



US 20120013827A1

(19) **United States**(12) **Patent Application Publication**
YOON(10) **Pub. No.: US 2012/0013827 A1**(43) **Pub. Date: Jan. 19, 2012**(54) **LIGHT EMITTING DIODE, METHOD OF
FABRICATING THE SAME, AND LIQUID
CRYSTAL DISPLAY INCLUDING THE SAME****Publication Classification**

(51) **Int. Cl.**
G02F 1/1335 (2006.01)
H01L 33/38 (2010.01)
H01L 33/08 (2010.01)
(52) **U.S. Cl.** **349/96**; 257/91; 438/34; 257/E33.066
(57) **ABSTRACT**

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Jul. 13, 2010 (KR) 10-2010-0067397

A light emitting diode includes a first grid layer on a substrate and made of a metal material; a p-n semiconductor multiple-layered film on the first grid layer; and a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material, wherein the first grid layer includes a base layer, and a plurality of first grid wires that protrudes from the base layer and are along a first direction, wherein the second grid layer includes a plurality of second grid wires along a second direction, and wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer.

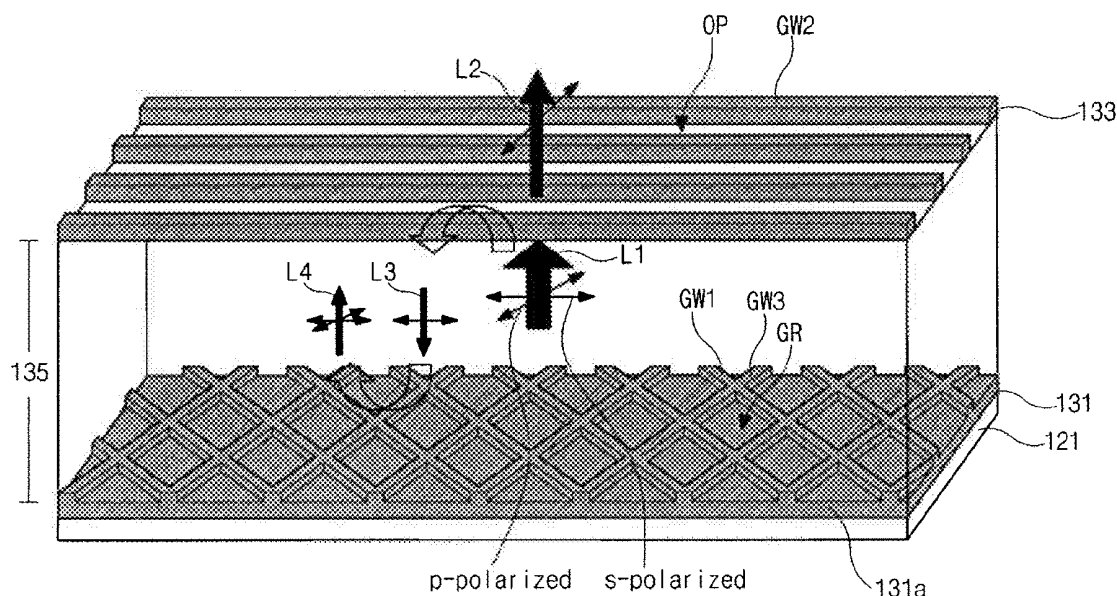


FIG. 1
RELATED ART

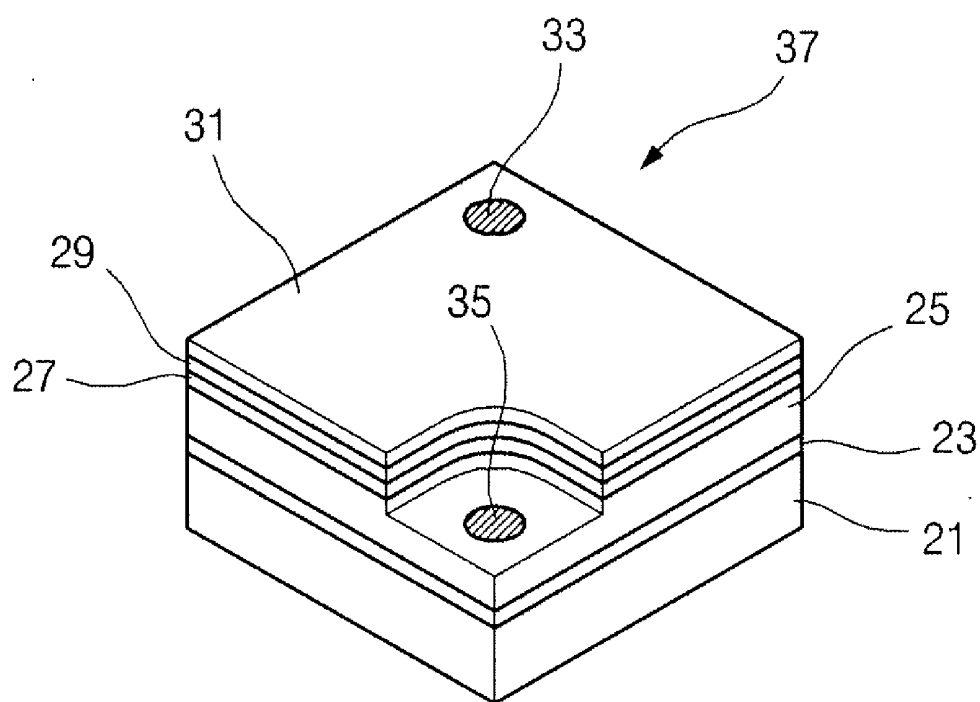


FIG. 2

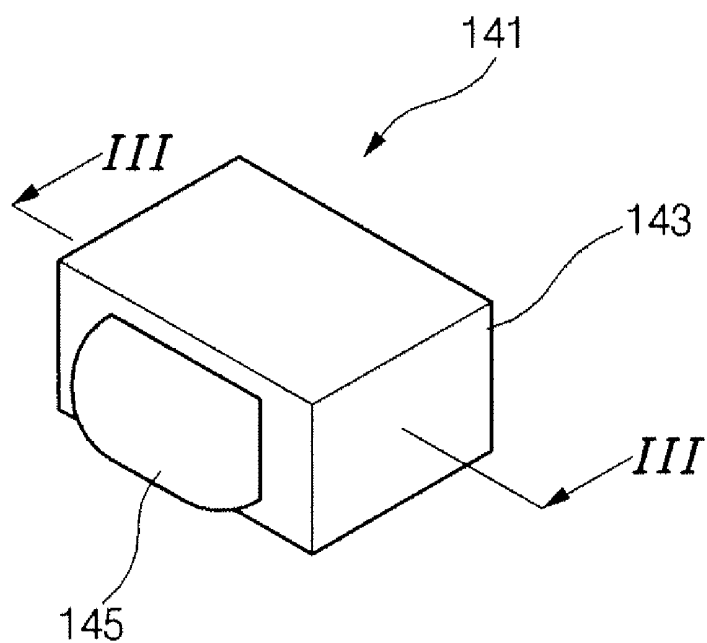


FIG. 3

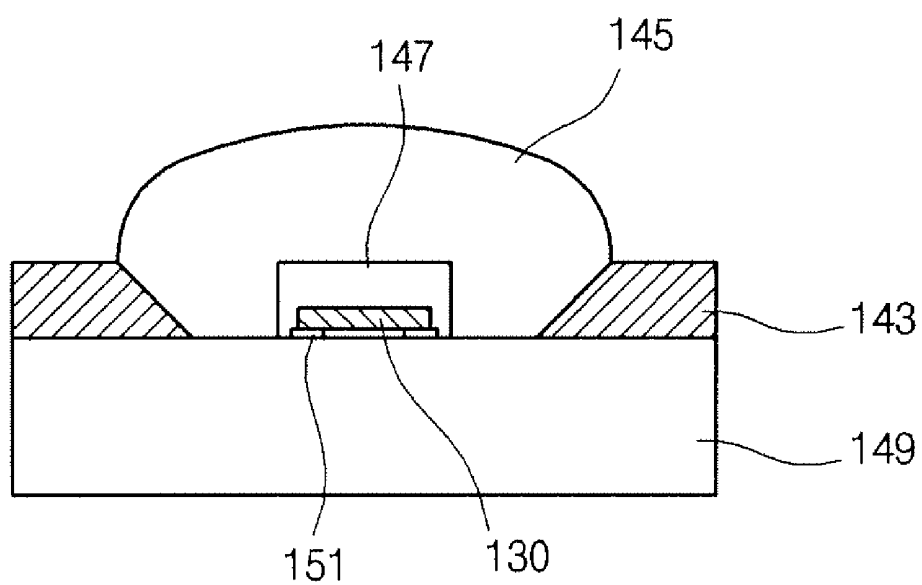


FIG. 4

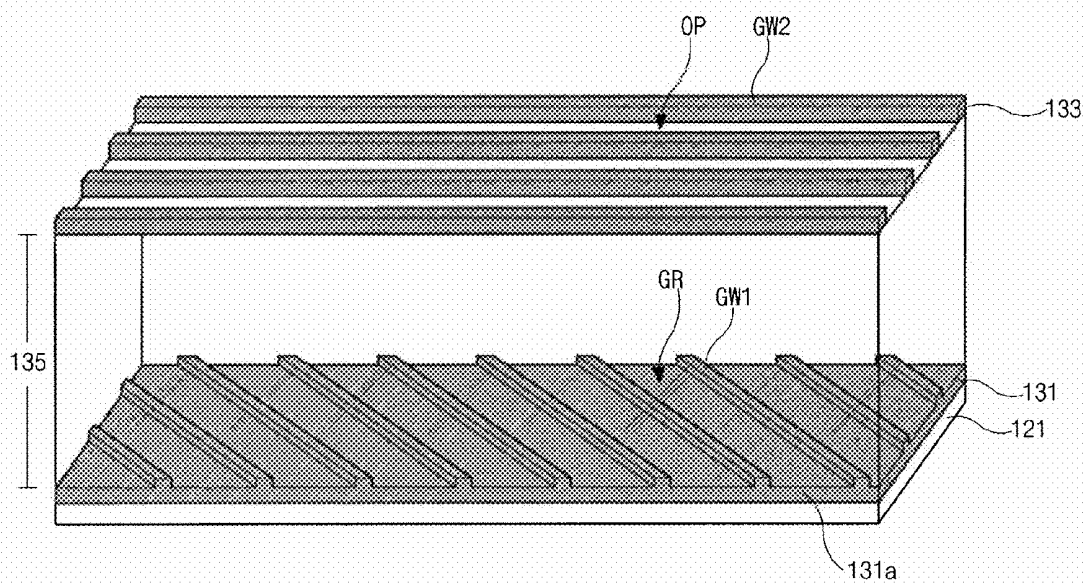
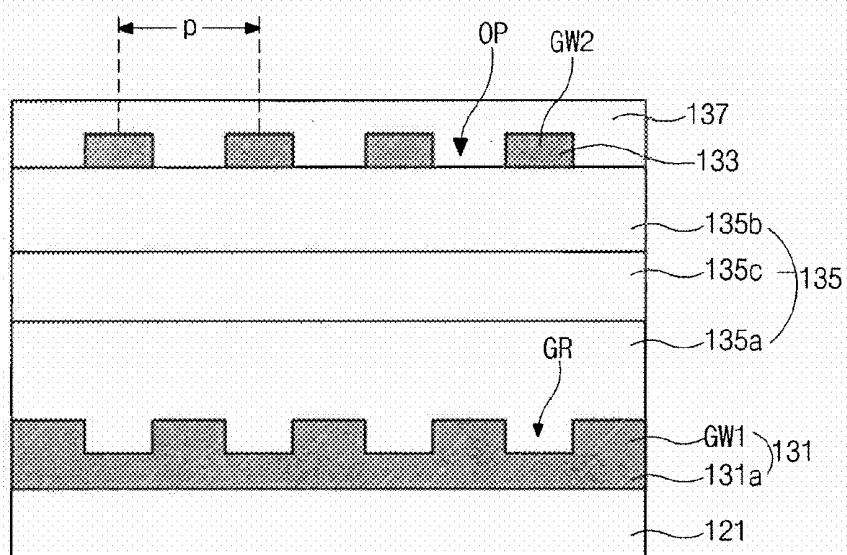


FIG. 5



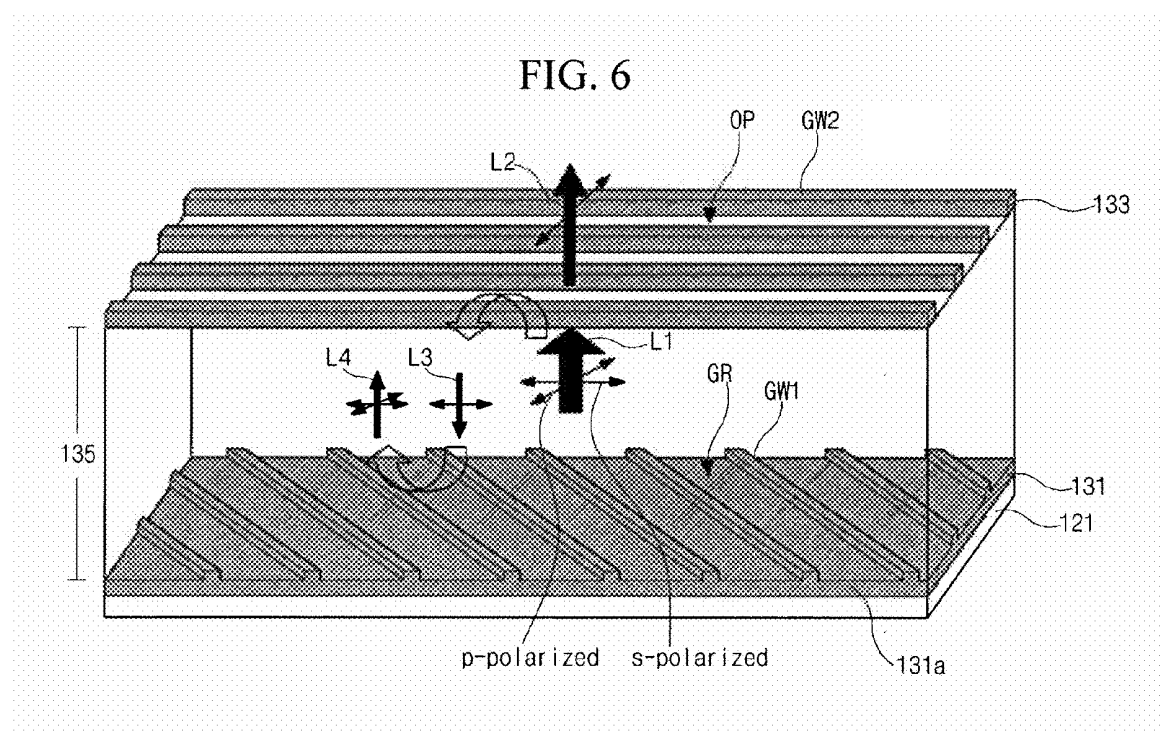


FIG. 7A

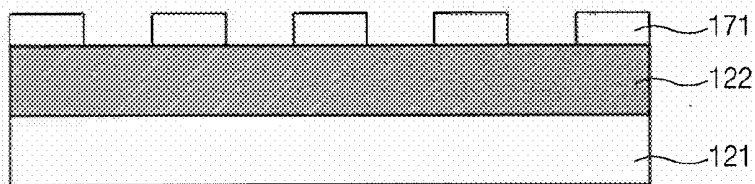


FIG. 7B

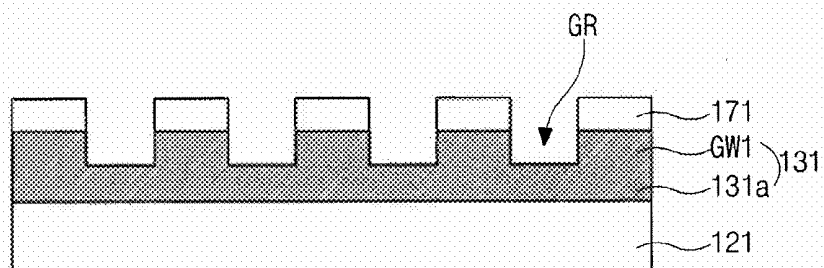


FIG. 7C

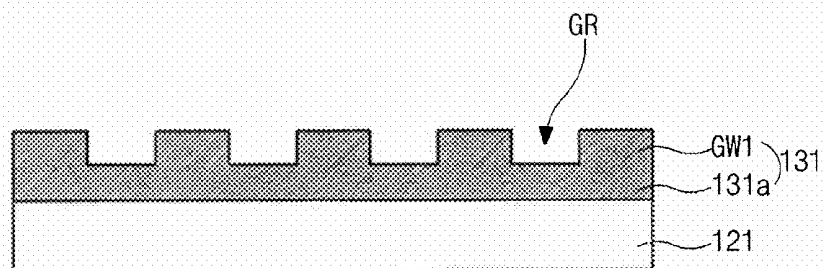


FIG. 7D

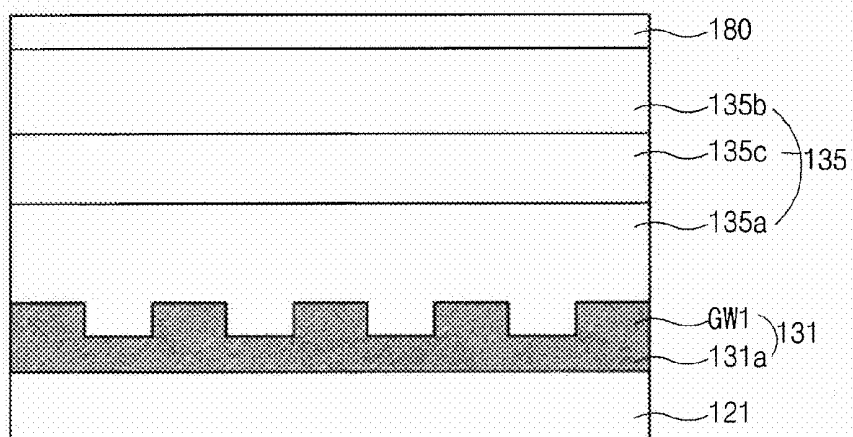


FIG. 7E

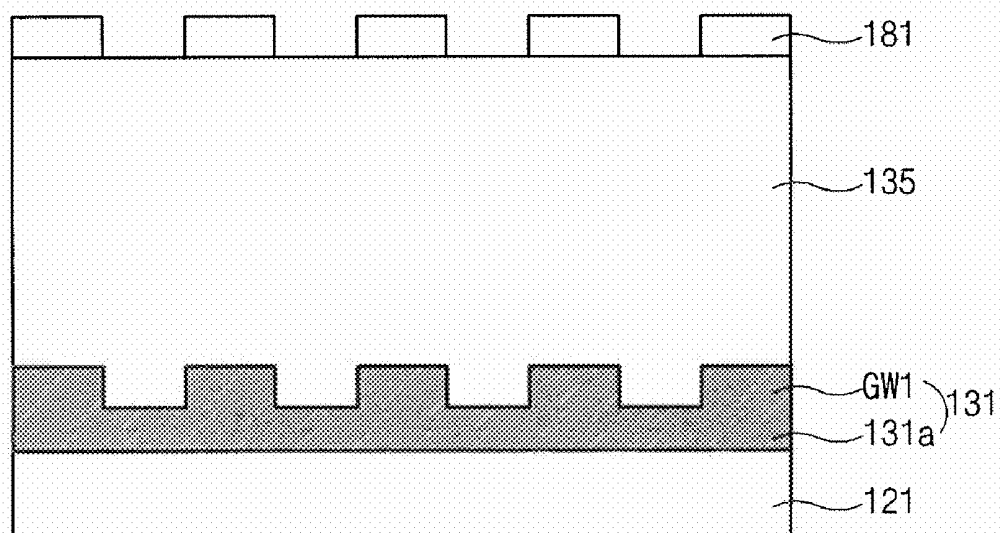


FIG. 7F

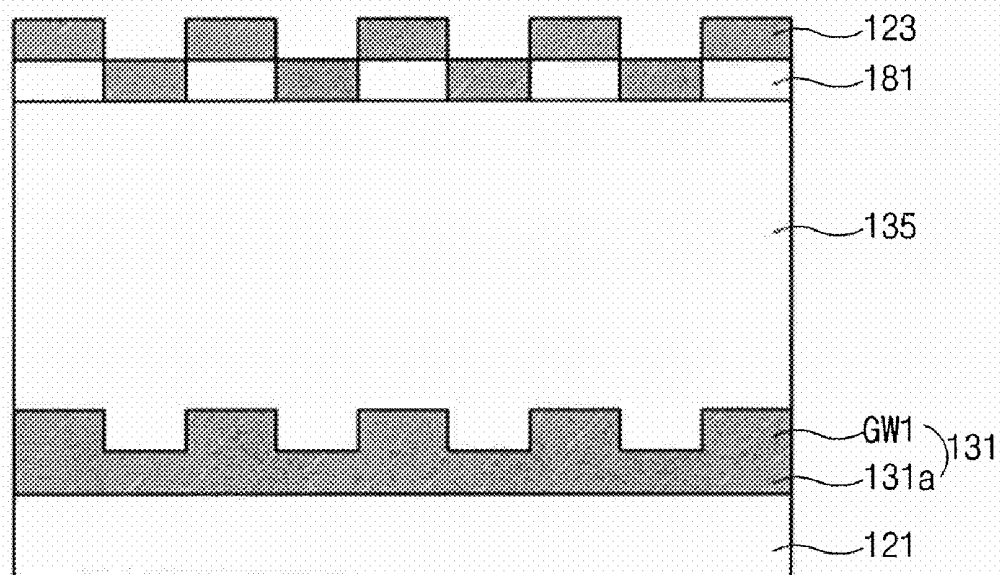


FIG. 7G

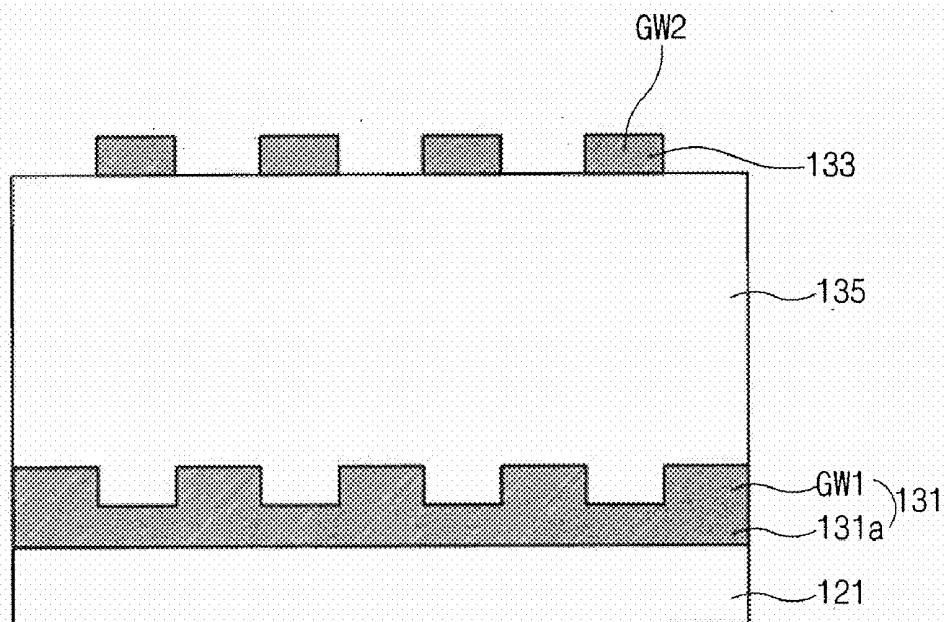


FIG. 7H

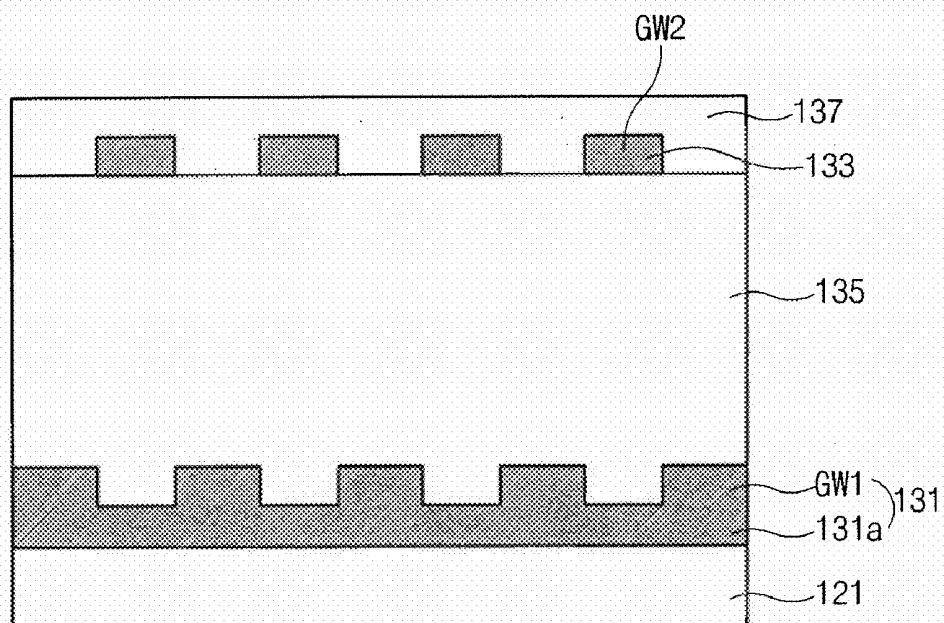


FIG. 8

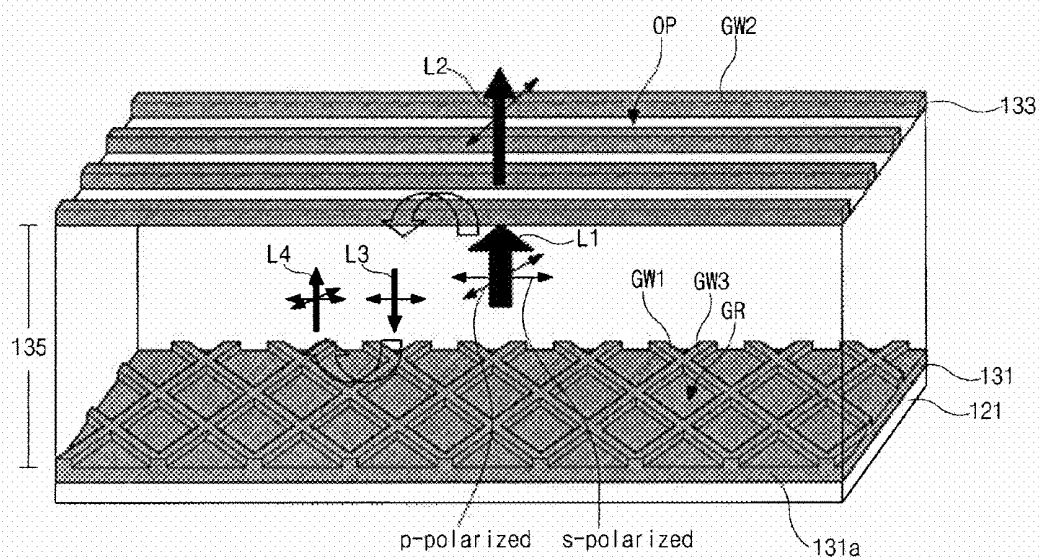
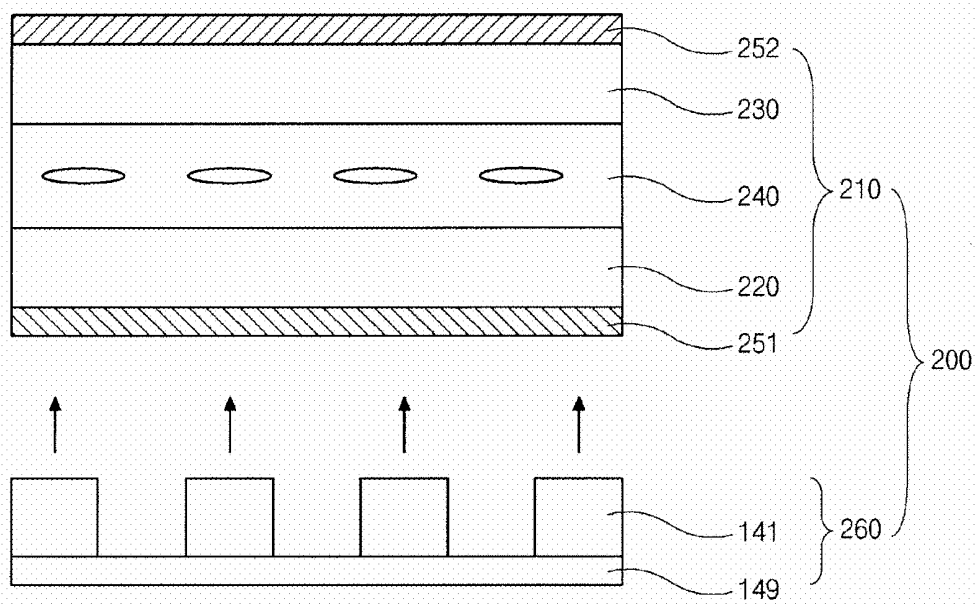


FIG. 9



**LIGHT EMITTING DIODE, METHOD OF
FABRICATING THE SAME, AND LIQUID
CRYSTAL DISPLAY INCLUDING THE SAME**

[0001] The present invention claims the benefit of Korean Patent Application No. 10-2010-0067397, filed in Korea on Jul. 13, 2010, which is hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a light emitting diode, and more particularly, to a light emitting diode, method of fabricating the same, and a liquid crystal display including the same.

[0004] 2. Discussion of the Related Art

[0005] Recently, light emitting diodes (LEDs) are widely used display devices because the LEDs have small size, low power consumption, high reliability and the like. A nitride semiconductor is used as a material of the LED.

[0006] FIG. 1 is a view illustrating a nitride semiconductor LED according to the related art.

[0007] Referring to FIG. 1, the nitride semiconductor LED 37 includes a buffer layer 23, an n (negative) type semiconductor layer 25, an active layer 27, a p (positive) type semiconductor layer 29, a transparent electrode 31, an n type metal electrode 35 and a p type metal electrode 33 that are on a substrate 21.

[0008] Since the nitride semiconductor LED 37 uses a sapphire substrate 21 of an insulator, the n type semiconductor layer 25 are partially etched in step shape in order to form the electrodes 33 and 35, and thus the electrodes are arranged in a Top-Top manner.

[0009] In other words, the n type metal electrode 35 is formed at a corner of the exposed n type semiconductor layer 25, and the p type metal electrode 33 is formed on the transparent electrode 31.

[0010] The nitride semiconductor LED 37 emits light through combination of holes from the p type metal electrode 33 and electrons from the n type metal electrode 35. The LED 37 are widely used for various field such as advertising boards, liquid crystal displays (LCDs) and the like that require light sources.

[0011] However, since a light emitted from the LED 37 is a non-polarized light like a natural scattered light, for a display device such as an LCD that needs a specific polarized light, additional materials such as a polarizing plate is required.

[0012] However, in this case, the light from the LED 37 is lost by about 40 to 50% passing through the polarizing plate. Accordingly, brightness of the display device is reduced. To prevent the reduction of brightness, increasing luminance of light emitted from the LED 37 might be suggested. This, however, causes increase of power consumption.

SUMMARY OF THE INVENTION

[0013] Accordingly, the present invention is directed to a light emitting diode, a method of fabricating the same, and a liquid crystal display including the same which substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

[0014] An advantage of the present invention is to provide a light emitting diode, a method of fabricating the same, and a liquid crystal display including the same that can improve loss of light.

[0015] Additional features and advantages of the present invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. These and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims thereof as well as the appended drawings.

[0016] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, a light emitting diode includes a first grid layer on a substrate and made of a metal material; a p-n semiconductor multiple-layered film on the first grid layer; and a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material, wherein the first grid layer includes a base layer, and a plurality of first grid wires that protrudes from the base layer and are along a first direction, wherein the second grid layer includes a plurality of second grid wires along a second direction, and wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer.

[0017] In another aspect, a method of fabricating a light emitting diode includes forming a first grid layer on a substrate and made of a metal material; forming a p-n semiconductor multiple-layered film on the first grid layer; and forming a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material, wherein the first grid layer includes a base layer, and a plurality of first grid wires that protrudes from the base layer and are along a first direction, wherein the second grid layer includes a plurality of second grid wires along a second direction, and wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer.

[0018] In yet another aspect, a liquid crystal display includes a liquid crystal panel; a backlight unit including a light emitting diode and supplying light to the liquid crystal panel; and a polarizing plate between the liquid crystal panel and the backlight unit, wherein the light emitting diode includes a first grid layer on a substrate and made of a metal material, a p-n semiconductor multiple-layered film on the first grid layer, and a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material, wherein the first grid layer includes a base layer, and a plurality of first grid wires that protrudes from the base layer and are along a first direction, wherein the second grid layer includes a plurality of second grid wires along a second direction, wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer, and wherein a polarizing axis of the polarizing plate is perpendicular to the second direction.

[0019] In yet another aspect, a light emitting diode includes a first grid layer on a substrate and made of a metal material; a p-n semiconductor multiple-layered film on the first grid layer; and a second grid layer on the p-n semiconductor

multiple-layered film and made of a metal material, wherein the first grid layer includes a base layer, a plurality of first grid wires that protrudes from the base layer and are along a first direction, and a plurality of third grid wires that protrudes from the base layer and are along a third direction, wherein the second grid layer includes a plurality of second grid wires along a second direction, and wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer.

[0020] In yet another aspect, a method of fabricating a light emitting diode includes forming a first grid layer on a substrate and made of a metal material; forming a p-n semiconductor multiple-layered film on the first grid layer; and forming a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material, wherein the first grid layer includes a base layer, a plurality of first grid wires that protrudes from the base layer and are along a first direction, and a plurality of third grid wires that protrudes from the base layer and are along a third direction, wherein the second grid layer includes a plurality of second grid wires along a second direction, and wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer.

[0021] In yet another aspect, a liquid crystal display includes a liquid crystal panel; a backlight unit including a light emitting diode and supplying light to the liquid crystal panel; and a polarizing plate between the liquid crystal panel and the backlight unit, wherein the light emitting diode includes a first grid layer on a substrate and made of a metal material, a p-n semiconductor multiple-layered film on the first grid layer, and a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material, wherein the first grid layer includes a base layer, a plurality of first grid wires that protrudes from the base layer and are along a first direction, and a plurality of third grid wires that protrudes from the base layer and are along a third direction, wherein the second grid layer includes a plurality of second grid wires along a second direction, wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer, and wherein a polarizing axis of the polarizing plate is perpendicular to the second direction.

[0022] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

[0024] In the drawings:

[0025] FIG. 1 is a view illustrating a nitride semiconductor LED according to the related art;

[0026] FIG. 2 is a view illustrating an LED element according to a first embodiment of the present invention;

[0027] FIG. 3 is a cross-sectional view taken along a line of FIG. 2;

[0028] FIG. 4 is a view illustrating a laminate structure of the LED according to the first embodiment of the present invention;

[0029] FIG. 5 is a cross-sectional view illustrating the LED according to the first embodiment of the present invention;

[0030] FIG. 6 is a view illustrating the polarization property of the LED according to the first embodiment of the present invention;

[0031] FIGS. 7A to 7H are cross-sectional views illustrating the LED according to the first embodiment of the present invention;

[0032] FIG. 8 is a view illustrating a laminate structure of an LED according to a second embodiment of the present invention; and

[0033] FIG. 9 is a cross-sectional view illustrating an LCD using the LEDs according to the embodiments of the present invention.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0034] Reference will now be made in detail to the illustrated embodiments of the present invention, which are illustrated in the accompanying drawings.

[0035] FIG. 2 is a view illustrating an LED element according to a first embodiment of the present invention, and FIG. 3 is a cross-sectional view taken along a line of FIG. 2.

[0036] Referring to FIGS. 2 and 3, in the LED 141 element, a reflecting frame 143 is formed on a printed circuit board (PCB) 149 and includes a space. An LED 130 that has polarization property is in the space of the reflecting frame 143 and faces the PCB 149 with a wiring portion 151 therebetween. A fluorescent material surrounds the LED 130.

[0037] A lens 145 is configured on the fluorescent material 147 and the LED 130 to uniformly radiate the light from the LED 130.

[0038] When a power is applied to the LED 130, light is emitted from the LED 130, incident on the fluorescent material 147 and passes through the lens 145 into the outside.

[0039] The reflecting frame 143 emits heat of high temperature accompanied by emission of light from the LED 130 into the outside. The reflecting frame 143 may be made of a material having a high reflectance.

[0040] A metal core PCB having property of heat radiation may be used as the PCB 149. The LED element 141 that uses a transparent synthetic resin colored in red, green, blue or the like may be employed.

[0041] The LED 130 having polarization property is explained in more detail with further reference to FIGS. 4 and 5.

[0042] FIG. 4 is a view illustrating a laminate structure of the LED according to the first embodiment of the present invention, and FIG. 5 is a cross-sectional view illustrating the LED according to the first embodiment of the present invention.

[0043] Referring to FIGS. 4 and 5, the LED 130 includes first and second grid layers 131 and 133 on a substrate 121, and a p-n (positive-negative) semiconductor multiple-layered film 135 between the first and second grid layers 131 and 133. A transparent protection layer 137 may be formed on the second grid layer 133 to protect the LED 130.

[0044] The first grid layer 131 may be made of a metal material having high reflectance. For example, the first grid

layer **131** may be made of, but not limited to, aluminum (Al), silver (Ag), gold (Au), palladium (Pd) or platinum (Pt), or mixture thereof. The first grid layer **131** may have a thickness of about 2-digit nanometers to about 3-digit nanometers.

[0045] The first grid layer **131** includes a base layer **131** a and a plurality of first grid wires GW1 that protrudes from the base layer **131** a and is along a first direction. A groove GR is between the neighboring first grid wires GW1 and along the first direction.

[0046] The first grid layer **131** has an uneven shape in cross section because the first grid wire GW1 and the groove GR are alternately arranged.

[0047] The first grid wire GW1 may have a size, for example, a width of a single-digit nanometer. Since the first grid wire GW1 has the nanometer size, it may be referred to as a nano wire.

[0048] The second grid layer **133** includes a plurality of second grid wires GW2 along a second direction. The second grid layer **133** may be made of, but not limited to, aluminum (Al), silver (Ag), gold (Au), palladium (Pd) or platinum (Pt), or mixture thereof. The second grid layer **133** may have a thickness of about 2-digit nanometers to about 3-digit nanometers.

[0049] An opening OP is between the neighboring second grid wires GW2 and along the second direction. The opening OP exposes a layer below the second grid layer **133**.

[0050] The plurality of second grid wires GW2 may be connected to one another at at least one ends thereof.

[0051] The second grid wire GW2 may have a size, for example, a width of a single-digit nanometer. An arrangement interval between the second grid wires GW2 i.e., a pitch may be 300 nanometers or less. Further, the pitch may be half the wavelength of light emitted from the LED **130** or less.

[0052] The first and second grid layers **131** and **133** may function as electrodes that are supplied with driving voltages for the LED **130**. For example, the first grid layer **131** functions as a first electrode i.e., an n type electrode, and the second grid layer **133** functions as a second electrode i.e., a p type electrode.

[0053] The extension directions i.e., the length directions of the first and second grid wires GW1 and GW2 may be in parallel with or cross each other. It is preferred that the first and second grid wires GW1 and GW2 make an angle of about 45 ± 5 degrees.

[0054] Each of the first and second grid wires GW1 and GW2 may have a polygonal shape, such as a triangle, quadrangle or the like, a circular shape, or other geometrical shape.

[0055] The p-n semiconductor multiple-layered film **135** may be made of a III-V group semiconductor material, for example, a III-V group nitride semiconductor material.

[0056] The p-n semiconductor multiple-layered film **135** may include multiple semiconductor layers, for example, an n type semiconductor layer **135a**, a p type semiconductor layer **135b**, and an active layer **135c**. The n type semiconductor layer **135a** may be on a top surface of the first grid layer **131**, the p type semiconductor layer **135b** may be on a bottom surface of the second grid layer **133**, and the active layer **135c** may be between the n type and p type semiconductor layers **135a** and **135b**.

[0057] Neighboring layers among the multiple layers of the p-n semiconductor multiple-layered film **135** may be made of the same material or different material. In other words, the p-n semiconductor multiple-layered film **135** may include at least one homojunction structure or at least one heterojunction

structure. In the embodiment, configuring the heterojunction is preferred, and this improves electron concentration and hole concentration and emission efficiency is thus improved.

[0058] In the p-n semiconductor multiple-layered film **135**, an n type gallium nitride (GaN) layer may be used as the n type semiconductor layer **135a**, and a p type gallium nitride (GaN) layer may be used as the p type semiconductor layer **135b**. The active layer **135c** may have a multi-quantum well (MQW) structure. For example, an indium gallium nitride/gallium nitride ((InGaN/GaN) layer may be used as the active layer **135c**.

[0059] A sapphire substrate, silicon (Si) substrate, gallium arsenic (GaAs) substrate, silicon carbide (SiC) substrate, or gallium nitride (GaN) substrate may be used as the substrate **121**. The substrate **121** may be transparent or opaque.

[0060] When the first and second grid layers **131** and **133** of the LED **130** as above are supplied with driving voltages, electrons of the n type semiconductor layer **131** and holes of the p type semiconductor layer **133** are combined at the active layer **135** to emit light. The active layer **135** emits a non-polarized light, which is converted into a light linearly polarized in a predetermined direction by the first and second grid layers **131** and **133**. Accordingly, the linearly-polarized light is finally emitted from the LED **130**. The polarization property of the LED **130** is explained in more detail with further reference to FIG. 6.

[0061] FIG. 6 is a view illustrating the polarization property of the LED according to the first embodiment of the present invention.

[0062] Referring to FIG. 6, when voltages are applied to the first and second grid layers **131** and **133**, the electrons from the n type semiconductor layer **135a** and the holes from the p type semiconductor layer **135b** are combined at the active layer **135c** so that a light L1 is emitted.

[0063] The light L1 emitted from the active layer **135c** is in non-polarization status. The non-polarized light L1 are categorized into a s-polarized light, which has a polarization direction parallel with the extension direction of the second grid wire GW2, and a p-polarized light which has a polarization direction perpendicular to the extension direction of the second grid wire GW2 (i.e., the width direction of the second grid wire GW2).

[0064] As to the p-polarized light, when it is incident on the second grid layer **133**, vibration, along the width direction of the nano wire, of free electrons in the second grid layer **133** is spatially limited. In other words, since the width of the second grid wire GW2 is negligibly much smaller than the length thereof, the vibration along the width direction of the free electrons is limited. Accordingly, most of the incident p-polarized light passes through the second grid layer **133**, a very few of the p-polarized light not passing through the second grid layer **133** is absorbed or reflected by the second grid layer **133**. Thus, most of the p-polarized light L2 passes through the second grid layer **133** and is emitted.

[0065] As to the s-polarized light, when it is incident on the second grid layer **133**, the free electrons in the second grid layer **133** vibrates along the extension direction i.e., the length direction of the nano wire and thus high reflectance property of metal is shown. Accordingly, most of the incident s-polarized light does not pass through the second grid layer **133** but is reflected by the second grid layer **133**, and a very few of the incident s-polarized light is absorbed by the second grid layer **133**. As such, the s-polarized light is substantially reflected by the second grid layer **133**.

[0066] The s-polarized light L3 reflected by the second grid layer 133 is incident on the first grid layer 131. The first grid layer 131 functions as a polarization conversion layer and a reflection layer as well. In other words, since the first grid wire GW1 protruding and extending along the first direction is configured in the first grid layer 131, the first grid layer 131 has an uneven shape and thus functions as a polarization conversion layer. Further, since the first grid layer 131 is made of a metal material having high reflectance, it functions as a reflection layer.

[0067] Accordingly, most of the light L3 incident on the first grid layer 131 is reflected and polarization thereof is converted. For example, when a s-polarized light is incident on the first grid layer 131, the s-polarized light is converted into p-polarized and s-polarized lights. Accordingly, the incident s-polarized light is mostly reflected, and the reflected light includes a p-polarized component and an s-polarized component.

[0068] The reflected light L4 reflected by the first grid layer 131 is incident again on the second grid layer 133. Referring to the above-described property of the second grid layer 133, among the reflected light L4, the p-polarized component (i.e., the p-polarized light) is emitted while the s-polarized light (i.e., the s-polarized light) is reflected.

[0069] Through repetition of the processes as above, the light generated in the LED 130 is emitted as the p-polarized light. As such, in the first embodiment, through the reflections between the first and second grid layers 131 and 133, a light-recycling process is conducted, and thus most of the generated light can be converted into a predetermined polarized light and emitted.

[0070] A wavelength range of the light emitted from the LED 130 can be adjusted according to adjustment of the pitch p of the second grid wire GW2. For example, to make a wavelength range of the light from the LED 130 wide or narrow, the pitch p of the second grid wire GW2 is appropriately adjusted. Accordingly, a light having a desired wavelength range can be provided.

[0071] A method of fabricating the LED according to the first embodiment of the present invention is explained with reference to FIGS. 7A to 7H.

[0072] FIGS. 7A to 7H are cross-sectional views illustrating the LED according to the first embodiment of the present invention.

[0073] Referring to FIG. 7A, a first metal material is deposited on a substrate 121 to form a first metal layer 122. Then, a first photoresist layer is formed on the first metal layer 122 and a photolithography process is performed using a photo mask. Accordingly, a first photoresist pattern 171 is formed.

[0074] Referring to FIG. 7B, the first metal layer 122 is etched using the first photoresist pattern as an etching mask. The etching process may be performed to partially remove the first metal layer 122. Accordingly, a first grid layer 131 is formed that includes a dent portion where the first metal layer 122 is removed and a protruded portion where the first metal layer 122 is not removed. The dent portion is a groove GR, and the protruded portion is a first grid wire GW1. The groove GR and the first grid wire GW1 extend along a first direction.

[0075] Referring to FIG. 7C, a striping process is performed to remove the first photoresist pattern 171.

[0076] Referring to FIG. 7D, a p-n semiconductor multiple-layered film 135 is formed on the first grid layer 131. For example, through a MOCVD (metal organic chemical vapor deposition) method, a MBE (molecular beam epitaxy)

method, a VPE (vapor phase epitaxy) method or the like, an n type semiconductor layer 135a, an active layer 135c and a p type semiconductor layer 135b are sequentially formed.

[0077] Then, a second photoresist layer 180 is formed on the p-n semiconductor multiple-layered film 135.

[0078] Referring to FIG. 7E, a photolithography process is performed for the second photoresist layer 180 to form a second photoresist pattern 181.

[0079] Referring to FIG. 7F, a second metal material is deposited on the substrate 121 having the second photoresist pattern 181 to form a second metal layer 123. The second metal layer 181 is formed on the second photoresist pattern 181 and fills openings of the second photoresist pattern 181.

[0080] Referring to FIG. 7G, a process to remove the second photoresist pattern 181 is performed. This process may be referred to as a lift-off process. Accordingly, the second metal layer 123 remaining on the second photoresist pattern 181 are removed while the second metal layer 123 in the openings of the second photoresist pattern 181 still remains. Accordingly, a second grid layer 133 including a second grid wire GW2 along a second direction is formed. Since the second photoresist pattern 181 is removed, an opening OP is formed between the neighboring second grid wires GW2.

[0081] Referring to FIG. 7H, a protection layer 137 is formed on the second grid layer 133. The protection layer 137 may be made of an organic insulating material or an inorganic insulating material.

[0082] Through the above-described processes, the LED 130 according to the first embodiment can be fabricated.

[0083] In the processes as above, the photolithography process is used to form the first and second grid layers 131 and 133. However, the photolithography process is one example to form the first and second grid layers 131 and 133, and other various methods may be employed. For example, a laser interference patterning method, a nano imprinting method, a self assembly method, a method of selectively inserting and dispersing nanoparticles, a method of thermally depositing nanoparticles, or the like may be used.

[0084] FIG. 8 is a view illustrating a laminate structure of an LED according to a second embodiment of the present invention.

[0085] Referring to FIG. 8, the LED 130 of the second embodiment is similar to that of the first embodiment except for configuration of the first grid layer 131. Accordingly, explanations of parts similar to parts of the first embodiment may be omitted.

[0086] The LED 130 of the second embodiment includes first and second grid layers 131 and 133 on a substrate 121, and a p-n semiconductor multiple-layered film 135 between the first and second grid layers 131 and 133. Further, a transparent protection layer may be formed on the second grid layer 133 to protect the LED 130 in similar to the first embodiment.

[0087] The first grid layer 131 may be made of a metal material having high reflectance.

[0088] The first grid layer 131 includes a base layer 131a, a plurality of first grid wires GW1 that protrudes from the base layer 131a and is along a first direction, and a plurality of third grid wires GW3 that protrudes from the base layer 131a and is along a third direction. The first and third grid wires GW1 and GW3 cross each other. The first and third grid wires GW1 and GW3 define a groove GR surrounded thereby.

[0089] The first grid layer 131 has an uneven shape in cross section because the first grid wire GW1 and the groove GR are

alternately arranged and the third grid wire GW3 and the groove GR are alternately arranged.

[0090] Each of the first and third grid wires GW1 and GW3 may have a size, for example, a width of a single-digit nanometer. Since each of the first and third grid wires GW1 and GW3 have the nanometer size, it may be referred to as a nano wire.

[0091] The second grid layer 133 includes a plurality of second grid wires GW2 along a second direction.

[0092] An opening OP is between the neighboring second grid wires GW2 and along the second direction. The opening OP exposes a layer below the second grid layer 133.

[0093] The plurality of second grid wires GW2 may be connected to one another at at least one ends thereof.

[0094] The second grid wire GW2 may have a size, for example, a width of a single-digit nanometer. An arrangement interval between the second grid wires GW2 i.e., a pitch may be 300 nanometers or less. Further, the pitch may be half the wavelength of light emitted from the LED 130 or less.

[0095] The first and second grid layers 131 and 133 may function as electrodes that are supplied with driving voltages for the LED 130. For example, the first grid layer 131 functions as a first electrode i.e., an n type electrode, and the second grid layer 133 functions as a second electrode i.e., a p type electrode.

[0096] The extension directions i.e., the length directions of the first or third grid wire GW1 or GW3, and second grid wire GW2 may be in parallel with or cross each other. It is preferred that the first and second grid wires GW1 and GW2 make an angle of about 45 ± 5 degrees, and the third and second grid wires GW3 and GW2 make an angle of about 45 ± 5 degrees. In this case, the first and third grid wires GW1 and GW3 make an angle of about 90 degrees.

[0097] Each of the first to third grid wires GW1 to GW3 may have a polygonal shape, such as a triangle, quadrangle or the like, a circular shape, or other geometrical shape.

[0098] The p-n semiconductor multiple-layered film 135 may be made of a III-V group semiconductor material, for example, a III-V group nitride semiconductor material.

[0099] The p-n semiconductor multiple-layered film 135 may include multiple semiconductor layers, for example, an n type semiconductor layer (135a of FIG. 5), a p type semiconductor layer (135b of FIG. 5), and an active layer (135c of FIG. 5), as described in the first embodiment.

[0100] A polarization property of the LED 130 according to the second embodiment of the present invention is explained in more detail.

[0101] When voltages are applied to the first and second grid layers 131 and 133, electrons from the n type semiconductor layer and holes from the p type semiconductor layer are combined at the active layer so that a light L1 is emitted.

[0102] The light L1 emitted from the active layer 135c is in non-polarization status. The non-polarized light L1 are categorized into a s-polarized light, which has a polarization direction parallel with the extension direction of the second grid wire GW2, and a p-polarized light which has a polarization direction perpendicular to the extension direction of the second grid wire GW2 (i.e., the width direction of the second grid wire GW2).

[0103] As to the p-polarized light, when it is incident on the second grid layer 133, vibration, along the width direction of the nano wire, of free electrons in the second grid layer 133 is spatially limited. In other words, since the width of the second grid wire GW2 is negligibly much smaller than the length

thereof, the vibration along the width direction of the free electrons is limited. Accordingly, most of the incident p-polarized light passes through the second grid layer 133, a very few of the p-polarized light not passing through the second grid layer 133 is absorbed or reflected by the second grid layer 133. Thus, most of the p-polarized light L2 passes through the second grid layer 133 and is emitted.

[0104] As to the s-polarized light, when it is incident on the second grid layer 133, the free electrons in the second grid layer 133 vibrates along the extension direction i.e., the length direction of the nano wire and thus high reflectance property of metal is shown. Accordingly, most of the incident s-polarized light does not pass through the second grid layer 133 but is reflected by the second grid layer 133, and a very few of the incident s-polarized light is absorbed by the second grid layer 133. As such, the s-polarized light is substantially reflected by the second grid layer 133.

[0105] The s-polarized light L3 reflected by the second grid layer 133 is incident on the first grid layer 131. The first grid layer 131 functions as a polarization conversion layer and a reflection layer as well. In other words, since the first grid wire GW1 protruding and extending along the first direction is configured in the first grid layer 131, the first grid layer 131 has an uneven shape and thus functions as a polarization conversion layer. Further, since the third grid wire GW3 crossing the first grid wire GW1 is further configured in the first grid layer 131, the polarization conversion property is improved better than that of the first embodiment.

[0106] Further, since the first grid layer 131 is made of a metal material having high reflectance, it functions as a reflection layer.

[0107] Accordingly, most of the light L3 incident on the first grid layer 131 is reflected and polarization thereof is converted. For example, when a s-polarized light is incident on the first grid layer 131, the s-polarized light is converted into p-polarized and s-polarized lights. Accordingly, the incident s-polarized light is mostly reflected, and the reflected light includes a p-polarized component and an s-polarized component.

[0108] The reflected light L4 reflected by the first grid layer 131 is incident again on the second grid layer 133. Referring to the above-described property of the second grid layer 133, among the reflected light L4, the p-polarized component (i.e., the p-polarized light) is emitted while the s-polarized light (i.e., the s-polarized light) is reflected.

[0109] Through repetition of the processes as above, the light generated in the LED 130 is emitted as the p-polarized light. As such, in the second embodiment, through the reflections between the first and second grid layers 131 and 133, a light-recycling process is conducted, and thus most of the generated light can be converted into a predetermined polarized light and emitted.

[0110] An LCD using the LEDs 130 of the embodiments of the present invention as above is explained with further reference to FIG. 9.

[0111] FIG. 9 is a cross-sectional view illustrating an LCD using the LEDs according to the embodiments of the present invention.

[0112] Referring further to FIG. 9, the LCD 200 includes a liquid crystal panel 210, a backlight unit 260 supplying light to the liquid crystal panel 210, and first and second polarizing plates 251 and 252.

[0113] The liquid crystal panel **210** includes first and second substrates **220** and **230**, and a liquid crystal layer **240** between the substrates **210** and **220**.

[0114] The first substrate **220** may be referred to as an array substrate. Although not shown in the drawings, gate and data lines crossing each other to define a pixel region may be formed at the first substrate **210**. A switching transistor connected to the gate and data lines and a pixel electrode connected to the switching transistor may be formed in the pixel region of the first substrate **220**.

[0115] The second substrate **230** may be referred to as a color filter substrate or an opposing substrate. Although not shown in the drawings, a black matrix, a color filter layer and a common electrode may be formed at the second substrate **230**. The black matrix may correspond to the gate and data lines and the switching transistor. The color filter layer may correspond to the pixel region. The common electrode may be formed on the color filter layer and face the pixel electrode.

[0116] The first and second polarizing plates **251** and **252** may be on outer surfaces of the first and second substrates **220** and **230**, respectively. The first and second polarizing plates **251** and **252** have respective polarizing axes. Accordingly, each of the first and second polarizing plates **251** and **252** passes a light polarized in parallel with the axis thereof.

[0117] The backlight unit **260** includes a plurality of LED elements **141**. The LED element **141** may be mounted on a printing circuit board **149**. The LED element **141** includes the LED **130** according to the first or second embodiment.

[0118] Although not shown in the drawings, the backlight unit **260** may include at least one optical sheet between the first polarizing plate **251** and the LED element **141**. For example, the at least one optical sheet may include a diffusion sheet and a prism sheet.

[0119] As described above, the LED **130** converts a non-polarized light generated therein into a predetermined polarized light, for example, a light polarized perpendicularly to the length direction of the second grid wire GW2.

[0120] The polarized light from the LED **130** is incident on the first polarizing plate **251**. The polarizing axis of the first polarizing plate **251** is substantially identical to the polarizing direction of the polarized light. In other words, the polarizing axis of the first polarizing plate **251** is parallel with the width direction of the second grid wire GW2 i.e., perpendicular to the length direction of the second grid wire GW2.

[0121] According to this configuration of the polarizing axis of the first polarizing plate **251**, Almost all of the light emitted from the LED element **141** can pass through the first polarizing plate **251**. In other words, loss rate of light through the first polarizing plate **251** reaches nearly 0%. Therefore, loss rate of light from the LED **130** can be remarkably reduced compared to the related art. Further, approach to increase power to compensate for loss of light in the related art is not needed, and thus it is efficient in aspect of power consumption.

[0122] A method of fabricating the LCD **210** is explained with reference to FIG. 9.

[0123] The first and second substrates **220** and **230** are separately fabricated and then coupled with each other with the liquid crystal layer **240** therebetween, and thus the liquid crystal panel **210** is fabricated. The first and second polarizing plates **251** and **252** are attached to the corresponding outer surfaces of the liquid crystal panel **210**.

[0124] The liquid crystal panel **210** having the polarizing plates **251** and **252** and the backlight unit **260** including the LED elements **141** are assembled using components, for example, a top case, a bottom case, a main supporter and the

like. In the assembling, a process of coupling driving circuit components with the liquid crystal panel **210** may be performed.

[0125] Through the above processes, the LCD **210** can be fabricated.

[0126] It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A light emitting diode, comprising:

a first grid layer on a substrate and made of a metal material;

a p-n semiconductor multiple-layered film on the first grid layer; and

a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material,

wherein the first grid layer includes a base layer, and a plurality of first grid wires that protrudes from the base layer and are along a first direction,

wherein the second grid layer includes a plurality of second grid wires along a second direction, and

wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer.

2. The diode according to claim 1, wherein the first and second directions make an angle of about 45±5 degrees.

3. The diode according to claim 1, wherein a pitch of the second grid wire is about 300 nanometers or less.

4. The diode according to claim 1, wherein the first and second grid layers are supplied with driving voltages.

5. A method of fabricating a light emitting diode, the method comprising:

forming a first grid layer on a substrate and made of a metal material;

forming a p-n semiconductor multiple-layered film on the first grid layer; and

forming a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material,

wherein the first grid layer includes a base layer, and a plurality of first grid wires that protrudes from the base layer and are along a first direction,

wherein the second grid layer includes a plurality of second grid wires along a second direction, and

wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer.

6. The method according to claim 5, wherein the first and second directions make an angle of about 45±5 degrees.

7. The method according to claim 5, wherein a pitch of the second grid wire is about 300 nanometers or less.

8. The method according to claim 5, wherein the first and second grid layers are supplied with driving voltages.

9. A liquid crystal display, comprising:

a liquid crystal panel;

a backlight unit including a light emitting diode and supplying light to the liquid crystal panel; and

- a polarizing plate between the liquid crystal panel and the backlight unit,
- wherein the light emitting diode includes a first grid layer on a substrate and made of a metal material, a p-n semiconductor multiple-layered film on the first grid layer, and a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material,
- wherein the first grid layer includes a base layer, and a plurality of first grid wires that protrudes from the base layer and are along a first direction,
- wherein the second grid layer includes a plurality of second grid wires along a second direction,
- wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer, and
- wherein a polarizing axis of the polarizing plate is perpendicular to the second direction.
10. The display according to claim 9, wherein the first and second directions make an angle of about 45 ± 5 degrees.
11. The display according to claim 9, wherein a pitch of the second grid wire is about 300 nanometers or less.
12. The display according to claim 9, wherein the first and second grid layers are supplied with driving voltages.
13. A light emitting diode, comprising:
- a first grid layer on a substrate and made of a metal material;
 - a p-n semiconductor multiple-layered film on the first grid layer; and
 - a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material,
- wherein the first grid layer includes a base layer, a plurality of first grid wires that protrudes from the base layer and are along a first direction, and a plurality of third grid wires that protrudes from the base layer and are along a third direction,
- wherein the second grid layer includes a plurality of second grid wires along a second direction, and
- wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer.
14. The diode according to claim 13, wherein the first and third directions cross each other, and each of the first and third directions and the second direction make an angle of about 45 ± 5 degrees.
15. The diode according to claim 13, wherein a pitch of the second grid wire is about 300 nanometers or less.
16. The diode according to claim 13, wherein the first and second grid layers are supplied with driving voltages.
17. A method of fabricating a light emitting diode, the method comprising:
- forming a first grid layer on a substrate and made of a metal material;
 - forming a p-n semiconductor multiple-layered film on the first grid layer; and

- forming a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material,
- wherein the first grid layer includes a base layer, a plurality of first grid wires that protrudes from the base layer and are along a first direction, and a plurality of third grid wires that protrudes from the base layer and are along a third direction,
- wherein the second grid layer includes a plurality of second grid wires along a second direction, and
- wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer.
18. The method according to claim 17, wherein the first and third directions cross each other, and each of the first and third directions and the second direction make an angle of about 45 ± 5 degrees.
19. The method according to claim 17, wherein a pitch of the second grid wire is about 300 nanometers or less.
20. The method according to claim 17, wherein the first and second grid layers are supplied with driving voltages.
21. A liquid crystal display, comprising:
- a liquid crystal panel;
 - a backlight unit including a light emitting diode and supplying light to the liquid crystal panel; and
 - a polarizing plate between the liquid crystal panel and the backlight unit,
- wherein the light emitting diode includes a first grid layer on a substrate and made of a metal material, a p-n semiconductor multiple-layered film on the first grid layer, and a second grid layer on the p-n semiconductor multiple-layered film and made of a metal material,
- wherein the first grid layer includes a base layer, a plurality of first grid wires that protrudes from the base layer and are along a first direction, and a plurality of third grid wires that protrudes from the base layer and are along a third direction,
- wherein the second grid layer includes a plurality of second grid wires along a second direction,
- wherein the p-n semiconductor multiple-layered film includes an active layer, a n type semiconductor layer between the first grid layer and the active layer, and a p type semiconductor layer between the second grid layer and the active layer, and
- wherein a polarizing axis of the polarizing plate is perpendicular to the second direction.
22. The display according to claim 21, wherein the first and third directions cross each other, and each of the first and third directions and the second direction make an angle of about 45 ± 5 degrees.
23. The display according to claim 21, wherein a pitch of the second grid wire is about 300 nanometers or less.
24. The display according to claim 21, wherein the first and second grid layers are supplied with driving voltages.

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专利名称(译)	发光二极管，其制造方法以及包括该发光二极管的液晶显示器		
公开(公告)号	US20120013827A1	公开(公告)日	2012-01-19
申请号	US13/181077	申请日	2011-07-12
[标]申请(专利权)人(译)	乐金显示有限公司		
申请(专利权)人(译)	LG DISPLAY CO. , LTD.		
当前申请(专利权)人(译)	LG DISPLAY CO. , LTD.		
[标]发明人	YOON MIN SUNG		
发明人	YOON, MIN-SUNG		
IPC分类号	G02F1/1335 H01L33/38 H01L33/08		
CPC分类号	H01L33/10 H01L33/12 G02F1/13362 H01L33/46 G02F1/133603 H01L33/44		
优先权	1020100067397 2010-07-13 KR		
其他公开文献	US8885122		
外部链接	Espacenet USPTO		

摘要(译)

发光二极管包括在基板上的第一栅格层，并且由金属材料制成；第一栅格层上的p-n半导体多层膜；所述pn半导体多层膜上的第二栅格层由金属材料制成，所述第一栅格层包括基层，以及从所述基层突出并沿第一方向的多个第一栅线，其中所述第二栅格层包括沿第二方向的多个第二栅极线，并且其中所述pn半导体多层膜包括有源层，位于所述第一栅格层和所述有源层之间的半导体层，以及p型半导体层在第二网格层和活动层之间。

