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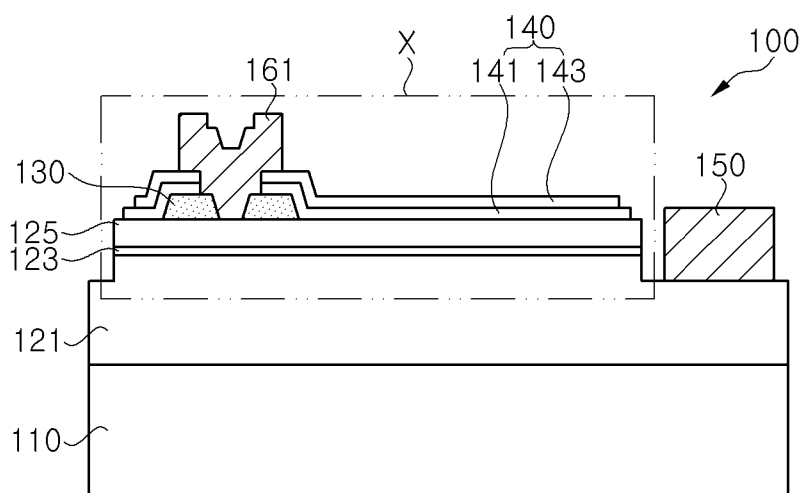
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(54) Title: LIGHT EMITTING DIODE



(57) Abstract: A light emitting diode is disclosed. The light emitting diode includes: a first conductive-type semiconductor layer; a second conductive-type semiconductor layer; an active layer; a current blocking unit disposed on one region of the second conductive-type semiconductor layer and including a through-hole formed in a thickness direction thereof; a transparent electrode covering at least a portion of an upper surface of the second conductive-type semiconductor layer and the current blocking unit, and including an opening exposing the through-hole; and a second electrode contacting the second conductive-type semiconductor layer through the through-hole and disposed on the current blocking unit, wherein the transparent electrode includes a first transparent electrode and a second transparent electrode disposed on the first transparent electrode and having a smaller area than the first transparent electrode, and the second electrode forms ohmic contact with side surfaces of the first and second transparent electrodes.



Description

Title of Invention: LIGHT EMITTING DIODE

Technical Field

- [1] The disclosed technology relates to a light emitting diode. Some implementations of the disclosed technology include a light emitting diode including a plurality of transparent electrode layers.

Background Art

- [2] In a light emitting diode using a nitride-based semiconductor, a nitride-based p-type semiconductor layer has lower electrical conductivity than an n-type semiconductor layer. As a result, electric current does not efficiently spread laterally in the p-type semiconductor layer, thereby causing current crowding at a certain portion of the semiconductor layer. When current crowding occurs in a semiconductor layer, the light emitting diode becomes vulnerable to electrostatic discharge and can suffer from current leakage and efficiency drop.
- [3] Thus, in order to secure efficient current spreading, a transparent electrode such as ITO (Indium tin oxide) is formed on the p-type semiconductor layer and a p-electrode is formed on the ITO electrode. However, the transparent electrode has a limit in uniform spreading of electric current throughout the p-type semiconductor layer. In order to solve this problem, a current blocking layer can be disposed under the p-electrode. The current blocking layer is formed of an insulation material and prevents electric current supplied to the p-electrode from directly flowing into the p-type semiconductor layer formed under the p-electrode, thereby promoting lateral current spreading.

Disclosure of Invention

Technical Problem

- [4] Exemplary embodiments of the disclosed technology provide a light emitting diode that includes a transparent electrode capable of improving electrical and optical characteristics and reliability.

Solution to Problem

- [5] In accordance with one aspect of the disclosed technology, a light emitting diode includes: a first conductive-type semiconductor layer; a second conductive-type semiconductor layer disposed on the first conductive-type semiconductor layer; an active layer interposed between the first and second conductive-type semiconductor layers; a current blocking unit disposed on one region of the second conductive-type semiconductor layer and including a through-hole formed in a thickness direction thereof; a transparent electrode covering at least a portion of an upper surface of the second

conductive-type semiconductor layer and the current blocking unit, and including an opening exposing the through-hole; and a second electrode contacting the second conductive-type semiconductor layer through the through-hole and disposed on the current blocking unit, wherein the transparent electrode includes a first transparent electrode and a second transparent electrode disposed on the first transparent electrode and having a smaller area than the first transparent electrode, and the second electrode forms an ohmic contact with side surfaces of the first and second transparent electrodes.

- [6] With this structure, the light emitting diode has improved electrical characteristics and reliability.
- [7] The second electrode may be formed within a contour of the first transparent electrode, and the side surface of the first transparent electrode adjoining the second electrode may be coplanar with the side surface of the second transparent electrode adjoining the second electrode.
- [8] In addition, an outermost contour of the second transparent electrode may have a shape corresponding to an outermost contour of the first transparent electrode.
- [9] Further, the light emitting diode may include a step formed between an outermost side surface of the second transparent electrode and an upper surface of the first transparent electrode.
- [10] A portion of the transparent electrode may be disposed between the second electrode and the current blocking unit.
- [11] The transparent electrode may have a thickness from 300 Å to 500 Å.
- [12] The first and second transparent electrodes may have the same thickness.
- [13] Each of the first and second transparent electrodes may include ITO and be deposited by sputtering.
- [14] The current blocking unit may have an inclined side surface.
- [15] The second electrode may adjoin a portion of an upper surface of the current blocking unit.
- [16] An upper surface of the second electrode disposed on the through-hole may have a surface profile corresponding to a profile of a lower surface of the second electrode.
- [17] The light emitting diode may further include a second electrode disposed on the first conductive-type semiconductor layer.
- [18] The second electrode may include a second electrode pad and a second electrode extension extending from the second electrode pad, in which the second electrode pad may adjoin the second conductive-type semiconductor layer through the through-hole of the current blocking unit.
- [19] Further, the first electrode may include a first electrode pad and a first electrode extension extending from the first electrode pad.

- [20] Further, the first and second electrodes may include a plurality of first and second electrode extensions, respectively, and the plurality of first electrode extensions and the plurality of second electrode extensions may be formed in a shape of interdigitating with each other.
- [21] The second electrode may form a Schottky contact with the second conductive-type semiconductor layer.
- [22] In accordance with one aspect of the disclosed technology, light emitting diode includes: a first conductive-type semiconductor layer; a second conductive-type semiconductor layer disposed over the first conductive-type semiconductor layer; an active layer interposed between the first and second conductive-type semiconductor layers; a current blocking unit formed over the second conductive-type semiconductor layer and exposing a portion of the second conductive-type semiconductor layer; a transparent electrode formed over the second conductive-type semiconductor and a portion of the current blocking unit and exposing the portion of the second conductive-type semiconductor layer, wherein the transparent electrode has a double-layer structure exhibiting improved step coverage characteristics as compared to a transparent electrode having a single-layer structure.
- [23] The transparent electrode may include a first transparent electrode and a second transparent electrode formed over the first transparent electrode.
- [24] The transparent electrode may form an ohmic contact with the second conductive-type semiconductor layer.
- [25] The light emitting diode may further include a first electrode formed over the first conductive-type semiconductor layer; and a second electrode formed over the second conductive-type semiconductor layer around the current blocking unit.

Advantageous Effects of Invention

- [26] According to exemplary embodiments of the disclosed technology, the light emitting diode includes a transparent electrode, which has excellent optical characteristics and can prevent increase in forward voltage of the light emitting diode and failure of the light emitting diode caused by electrostatic discharge, thereby providing improved reliability of the light emitting diode.

Brief Description of Drawings

- [27] Figure 1 to Figure 2b are a plan view and sectional views of a light emitting diode according to one exemplary embodiment of the disclosed technology.
- [28] Figure 3 is a plan view of a light emitting diode according to another exemplary embodiment of the disclosed technology.
- [29] Figure 4 to Figure 5b are a plan view and sectional views of a light emitting diode according to a further exemplary embodiment of the disclosed technology.

- [30] Figure 6 to Figure 7b are a plan view and sectional views of a light emitting diode according to yet another exemplary embodiment of the disclosed technology.
- [31] Figure 8 to Figure 9b are a plan view and sectional views of a light emitting diode according to yet another exemplary embodiment of the disclosed technology.
- [32] Figure 10 to Figure 11b are a plan view and sectional views of a light emitting diode according to yet another exemplary embodiment of the disclosed technology.

Mode for the Invention

- [33] Hereinafter, exemplary embodiments of the disclosed technology will be described in more detail with reference to the accompanying drawings. The following embodiments are provided by way of example so as to facilitate the understanding of some implementations of the disclosed technology to those skilled in the art to which the disclosed technology pertains. Accordingly, the disclosed technology is not limited to the embodiments disclosed herein and may also be implemented in different forms. In the drawings, widths, lengths, thicknesses, and the like of elements may be exaggerated for clarity and descriptive purposes. When an element or layer is referred to as being "disposed on" or "disposed on" another element or layer, it may be directly "disposed on" or "disposed on" the other element or layer or intervening elements or layers may be present. Throughout the specification, like reference numerals denote like elements having the same or similar functions.
- [34] In a light emitting diode, a transparent electrode is formed to a relatively small thickness or is patterned to expose a p-type semiconductor layer in order to improve transparency of the transparent electrode in the related art. However, this technique has a problem of increase in forward voltage (V_f) due to increase in resistance. For example, a relatively thin thickness of the transparent electrode can cause adverse effects on current spreading due to increase in resistance in the horizontal direction. Further, patterning of the transparent electrode may be performed by dry etching or wet etching. Dry etching has difficulty in regulation of etching thickness and can cause unintended etching of the p-type semiconductor layer, thereby causing defects of the light emitting diode resulting from damage to the semiconductor layer. In addition, wet etching can increase surface roughness of the transparent electrode and has low reproducibility.
- [35] Moreover, when a current blocking layer is provided to the light emitting diode, the transparent electrode is formed to cover a surface of the current blocking layer. In this case, the transparent electrode has undesired step coverage on a side surface of the current blocking layer, whereby disconnection of the transparent electrode or electrostatic discharge can occur thereon. Accordingly, there is a need for a transparent electrode structure that can secure good electrical properties in terms of forward

voltage and current spreading, high reliability, and good transparency.

- [36] Figure 1 to Figure 2b are a plan view and sectional views of a light emitting diode according to one exemplary embodiment of the disclosed technology. Figure 2a is a sectional view taken along line A-A of Figure 1 and Figure 2b is an enlarged view of region X of Figure 2a.
- [37] Referring to Figure 1 to Figure 2b, a light emitting diode 100 includes a first conductive-type semiconductor layer 121, an active layer 123, a second conductive-type semiconductor layer 125, a current blocking unit 130, a transparent electrode 140, and a second electrode 160. The light emitting diode 100 may further include a substrate 110 and a first electrode 150.
- [38] The substrate 110 may be a growth substrate for growing the semiconductor layers 121, 123, and 125, and may include, for example, a sapphire substrate, a silicon carbide substrate, a silicon substrate, a spinel substrate, a gallium nitride substrate, or an aluminum nitride substrate, and the like. However, it should be understood that the disclosed technology is not limited thereto and the substrate 110 may be or include a secondary substrate for supporting the semiconductor layers 121, 123, and 125.
- [39] Although the first conductive-type semiconductor layer 121 is illustrated as being disposed on the substrate 110 in this embodiment, the substrate 110 may be omitted in other exemplary embodiments. When the substrate 110 is or includes a growth substrate capable of growing the semiconductor layers 121, 123, and 125 thereon, the substrate may be separated or removed through a physical and/or chemical process after growth of the semiconductor layers 121, 123, and 125.
- [40] The first conductive-type semiconductor layer 121, the active layer 123, and the second conductive-type semiconductor layer 125 may be sequentially deposited on the substrate 110. In some implementations, an additional layer may be disposed between the semiconductor layers and may include, for example, a buffer layer (not shown) disposed between the substrate 110 and the first conductive-type semiconductor layer 121.
- [41] The first conductive-type semiconductor layer 121, the active layer 123 and the second conductive-type semiconductor layer 125 may be grown in a chamber by a well-known method such as MOCVD. Further, the first conductive-type semiconductor layer 121, the active layer 123 and the second conductive-type semiconductor layer 125 may include III-V based compound semiconductors and may include, for example, nitride-based semiconductors such as (Al, Ga, In)N. The first conductive-type semiconductor layer 121 may include an n-type dopant (for example, Si) and the second conductive-type semiconductor layer 125 may include a p-type dopant (for example, Mg), or vice versa. The active layer 123 may include a multi-quantum well (MQW) structure and may emit light in a desired wavelength range

through adjustment of a composition of the nitride-based semiconductor thereof. For example, in this embodiment, the second conductive-type semiconductor layer 125 may be or include a p-type semiconductor layer.

- [42] The light emitting diode 100 may include a mesa structure formed by mesa etching and including the second conductive-type semiconductor layer 125 and the active layer 123. Accordingly, an upper surface of the first conductive-type semiconductor layer 121 may be partially exposed around the mesa structure, and the first electrode 150 may be disposed on the exposed region of the first conductive-type semiconductor layer 121. However, it should be understood that the disclosed technology is not limited thereto and the exposed region of the first conductive-type semiconductor layer 121 may not be formed. When the light emitting diode has a structure (for example, a vertical structure) other than the lateral structure, the upper surface of the first conductive-type semiconductor layer 121 may not be exposed.
- [43] The current blocking unit 130 may be disposed on one region of the second conductive-type semiconductor layer 125. The current blocking unit 130 may include a through-hole 131 formed in a thickness direction thereof to expose an upper surface of the second conductive-type semiconductor layer 125. Further, the current blocking unit 130 may have an inclined side surface 130s.
- [44] The through-hole 131 may be placed corresponding to a second electrode pad 161, as will be described below in more detail. In addition, although one through-hole 131 of a circular shape is formed in this embodiment, the disclosed technology is not limited thereto. The through-hole 131 may have a polygonal shape in a plan view and a plurality of through-holes 131 may be formed.
- [45] The current blocking unit 130 may be placed in a region corresponding to the second electrode 160 on the second conductive-type semiconductor layer 125 and may be adjacent to one corner of the light emitting diode 100, as shown in Figure 1. Here, the exposed region of the first conductive-type semiconductor layer 121 in which the first electrode 150 is formed, and the current blocking unit 130 may be placed at opposite corners of the light emitting diode, respectively.
- [46] In addition, the current blocking unit 130 may have a substantially similar shape to the shape of the second electrode in a plan view. That is, the current blocking unit 130 may be formed in a similar shape to the shape of the second electrode depending upon the region in which the second electrode 160 is disposed. However, it should be understood that the disclosed technology is not limited thereto and the current blocking unit and the second electrode may have different shapes.
- [47] The current blocking unit 130 can prevent electric current supplied from an electrode from directly flowing into a semiconductor layer, thereby preventing current crowding. Thus, the current blocking unit 130 may include an insulation material and may be

composed of a single layer or multiple layers. For example, the current blocking unit 130 may include SiO_2 , SiN_x , MgF_2 , ZrO_2 , or Al_2O_3 , and the like, and may include a distributed Bragg reflector in which insulation materials having different indices of refraction are stacked one above another. Accordingly, the current blocking unit 130 may exhibit light transmission or may have light reflectivity.

- [48] For example, when the current blocking unit 130 includes a distributed Bragg reflector and exhibits light reflectivity, the distributed Bragg reflector can prevent light from being absorbed into or lost by the second electrode 160 by preventing light from traveling towards the second electrode 160. Thus, depending upon a peak wavelength of light emitted from the active layer 123, a material and thickness of each of layers constituting the distributed Bragg reflector may be determined to reflect light in a desired wavelength band.
- [49] The transparent electrode 140 may be disposed on the second conductive-type semiconductor layer 125. Further, the transparent electrode 140 may cover the upper surface of the second conductive-type semiconductor layer 125 and at least a portion of the current blocking unit 130, and may include an opening through which the through-hole 131 of the current blocking unit 130 is exposed. For example, the transparent electrode 140 may extend from one region of the second conductive-type semiconductor layer 125 in which the current blocking unit 130 is placed to the other region of the second conductive-type semiconductor layer 125.
- [50] For example, the transparent electrode 140 is formed in a shape corresponding to a contour of the upper surface of the second conductive-type semiconductor layer 125 to cover the upper surface of the second conductive-type semiconductor layer 125, and outer side surfaces and a portion of an upper surface of the current blocking unit 130. Thus, the transparent electrode 140 may not be formed on the remaining portion of the upper surface of the current blocking unit 130 and on the through-hole 131. On the other hand, the opening of the transparent electrode 140 may have a shape corresponding to the shape of the through-hole 131. For example, when the through-hole 131 has a circular shape in a plan view, the opening of the transparent electrode 140 may also have a circular shape corresponding thereto and may have a greater diameter than the through-hole 131.
- [51] In addition, the transparent electrode 140 may include a first transparent electrode 141 and a second transparent electrode 143 disposed on the first transparent electrode 141. The second transparent electrode 143 may have a smaller area than the first transparent electrode 141 and may be placed within an outer contour of the first transparent electrode 141. With this structure, some area of the first transparent electrode 141 may be exposed instead of being covered by the second transparent electrode 143. For example, as shown in the drawings, the upper surface of the first

transparent electrode 141 may be partially exposed around an outer periphery of the first transparent electrode 141, and a step may be created between such an exposed portion of the upper surface of the first transparent electrode 141 and the outer side surface of the second transparent electrode 143.

- [52] On a side surface of the opening of the transparent electrode 140 disposed on the through-hole 131, a side surface of the first transparent electrode 141 may be coplanar with a side surface of the second transparent electrode 143. Accordingly, the side surfaces of the first and second transparent electrodes 141 and 143 disposed on the side surface of the opening may adjoin the second electrode 160 on the same plane. However, it should be understood that the disclosed technology is not limited thereto and a step can be formed between the upper surface of the first transparent electrode 141 and the side surface of the second transparent electrode 143 on the side surface of the opening.
- [53] The transparent electrode 140 may be formed on a side surface 130s of the current blocking unit 130 and have a step coverage shape corresponding to the side surface 130s and the upper surface of the current blocking unit 130. As the transparent electrode 140 includes the first and second transparent electrodes 141 and 143, the transparent electrode can provide excellent step coverage on the side surface 130s of the current blocking unit 130. This structure will be described in more detail below.
- [54] The first transparent electrode 141 and the second transparent electrode 143 may include a light transmitting and electrically conductive material, and may include at least one of conductive oxides, for example, ITO, ZnO, IZO, IZTO, IAZO, AZO, or GZO and the like, and light transmitting metals such as Ni/Au. The transparent electrode 140 may have a total thickness from about 300 Å to about 500 Å, and the first and second transparent electrodes 141 and 143 may have substantially the same thickness. For example, each of the first and second transparent electrodes 141 and 143 may have a thickness of about 200 Å or less. Within this thickness range, the transparent electrode 140 can exhibit excellent optical characteristics.
- [55] Further, the first transparent electrode 141 and the second transparent electrode 143 may include the same material and may be formed by the same process. For example, both the first transparent electrode 141 and the second transparent electrode 143 may be formed of or include ITO and may be deposited on the second conductive-type semiconductor layer 125 by sputtering. Further, each of the first transparent electrode 141 and the second transparent electrode 143 may be formed at a desired location through deposition and lift-off.
- [56] Further, the transparent electrode 140 may form ohmic contact with the second conductive-type semiconductor layer 125, and the second electrode 160 may form Schottky contact with the second conductive-type semiconductor layer 125. Ac-

cordingly, contact resistance between the second electrode 160 and the second conductive-type semiconductor layer 125 may be higher than the contact resistance between the transparent electrode 140 and the second conductive-type semiconductor layer 125, and thus electric current is likely to flow to the transparent electrode layer 140 having low resistance when supplied through the second electrode 160. As a result, the electric current can be effectively spread in the horizontal direction by the transparent electrode layer 140.

[57] On the other hand, although the transparent electrode 140 is illustrated as including the first and second transparent electrodes 141 and 143 in this embodiment, it should be understood that the disclosed technology is not limited thereto and the light emitting diode may include three or more transparent electrode layers in some exemplary embodiments of the disclosed technology.

[58] The first electrode 150 may be disposed on the first conductive-type semiconductor layer 121. As shown in the drawings, the first electrode 150 may be disposed on the exposed region of the upper surface of the first conductive-type semiconductor layer 121 from which the second conductive-type semiconductor layer 125 and the active layer 123 are partially removed. On the other hand, the position of the first electrode 150 is not limited thereto and may vary depending upon the shape of the light emitting diode. In addition, the first electrode 150 may include a first electrode pad and a first electrode extension.

[59] The first electrode 150 may serve to supply external power to the first conductive-type semiconductor layer 121 and may include a metallic material such as Ti, Pt, Au, Cr, Ni, or Al, and the like. Further, the first electrode 150 may be composed of or include a single layer or multiple layers.

[60] The second electrode 160 is disposed on the second conductive-type semiconductor layer 125 on a region in which the current blocking layer 130 is placed. Thus, a portion of the transparent electrode 140 may be disposed between the second electrode 160 and the current blocking layer 130. Furthermore, the second electrode 160 may contact a portion of the second conductive-type semiconductor layer 125 through the through-hole 131 of the current blocking layer 130. Here, the second electrode 160 and the second conductive-type semiconductor layer 125 can provide Schottky contact.

[61] The second electrode 160 may include the second electrode pad 161 and a second electrode extension 163, which extends from the second electrode pad 161 and serves to provide uniform current spreading in the horizontal direction.

[62] On the other hand, a portion of the second electrode 160, for example, the second electrode pad 161, may be disposed on the through-hole 131 of the current blocking layer 130 and may contact a portion of the upper surface of the second conductive-type semiconductor layer 125 through the through-hole 131. Further, the second electrode

pad 161 may adjoin the side surfaces of the first and second transparent electrodes 141 and 143 to form ohmic contact therewith. Electric current supplied through the second electrode pad 161 can be effectively spread in the horizontal direction through the first and second transparent electrodes 141 and 143.

- [63] An upper surface profile of the second electrode pad 161 may correspond to a lower surface profile of a region on which the second electrode pad is formed. For example, as shown in the drawings, the upper surface of the second electrode pad 161 may have a surface profile defined by the upper surface of the transparent electrode layer 140, the upper surface of the current blocking unit 130 and the upper surface of the second conductive-type semiconductor layer 125 at the location at which the second electrode pad is formed. Accordingly, the second electrode 163 may include a recess 161a formed on the upper surface thereof, in which the recess 161a is placed in a corresponding region to the location of the through-hole 131.
- [64] As the upper surface of the second electrode pad 161 has a non-planar surface profile, adhesion between a wire and the second electrode pad 161 can be enhanced when the upper surface of the second electrode pad 161 is subjected to wire bonding. Accordingly, it is possible to effectively prevent disconnection between the wire and the second electrode 163. Furthermore, since a portion of the transparent electrode 140 is fitted between the current blocking unit 130 and the second electrode pad 161, the transparent electrode 140 is further stably disposed, thereby preventing delamination of the transparent electrode 140. Thus, structural stability between the second electrode pad 161, the current blocking unit 130 and the transparent electrode 140 can be improved.
- [65] The second electrode may include a plurality of second electrode extensions 163, for example, a plurality of second electrode extensions extending in different or opposite directions, as shown in Figure 1. The second electrode extensions 163 may be formed in a shape of enclosing or surrounding the first electrode 150.
- [66] The second electrode 160 may include a conductive material, for example, a metallic material such as Ti, Pt, Au, Cr, Ni, Al, or Mg, and the like, and may be composed of a single layer or multiple layers. When the second electrode 160 is composed of multiple layers, the second electrode 160 may include at least one metal stack structure of Ti/Au layers, Ti/Pt/Au layers, Cr/Au layers, Cr/Pt/Au layers, Ni/Au layers, Ni/Pt/Au layers, or Cr/Al/Cr/Ni/Au layers.
- [67] As such, the transparent electrode 140 includes the first and second transparent electrodes 141 and 143, thereby providing excellent step coverage on the side surface 130s of the current blocking unit 130. For example, if the transparent electrode 140 is generally formed on the inclined side surface 130s of the current blocking unit 130 as described above, the transparent electrode 140 can be disconnected at this portion due

to poor step coverage thereof. However, according to the exemplary embodiments of the disclosed technology, the transparent electrode 140 has a dual structure of the first transparent electrode 141 and the second transparent electrode 143, in which the second transparent electrode 143 is formed on the first transparent electrode 141 using the same process and the same material as those of the first transparent electrode 141 and exhibit better step coverage on the inclined side surface than the first transparent electrode 141. Thus, even in the case where the first transparent electrode 141 has poor step coverage on the side surface 130s of the current blocking unit, the second transparent electrode 143 may be formed to a sufficiently thick thickness on the side surface 130s of the current blocking unit. Accordingly, the overall transparent electrode 140 may have enhanced step coverage on the side surface 130s of the current blocking unit. Thus, it is possible to prevent electrostatic discharge or increase in forward voltage of the light emitting diode due to deterioration in step coverage of the transparent electrode.

[68] Further, since both the first transparent electrode 141 and the second transparent electrode 143 are formed by sputtering, deposition can be performed at a relatively low temperature. Thus, in formation of the transparent electrode 140, a photoresist including a polymer applicable to a low temperature process can be used. When the transparent electrode is formed by e-beam evaporation, which is performed at a relatively high temperature, a metallic photoresist is used, thereby causing a problem of damage to the transparent electrode in the course of removing the photoresist. However, according to the exemplary embodiments of the disclosed technology, both the first transparent electrode 141 and the second transparent electrode 143 are deposited by sputtering using a photoresist applicable to a low temperature process, thereby preventing damage to the transparent electrode in the course of removing the photoresist.

[69] Furthermore, according to some exemplary embodiments of the disclosed technology, the transparent electrode 140 including the first and second transparent electrodes 141 and 143 may be formed through multi-deposition without patterning the transparent electrode, thereby preventing deterioration in reliability of the light emitting diode due to damage to the transparent electrode or the semiconductor layers in the process of patterning the transparent electrode.

[70] In this embodiment, the light emitting diode has the lateral structure. However, it should be understood that the disclosed technology is not limited thereto and other implementations are also possible. For example, the insulation layer 150 may also be applied to a vertical type or flip-chip type light emitting diode, and this structure is also within the scope of the disclosed technology.

[71] Next, light emitting diodes according to various exemplary embodiments of the

disclosed technology will be described with reference to Figure 3 to Figure 11b. In descriptions of the following embodiments, substantially the same components as those of the embodiments shown in Figure 1 to Figure 2b are indicated by the same reference numeral, and repeated descriptions thereof will be omitted.

- [72] Figure 3 is a plan view of a light emitting diode according to another exemplary embodiment of the disclosed technology.
- [73] Referring to Figure 3, a light emitting diode 100a includes a first conductive-type semiconductor layer 121, an active layer 123, a second conductive-type semiconductor layer 125, a current blocking unit 130, a transparent electrode 140, and a second electrode 160. The light emitting diode 100a may further include a substrate 110 and a first electrode 150. Unlike the light emitting diode according to the embodiment of Figure 1 to Figure 2b, the first electrode 150 of the light emitting diode 100a according to this embodiment includes a first electrode pad 151 and a first electrode extension 153. Now, the light emitting diode according to this embodiment will be described with a focus on such difference.
- [74] The first electrode 150 includes the first electrode pad 151 and the first electrode extension 153 extending from the first electrode pad 151. The second electrode 160 includes a second electrode pad 161 and a second electrode extension 163 extending from the second electrode pad 161. A sectional view taken along line B-B of Figure 3 is similar to Figure 2a and thus is omitted.
- [75] The light emitting diode 100a according to this embodiment has a substantially rectangular shape, one side of which has a greater length than the other side thereof. Thus, the light emitting diode 100a may be applied to products, such as backlight units, which require a slim light emitting diode.
- [76] The first electrode 150 and the second electrode 160 are disposed in a generally point symmetrical arrangement. That is, the first electrode pad 151 and the second electrode pad 161 are disposed at opposite sides, the first electrode extension 153 is disposed along one side of the light emitting diode 100a, and the second electrode extension 163 is disposed along the other side of the light emitting diode 100a.
- [77] With such arrangement of the first electrode 150 and the second electrode 160 as shown in Figure 3, the light emitting diode 100a allows uniform current spreading in the horizontal direction.
- [78] In this embodiment, the first conductive-type semiconductor layer 121, the active layer 123, the second conductive-type semiconductor layer 125, the current blocking unit 130, the transparent electrode 140, and the substrate 110 are generally similar to those of the light emitting diode described above with reference to Figure 1 to Figure 2b, and detailed descriptions thereof are omitted.
- [79] Figure 4 to Figure 5b are a plan view and sectional views of a light emitting diode

according to a further exemplary embodiment of the disclosed technology. Figure 5a is a sectional view taken along line C-C of Figure 4 and Figure 5b is a sectional view taken along line C'-C' of Figure 4.

- [80] Referring to Figure 4 to Figure 5b, a light emitting diode 100b according to this embodiment includes a first conductive-type semiconductor layer 121, an active layer 123, a second conductive-type semiconductor layer 125, a current blocking unit 130, a transparent electrode 140, and a second electrode 160. The light emitting diode 100b may further include a substrate 110 and a first electrode 150. Unlike the light emitting diode according to the embodiment of Figure 1 to Figure 2b, the light emitting diode 100b includes a plurality of first electrodes 150 and a plurality of second electrodes 160. Now, the light emitting diode according to this embodiment will be described with a focus on such difference.
- [81] The light emitting diode 100b according to this embodiment has a rectangular shape, for example, a substantially square shape.
- [82] The light emitting diode 100b may include the plurality of first electrodes 150, which are disposed at two corners adjacent one side of the light emitting diode 100b, respectively. The light emitting diode 100b may include the plurality of second electrodes 160, each of which includes a second electrode pad 161 and a second electrode extension 163. The second electrode pads 161 are disposed adjacent the other side of the light emitting diode 100b and each of the second electrode extensions 163 may extend from the second electrode pad 161 towards the one side of the light emitting diode 100a.
- [83] With such arrangement of the first electrodes 150 and the second electrodes 160 as shown in Figure 4, the light emitting diode 100b allows uniform current spreading in the horizontal direction.
- [84] In this embodiment, the first conductive-type semiconductor layer 121, the active layer 123, the second conductive-type semiconductor layer 125, the current blocking unit 130, the transparent electrode 140, and the substrate 110 are generally similar to those of the light emitting diode described above with reference to Figure 1 to Figure 2b, and detailed descriptions thereof are omitted.
- [85] Figure 6 to Figure 7b are a plan view and sectional views of a light emitting diode according to yet another exemplary embodiment of the disclosed technology. Figure 7a is a sectional view taken along line D-D of Figure 6 and Figure 7b is a sectional view taken along line D'-D' of Figure 6.
- [86] Referring to Figure 6 to Figure 7b, a light emitting diode 100c according to this embodiment includes a first conductive-type semiconductor layer 121, an active layer 123, a second conductive-type semiconductor layer 125, a current blocking unit 130, a transparent electrode 140, and a second electrode 160. The light emitting diode 100c

may further include a substrate 110 and a first electrode 150. Unlike the light emitting diode according to the embodiment of Figure 1 to Figure 2b, the light emitting diode 100c according to this embodiment includes a plurality of first electrodes 150 and a plurality of second electrodes 160, in which the first electrodes 150 include first electrode pads 151 and first electrode extensions 153. Now, the light emitting diode according to this embodiment will be described with a focus on such difference.

[87] The light emitting diode 100c according to this embodiment has a rectangular shape, for example, a substantially square shape.

[88] The first electrodes 150 may include a plurality of first electrode pads 151 and a plurality of first electrode extensions 153. The first electrode pads 151 may be disposed adjacent one side of the light emitting diode 100c and each of the first electrode pads 151 may include first electrode extensions 153 extending in three directions. For each of the first electrode pads 151, one first electrode extension 153 extends towards the other side of the light emitting diode 100c and two first electrode extensions 153 include a portion extending perpendicular to the extending direction of the one first electrode extension 153 and another portion bent from the portion and extending to the other side of the light emitting diode 100c. Here, one of the first electrode extensions 153 extending from one first electrode pad 151 may merge with the first electrode extension 153 extending from another first electrode pad 151 and extend together to the other side of the light emitting diode 100c. Further, each of the first electrode extensions 153 may include a bent portion at a portion at which the first electrode extension 153 is placed adjacent the second electrode pad 161 in order to maintain a predetermined distance from the second electrode pad 161.

[89] The second electrodes 160 may include a plurality of second electrode pads 161 and a plurality of second electrode extensions 163. The second electrode pad 161 may be disposed adjacent the other side of the light emitting diode 100c, and each of the second electrode pads 161 may include second electrode extensions 163 extending in three directions. For each of the second electrode pads 161, one second electrode extension 163 extends towards the other side of the light emitting diode 100c and two second electrode extensions 163 include a portion extending perpendicular to the extending direction of the one second electrode extension 163 and another portion bent from the portion and extending to the other side of the light emitting diode 100c. Further, each of the second electrode extensions 163 may include a bent portion at a portion at which the second electrode extension 163 is placed adjacent the first electrode pad 151 in order to maintain a predetermined distance from the first electrode pad 151.

[90] The first electrode extensions 153 and the second electrode extensions 163 extend from opposite sides of the light emitting diode 100c and are formed in a shape of inter-

digitating with each other.

- [91] With such arrangement of the first electrodes 150 and the second electrodes 160 as shown in Figure 6, the light emitting diode 100c allows uniform current spreading in the horizontal direction. For example, the arrangement of the first electrodes 150 and the second electrodes 160 according to this embodiment can provide uniform current spreading in the horizontal direction in the light emitting diode.
- [92] In this embodiment, the first conductive-type semiconductor layer 121, the active layer 123, the second conductive-type semiconductor layer 125, the current blocking unit 130, the transparent electrode 140, and the substrate 110 are generally similar to those of the light emitting diode described above with reference to Figure 1 to Figure 2b, and detailed descriptions thereof are omitted.
- [93] Figure 8 to Figure 9b are a plan view and sectional views of a light emitting diode according to yet another exemplary embodiment of the disclosed technology. Figure 9a is a sectional view taken along line E-E of Figure 8 and Figure 9b is a sectional view taken along line E'-E' of Figure 8.
- [94] Referring to Figure 8 to Figure 9b, a light emitting diode 100d according to this embodiment includes a first conductive-type semiconductor layer 121, an active layer 123, a second conductive-type semiconductor layer 125, a current blocking unit 130, a transparent electrode 140, and a second electrode 160. The light emitting diode 100d may further include a substrate 110 and a first electrode 150. Unlike the light emitting diode according to the embodiment of Figure 1 to Figure 2b, the light emitting diode 100d according to this embodiment includes a plurality of first electrodes 150, a plurality of second electrodes 160, and a plurality of mesas M. Now, the light emitting diode according to this embodiment will be described with a focus on such difference.
- [95] The light emitting diode 100d according to this embodiment has a rectangular shape. In addition, the light emitting diode 100d may include the plurality of mesas M, each of which includes the second conductive-type semiconductor layer 125 and the active layer 123. An upper surface of the first conductive-type semiconductor layer 121 may be partially exposed around the mesas M. The plurality of mesas M may extend in the same direction to have an elongated shape, without being limited thereto.
- [96] The light emitting diode 100d may include the plurality of first electrodes 150, which may be disposed at two corners near one side of the light emitting diode 100d and at or around the middle between the two corners, respectively. The mesas M may include chamfered portions at corners thereof so as to correspond to the regions in which the first electrodes 150 are formed.
- [97] The light emitting diode 100d may include the plurality of second electrodes 160, each of which includes a second electrode pad 161 and a second electrode extension 163. Each of the second electrode pads 161 may be disposed on the corresponding

mesa M and the second electrode extension 163 may extend from the second electrode pad 161 to opposite sides of the light emitting diode 100d.

[98] With such arrangement of the first electrodes 150 and the second electrodes 160 as shown in Figure 8, the light emitting diode 100d allows uniform current spreading in the horizontal direction. For example, since a light emitting area is divided into the plurality of mesas M, electric current can be uniformly spread in each of the mesas M, thereby improving luminous efficacy of the light emitting diode 100d.

[99] In this embodiment, the first conductive-type semiconductor layer 121, the active layer 123, the second conductive-type semiconductor layer 125, the current blocking unit 130, the transparent electrode 140, and the substrate 110 are generally similar to those of the light emitting diode described above with reference to Figure 1 to Figure 2b, and detailed descriptions thereof are omitted.

[100] Figure 10 to Figure 11b are a plan view and sectional views of a light emitting diode according to yet another exemplary embodiment of the disclosed technology. Figure 11a is a sectional view taken along line F-F of Figure 10 and Figure 11b is a sectional view taken along line F'-F' of Figure 10.

[101] Referring to Figure 10 to Figure 11b, a light emitting diode 100e according to this embodiment includes a first conductive-type semiconductor layer 121, an active layer 123, a second conductive-type semiconductor layer 125, a current blocking unit 130, a transparent electrode 140, and a second electrode 160. The light emitting diode 100e may further include a substrate 110 and a first electrode 150. Unlike the light emitting diode according to the embodiment of Figure 1 to Figure 2b, the light emitting diode 100e according to this embodiment includes a plurality of first electrodes 150, a plurality of second electrodes 160, and a plurality of mesas M. Now, the light emitting diode according to this embodiment will be described with a focus on such difference.

[102] The light emitting diode 100e according to this embodiment has a rectangular shape. In addition, the light emitting diode 100e may include the plurality of mesas M, each of which includes the second conductive-type semiconductor layer 125 and the active layer 123. An upper surface of the first conductive-type semiconductor layer 121 may be partially exposed around the mesas M. The plurality of mesas M may extend in the same direction to have an elongated shape, without being limited thereto.

[103] The light emitting diode 100e may include the plurality of first electrodes 150, each of which includes a first electrode pad 151 and a first electrode extension 153. As shown in Figure 10, the first electrode pads 151 are disposed adjacent one side of the light emitting diode 100e and the first electrode extensions 153 may extend toward the other side of the light emitting diode 100e in the form of penetrating the mesas M.

[104] The light emitting diode 100e may include the plurality of second electrodes 160, each of which includes a second electrode pad 161 and a second electrode extension

163. Each of the second electrode pads 161 may be disposed on the corresponding mesa M and be adjacent the other side of the light emitting diode 100e. Two second electrode extensions 163 may extend from one second electrode pad 161 towards one side of the light emitting diode 100e and may be arranged to surround the first electrode extension 153. Accordingly, the first electrode extension 153 may be formed in the form of being fitted between the second electrode extensions 163.

[105] With such arrangement of the first electrodes 150 and the second electrodes 160 as shown in Figure 10, the light emitting diode 100e allows uniform current spreading in the horizontal direction. For example, since a light emitting area is divided into the plurality of mesas M, electric current can be uniformly spread in each of the mesas M, thereby improving luminous efficacy of the light emitting diode 100e.

[106] In this embodiment, the first conductive-type semiconductor layer 121, the active layer 123, the second conductive-type semiconductor layer 125, the current blocking unit 130, the transparent electrode 140, and the substrate 110 are generally similar to those of the light emitting diode described above with reference to Figure 1 to Figure 2b, and detailed descriptions thereof are omitted.

[107] Although some exemplary embodiments have been described herein, it should be understood by those skilled in the art that these embodiments are given by way of illustration only, and that various modifications, variations, and alterations can be made without departing from the spirit and scope of the disclosed technology.

Claims

- [Claim 1] A light emitting diode comprising:
a first conductive-type semiconductor layer;
a second conductive-type semiconductor layer disposed over the first conductive-type semiconductor layer;
an active layer interposed between the first and second conductive-type semiconductor layers;
a current blocking unit disposed over one region of the second conductive-type semiconductor layer and including a through-hole formed in a thickness direction thereof;
a transparent electrode covering at least a portion of an upper surface of the second conductive-type semiconductor layer and the current blocking unit, and including an opening exposing the through-hole; and
a second electrode contacting the second conductive-type semiconductor layer through the through-hole and disposed over the current blocking unit,
wherein the transparent electrode includes a first transparent electrode and a second transparent electrode disposed over the first transparent electrode and having a smaller area than the first transparent electrode, and the second electrode forms an ohmic contact with side surfaces of the first and second transparent electrodes.
- [Claim 2] The light emitting diode of claim 1, wherein the second electrode is formed within a contour of the first transparent electrode, and the side surface of the first transparent electrode adjoining the second electrode is coplanar with the side surface of the second transparent electrode adjoining the second electrode.
- [Claim 3] The light emitting diode of claim 2, wherein an outermost contour of the second transparent electrode has a shape corresponding to an outermost contour of the first transparent electrode.
- [Claim 4] The light emitting diode of claim 3, including a step formed between an outermost side surface of the second transparent electrode and an upper surface of the first transparent electrode.
- [Claim 5] The light emitting diode of claim 1, wherein a portion of the transparent electrode is disposed between the second electrode and the current blocking unit.
- [Claim 6] The light emitting diode of claim 1, wherein the transparent electrode has a thickness from 300 Å to 500 Å.

- [Claim 7] The light emitting diode of claim 6, wherein the first and second transparent electrodes have the substantially same thickness.
- [Claim 8] The light emitting diode of claim 1, wherein each of the first and second transparent electrodes includes ITO (Indium tin oxide).
- [Claim 9] The light emitting diode of claim 5, wherein the current blocking unit has an inclined side surface.
- [Claim 10] The light emitting diode of claim 1, wherein the second electrode adjoins a portion of an upper surface of the current blocking unit.
- [Claim 11] The light emitting diode of claim 1, wherein an upper surface of the second electrode disposed over the through-hole has a surface profile corresponding to a profile of a lower surface of the second electrode.
- [Claim 12] The light emitting diode of claim 1, further including a first electrode disposed over the first conductive-type semiconductor layer.
- [Claim 13] The light emitting diode of claim 12, wherein the second electrode includes a second electrode pad and a second electrode extension extending from the second electrode pad, and
the second electrode pad adjoining the second conductive-type semiconductor layer through the through-hole of the current blocking unit.
- [Claim 14] The light emitting diode of claim 13, wherein the first electrode includes a first electrode pad and a first electrode extension extending from the first electrode pad.
- [Claim 15] The light emitting diode of claim 14, wherein the first and second electrodes include a plurality of first and second electrode extensions, respectively, and
the plurality of first electrode extensions and the plurality of second electrode extensions are formed in a shape of interdigitating with each other.
- [Claim 16] The light emitting diode of claim 1, wherein the second electrode forms a Schottky contact with the second conductive-type semiconductor layer.
- [Claim 17] A light emitting diode comprising:
a first conductive-type semiconductor layer;
a second conductive-type semiconductor layer disposed over the first conductive-type semiconductor layer;
an active layer interposed between the first and second conductive-type semiconductor layers;
a current blocking unit formed over the second conductive-type semiconductor layer and exposing a portion of the second conductive-type

semiconductor layer;

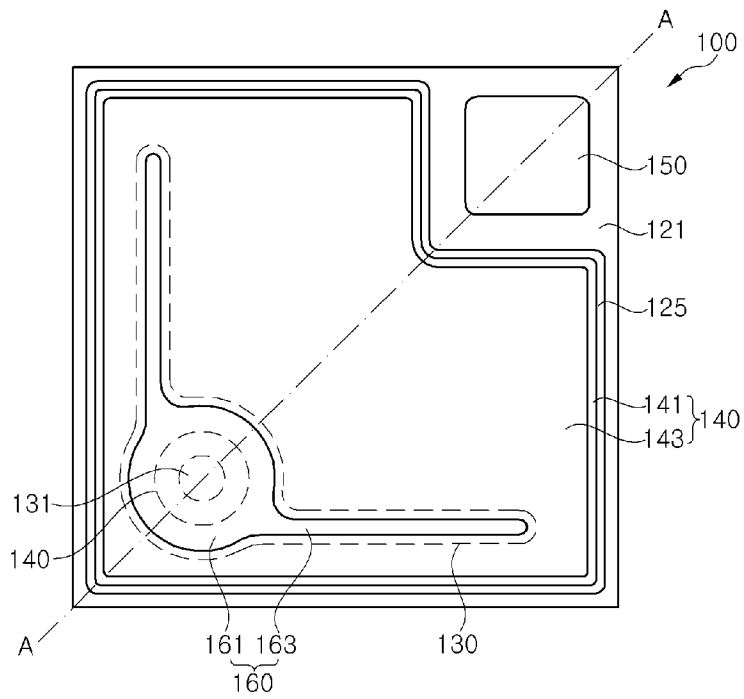
a transparent electrode formed over the second conductive-type semiconductor and a portion of the current blocking unit and exposing the portion of the second conductive-type semiconductor layer, wherein the transparent electrode has a double-layer structure exhibiting improved step coverage characteristics as compared to a transparent electrode having a single-layer structure.

[Claim 18] The light emitting diode of claim 1, wherein the transparent electrode includes a first transparent electrode and a second transparent electrode formed over the first transparent electrode.

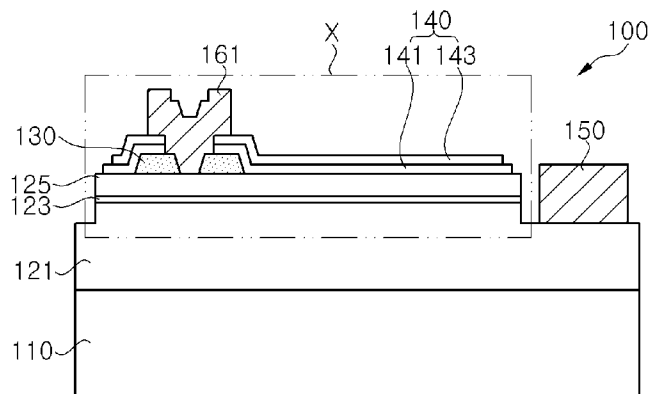
[Claim 19] The light emitting diode of claim 1, wherein the transparent electrode forms an ohmic contact with the second conductive-type semiconductor layer.

[Claim 20] The light emitting diode of claim 1, further comprising:
a first electrode formed over the first conductive-type semiconductor layer; and
a second electrode formed over the second conductive-type semiconductor layer around the current blocking unit.

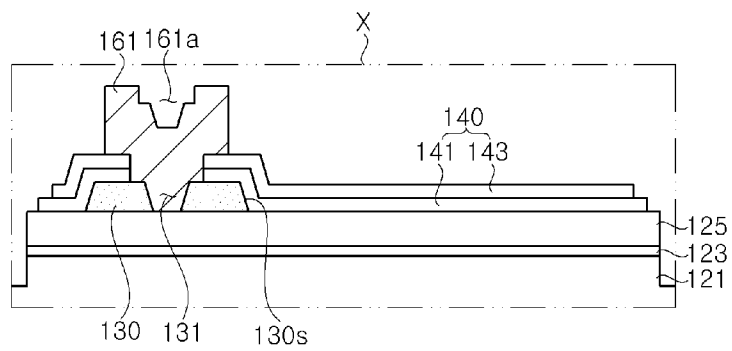
[Fig. 1]



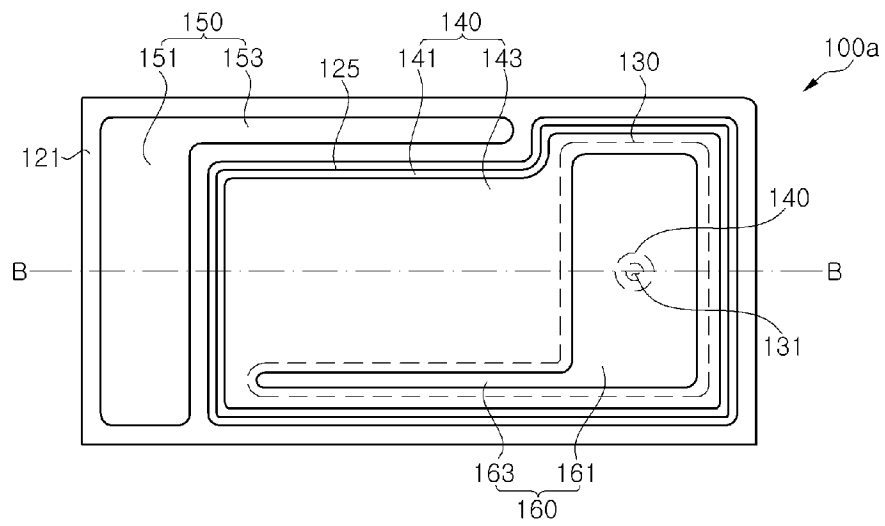
[Fig. 2a]



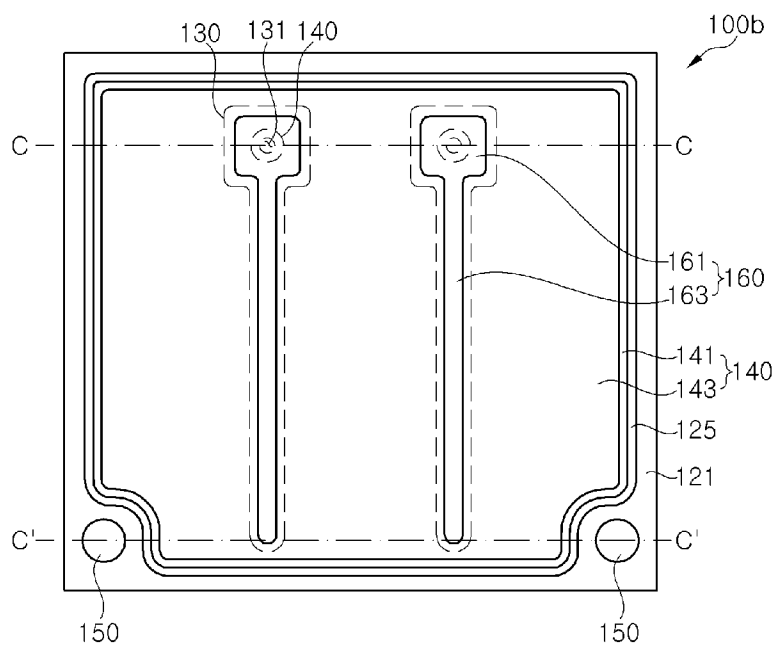
[Fig. 2b]



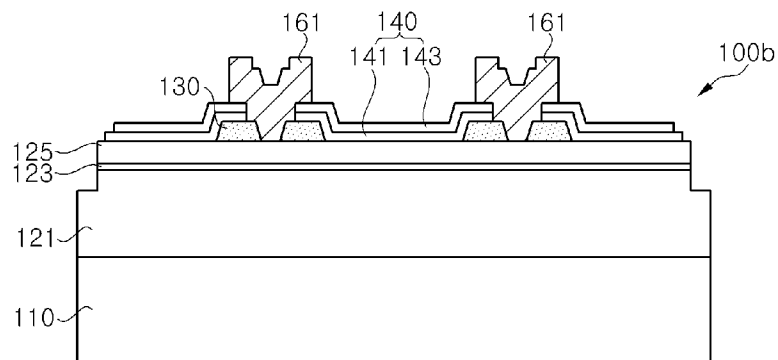
[Fig. 3]



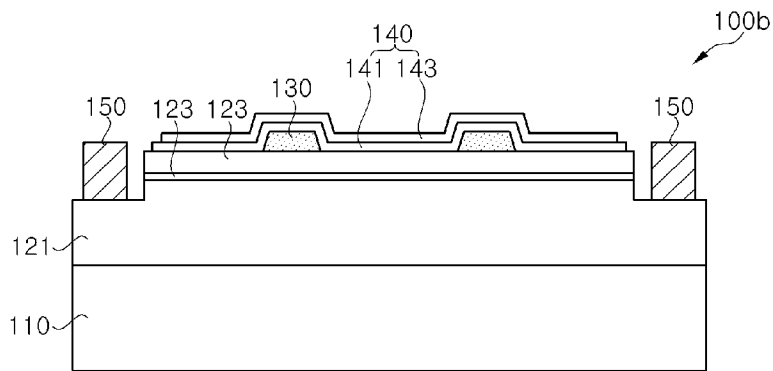
[Fig. 4]



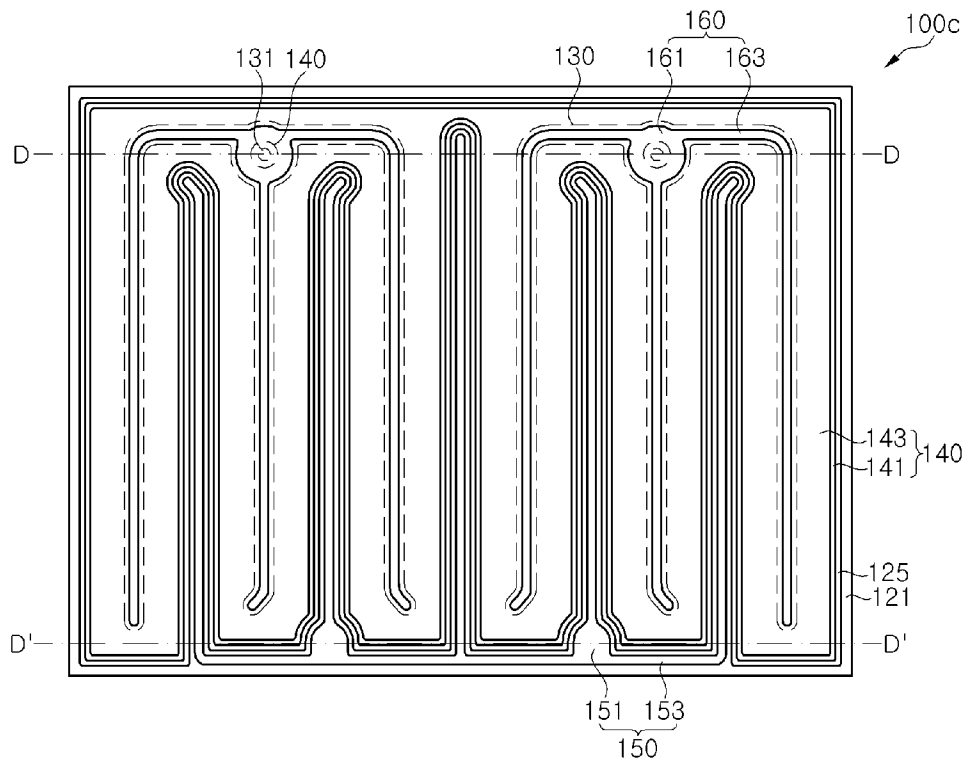
[Fig. 5a]



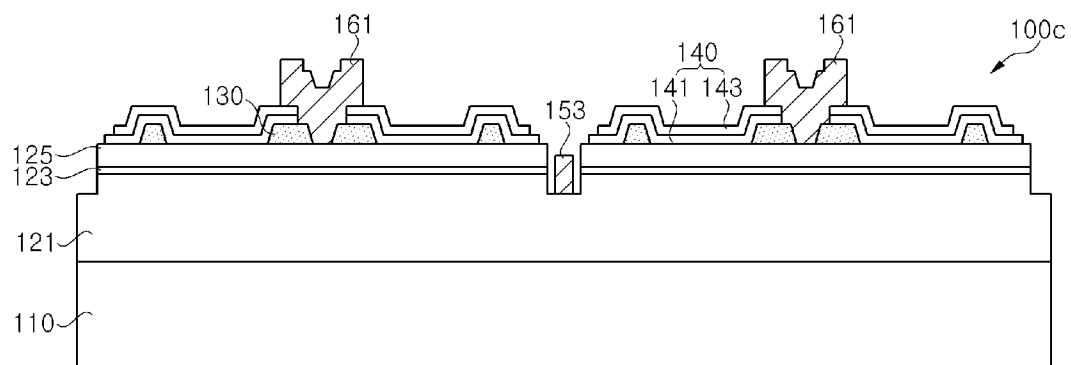
[Fig. 5b]



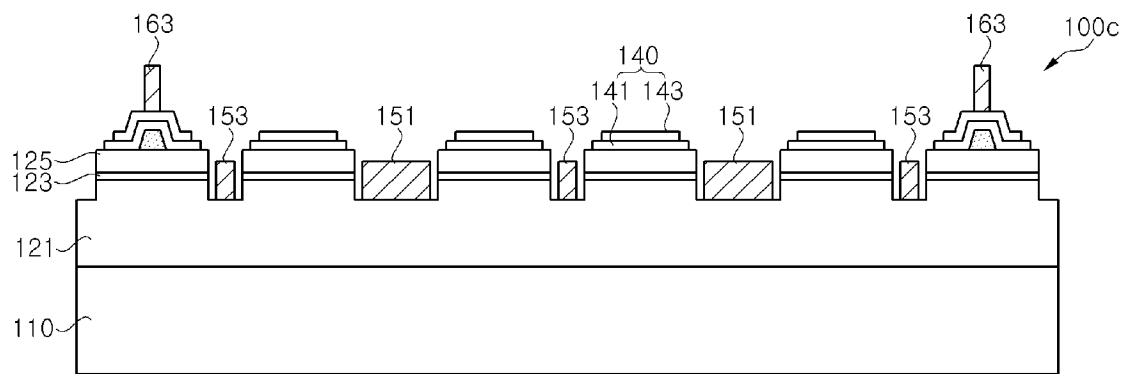
[Fig. 6]



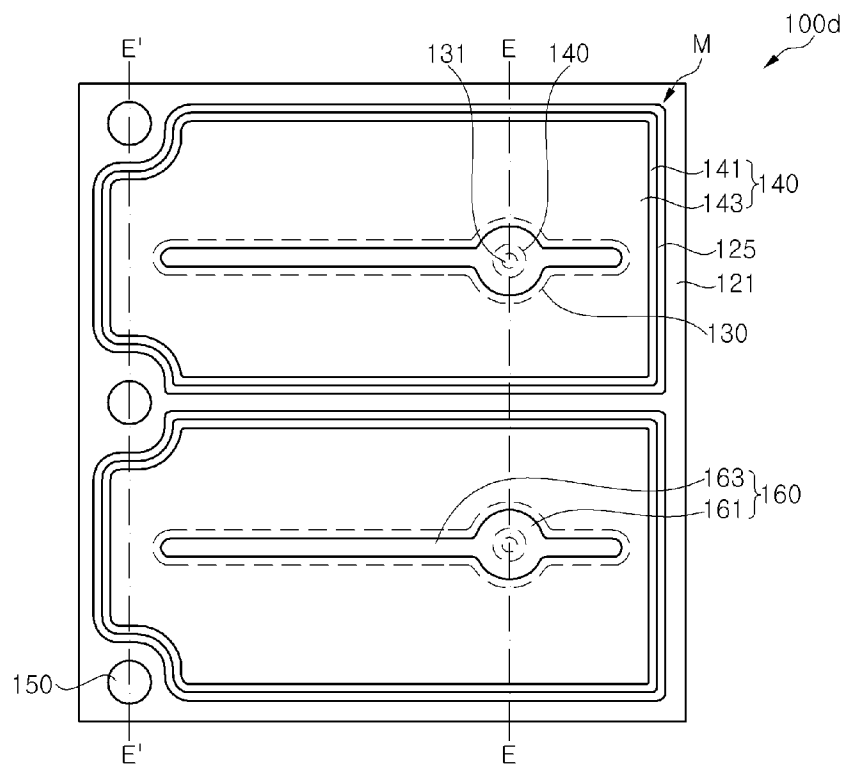
[Fig. 7a]



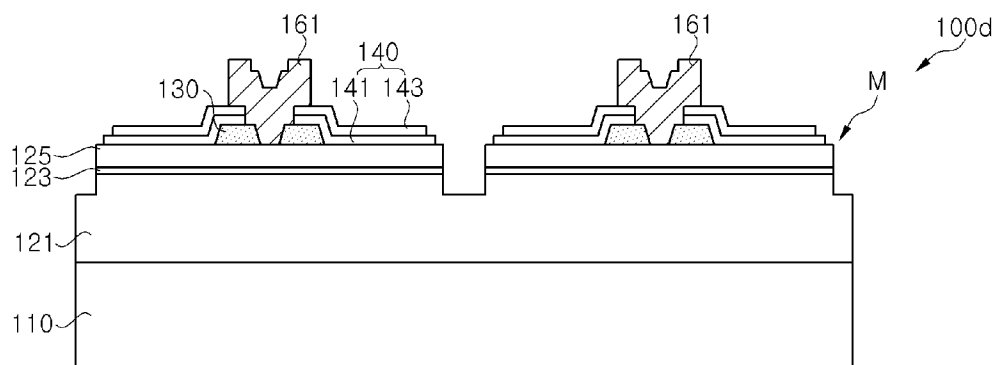
[Fig. 7b]



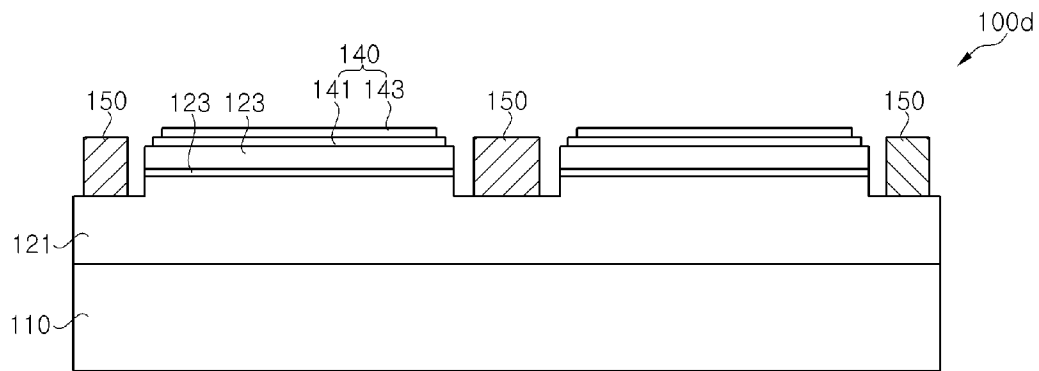
[Fig. 8]



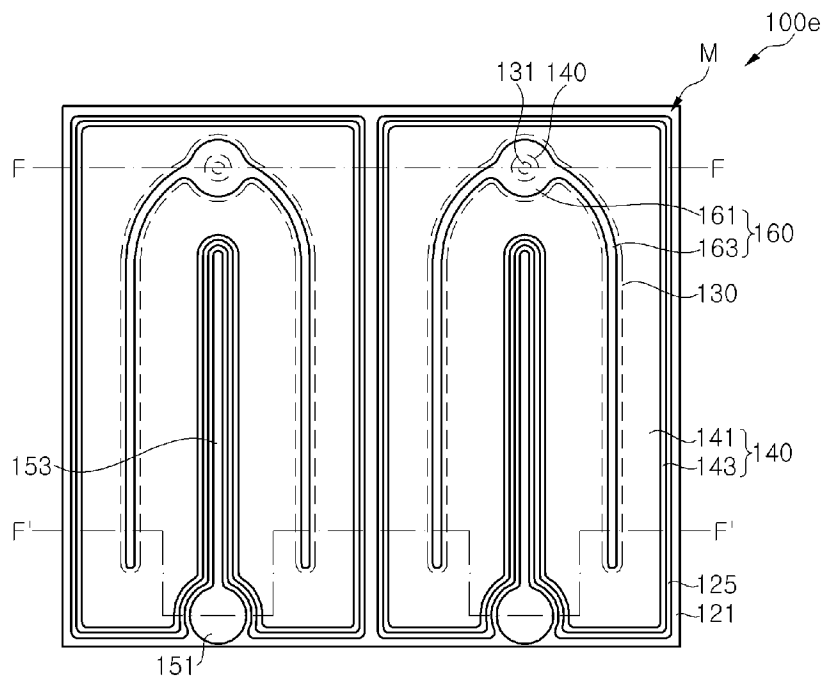
[Fig. 9a]



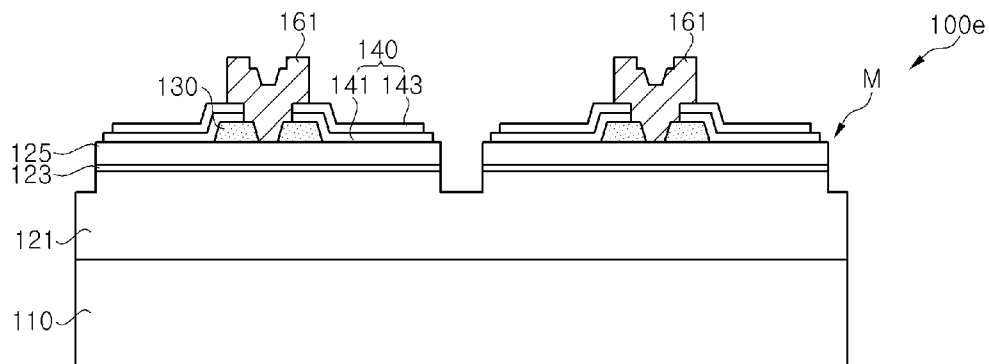
[Fig. 9b]



[Fig. 10]



[Fig. 11a]



A. CLASSIFICATION OF SUBJECT MATTER**H01L 33/42(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 33/42; H01L 33/36; H01L 33/00; H01L 33/14; H01J 1/63

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, transparent electrode, current blocking, through-hole

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2012-0037636 A (LG INNOTEK CO., LTD.) 20 April 2012 See abstract, paragraphs 17-38 and figure 1.	1-20
Y	US 2008-0241526 A1 (CHEN OU et al.) 02 October 2008 See abstract, paragraphs 6, 21-28, 40-42 and figures 1A, 4A-4B.	1-20
A	KR 10-2014-0086185 A (ILJIN-LED CO., LTD.) 08 July 2014 See abstract, paragraphs 14-27, claims 1-8 and figure 1.	1-20
A	JP 2005-183592 A (ROHM CO., LTD.) 07 July 2005 See paragraphs 18-20, 24-37 and figures 1-2.	1-20
A	KR 10-2008-0033721 A (SEOUL OPTO DEVICE CO., LTD.) 17 April 2008 See abstract, paragraphs 25-34, claims 1-6 and figure 1.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"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

22 January 2016 (22.01.2016)

Date of mailing of the international search report

25 January 2016 (25.01.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

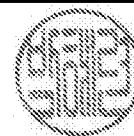
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2015/009068

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