer comprises Ni.
- [Claim 5] The light emitting diode according to claim 3, wherein the current blocking layer comprises a first region adjoining the second conductive type semiconductor layer, the first reflective metal layer comprises a second region adjoining the second conductive type semiconductor

layer, and the second reflective metal layer comprises a third region adjoining the second conductive type semiconductor layer, the first region, the second region and the third region having different electrical junction characteristics.

- [Claim 6] The light emitting diode according to claim 5, wherein the third region and the second reflective metal layer form Schottky junction therebetween.
- [Claim 7] The light emitting diode according to claim 6, wherein the third region has a smaller area than the second region.
- [Claim 8] The light emitting diode according to claim 1, wherein a portion of the second reflective metal layer covers a side surface of the current blocking layer.
- [Claim 9] The light emitting diode according to claim 8, wherein the side surface of the current blocking layer comprises an inclined surface.
- [Claim 10] The light emitting diode according to claim 1, wherein the second reflective metal layer a protrusion protruding beyond a side surface of the light emitting structure.
- [Claim 11] The light emitting diode according to claim 10, further comprising: an insulation layer disposed on an upper surface and a side surface of the light emitting structure.
- [Claim 12] The light emitting diode according to claim 11, wherein a portion of the current blocking layer is placed on an upper surface of the protrusion.
- [Claim 13] The light emitting diode according to claim 12, wherein the insulation layer and the current blocking layer adjoin each other.
- [Claim 14] The light emitting diode according to claim 13, wherein the insulation layer and the current blocking layer are formed of the same material.
- [Claim 15] The light emitting diode according to claim 1, wherein the first electrode comprises an electrode pad and an upper extension, the upper extension comprising a region overlapping the current blocking layer, the current blocking layer having a greater width than the upper extension such that portions of the current blocking layer are placed beyond both sides of the upper extension in a width direction in a view showing the upper extension overlapping the current blocking layer, and wherein each of portions of the current blocking layer placed beyond both sides of the upper extension in the width direction has the same or greater width than the upper extension.

[Claim 16]

A light emitting diode comprising:
a light emitting structure comprising a second conductive type semiconductor layer, an active layer disposed on an upper surface of the second conductive type semiconductor layer, and a first conductive semiconductor layer disposed on an upper surface of the active layer;
at least one first electrode disposed on an upper surface of the light emitting structure and electrically connected to the first conductive type semiconductor layer;
a current blocking layer disposed on a lower surface of the light emitting structure; and
a second electrode disposed on a lower surface of the light emitting structure and electrically connected to the second conductive type semiconductor layer,
wherein the second electrode comprises:
a first reflective metal layer adjoining the second conductive type semiconductor layer; and
a second reflective metal layer covering a lower surface of the current blocking layer and a lower surface of the first reflective metal layer,
and
wherein bonding strength between the current blocking layer and the second reflective metal layer is greater than bonding strength between the current blocking layer and the first reflective metal layer.

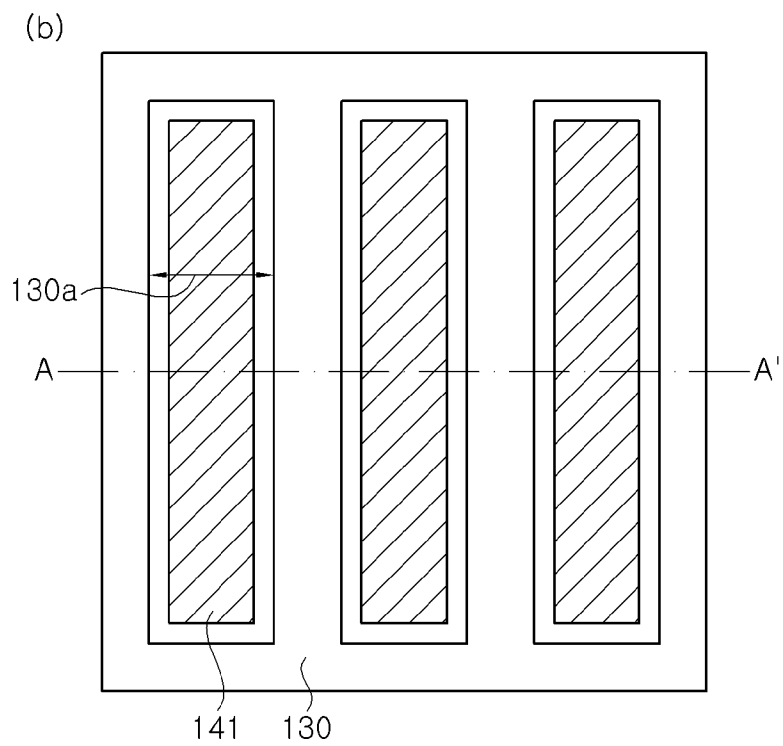
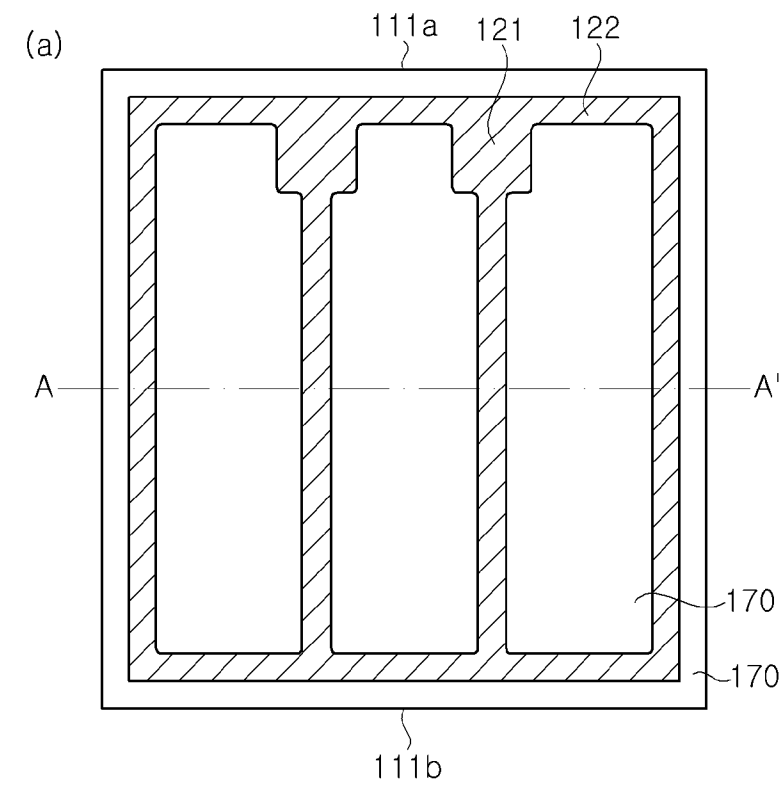
[Claim 17]

The light emitting diode according to claim 16, wherein the second reflective metal layer comprises Al.

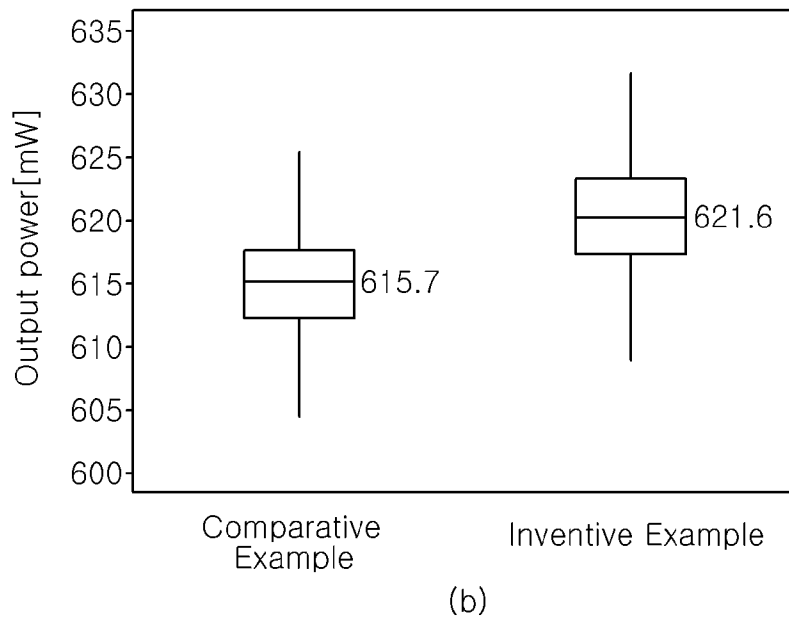
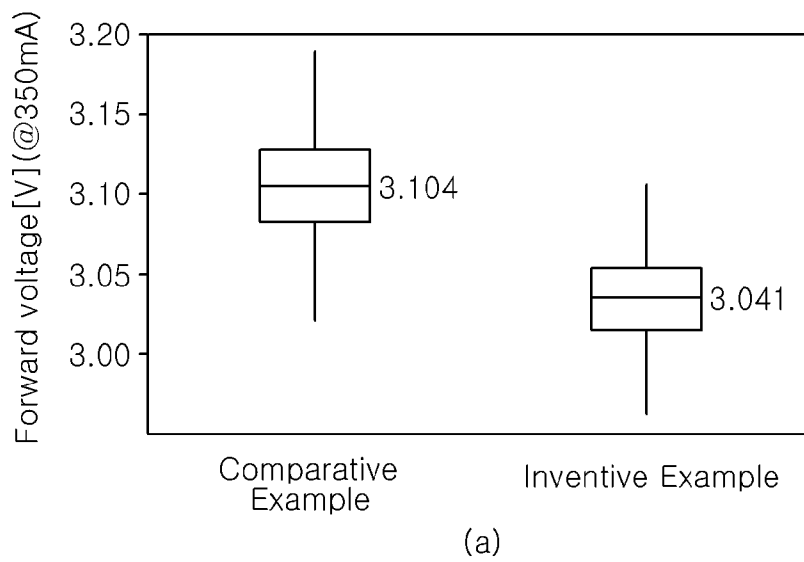
[Claim 18]

The light emitting diode according to claim 16, wherein a portion of the second reflective metal layer covers a side surface of the current blocking layer, and separates the current blocking layer from the first reflective metal layer.

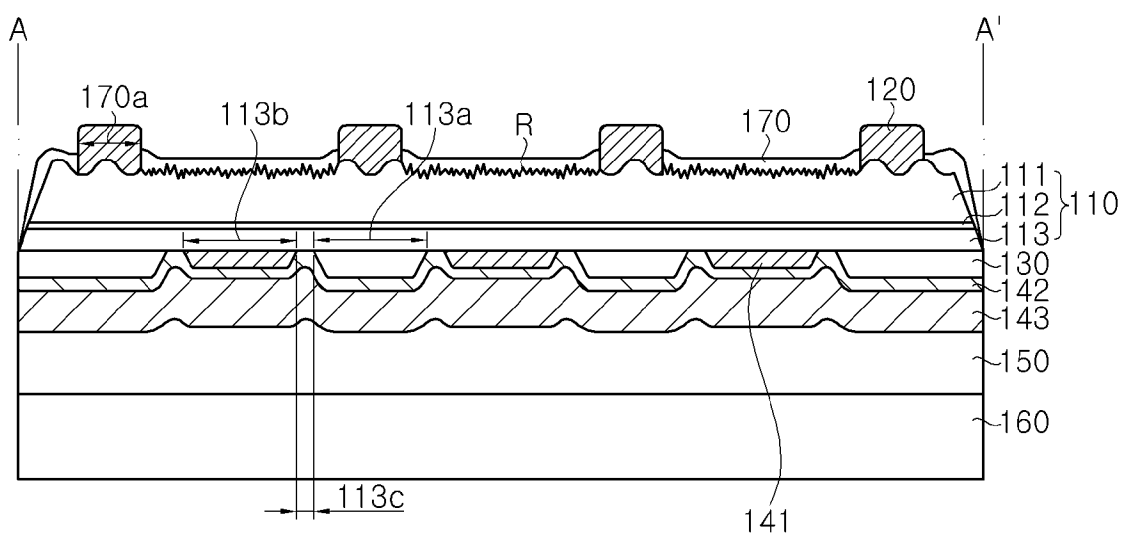
[Fig. 1]



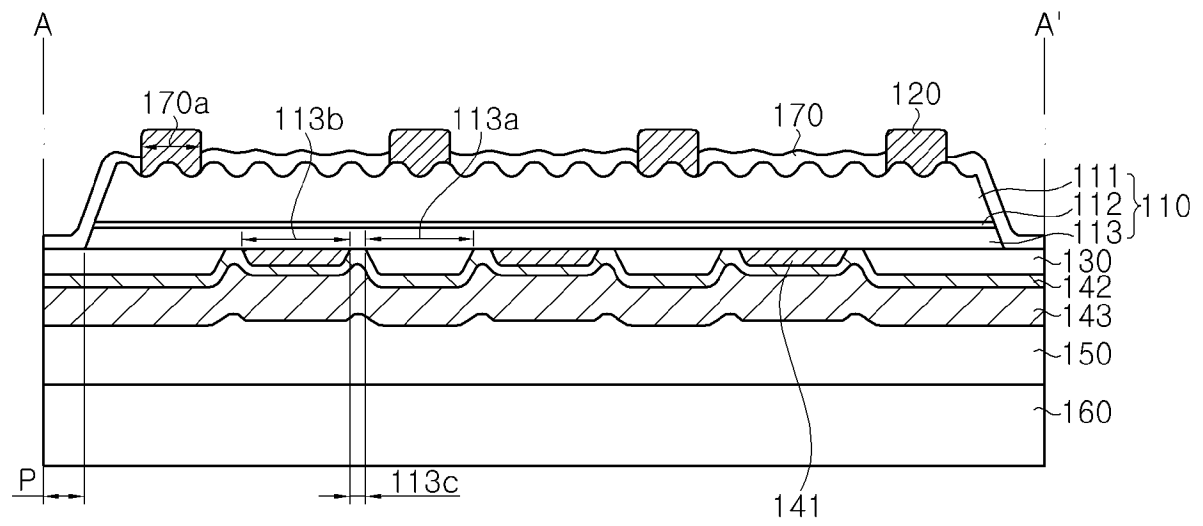
[Fig. 4]



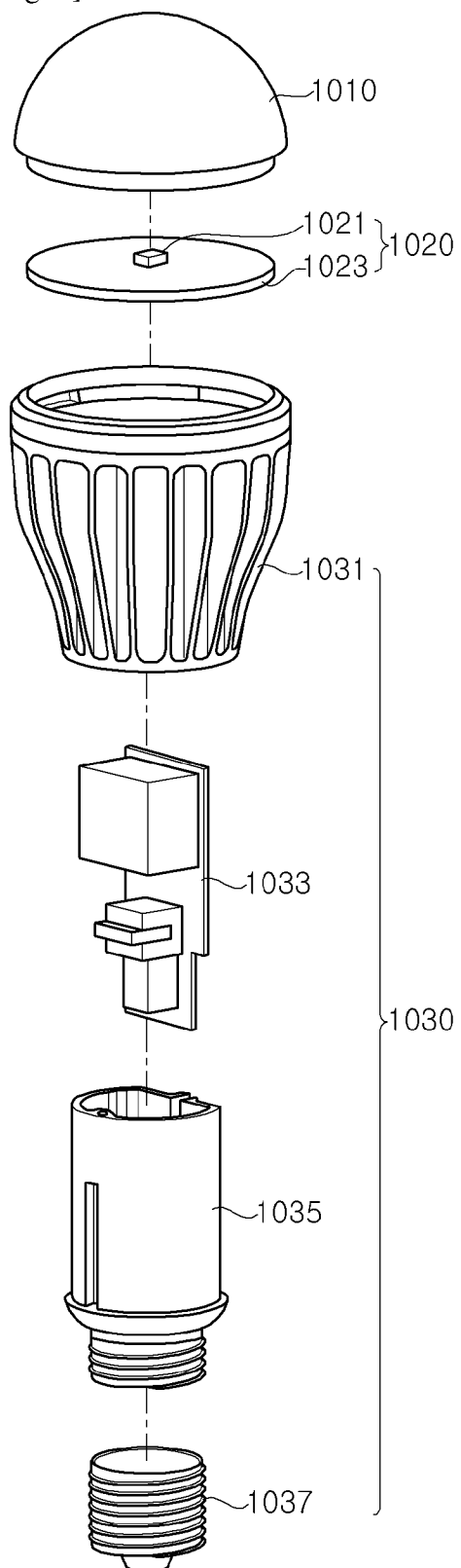
[Fig. 5]



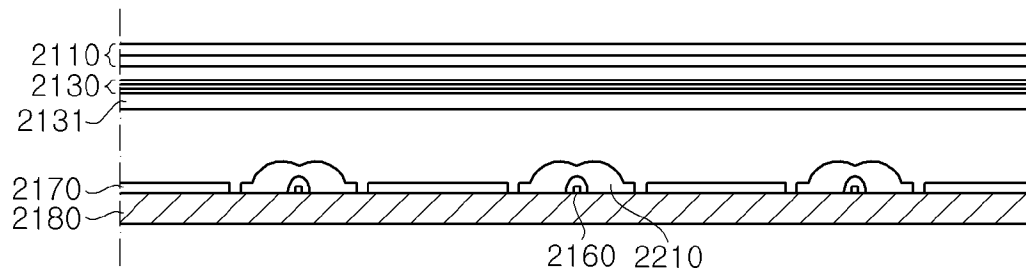
[Fig. 6]



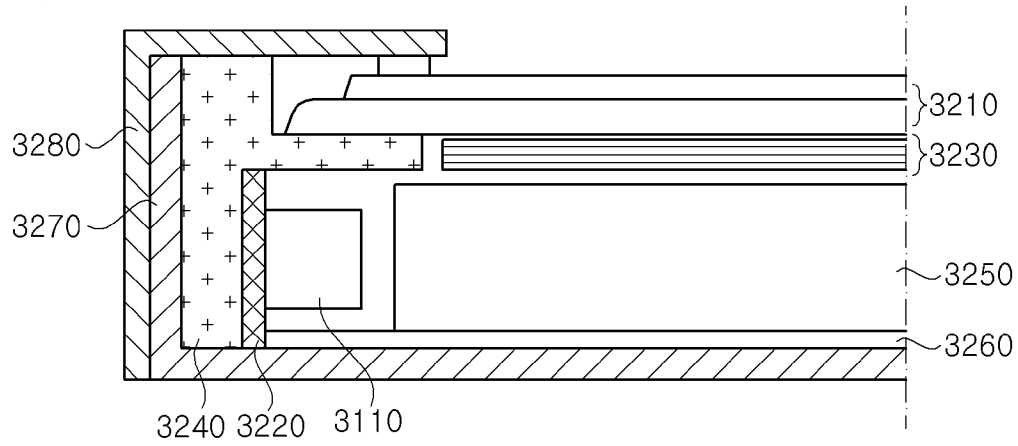
[Fig. 7]



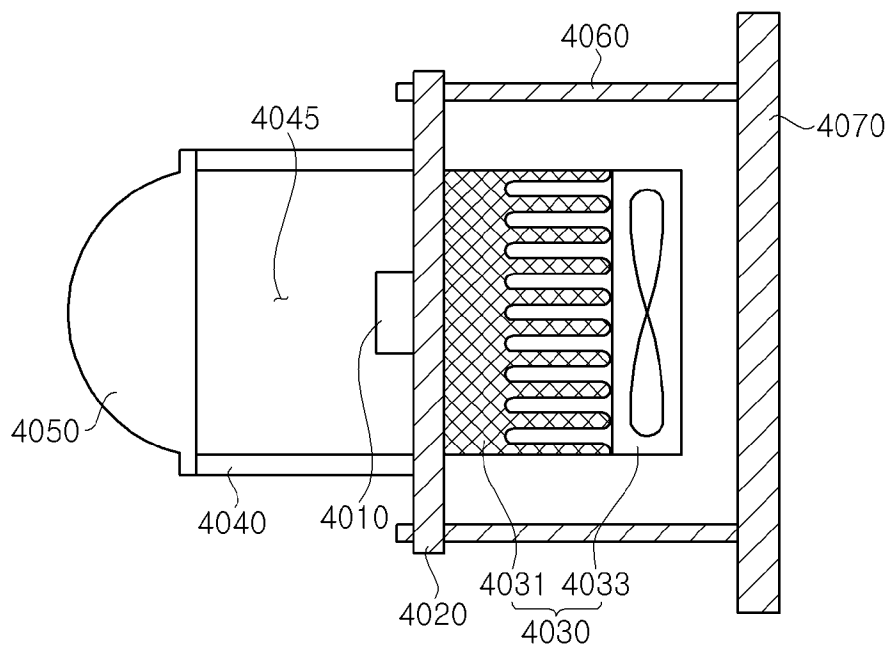
[Fig. 8]



[Fig. 9]



[Fig. 10]



A. CLASSIFICATION OF SUBJECT MATTER**H01L 33/36(2010.01)i, H01L 33/40(2010.01)i, H01L 33/10(2010.01)i, H01L 33/46(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)

H01L 33/36; H01L 33/46; H01L 21/28; H01L 33/10; H01L 33/00; H01L 33/14; H01L 33/44; H01L 33/40

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: metal, reflect, Schottky, resistance, insulation

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	KR 10-2012-0037636 A (LG INNOTEK CO., LTD.) 20 April 2012 See paragraphs 43-58, 63-74, claims 1-12 and figures 2-4.	1-10, 16-18
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Y	KR 10-2012-0039811 A (SEOUL OPTO DEVICE CO., LTD.) 26 April 2012 See paragraphs 20-29, 41-50, claims 1-10 and figures 2-5.	11-15
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A	JP 2007-221029 A (SONY CORP.) 30 August 2007 See paragraphs 32-38, claims 1-7 and figures 1-4.	1-18



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

09 August 2016 (09.08.2016)

Date of mailing of the international search report

09 August 2016 (09.08.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

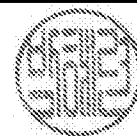
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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