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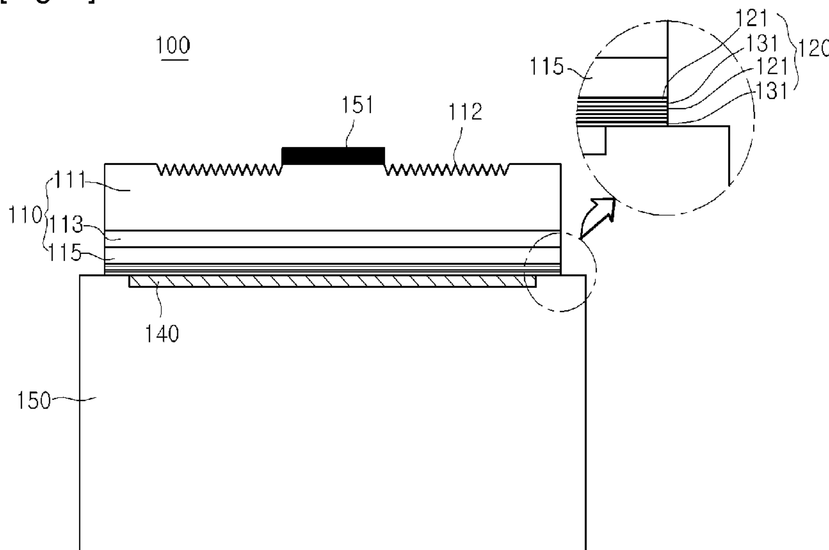
(54) **Title:** SEMICONDUCTOR LIGHT EMITTING DEVICE



(57) **Abstract:** Disclosed are a semiconductor light emitting device. The semiconductor light emitting device comprises a light emitting structure comprising a III-V group compound semiconductor, a reflective layer comprising mediums, which are different from each other and alternately stacked under the light emitting structure, and a second electrode layer under the reflective layer.

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Description

SEMICONDUCTOR LIGHT EMITTING DEVICE

Technical Field

[1] The present disclosure relates to a semiconductor light emitting device.

Background Art

[2] III-V group nitride semiconductors have been variously applied to an optical device such as blue and green LEDs (Light Emitting Diodes), a high speed switching device, such as a MOSFET (Metal Semiconductor Field Effect Transistor) and an HEMT (Hetero junction Field Effect Transistors), and a light source of a lighting device or a display device. Particularly, a light emitting device using the group III nitride semiconductor has a direct transition-type bandgap corresponding to the range of visible rays to ultraviolet rays, and can perform high efficient light emission.

[3] A nitride semiconductor is mainly used for the LED or an LD (laser diode), and studies have been continuously conducted to improve the manufacturing process or the light efficiency of the nitride semiconductor.

Disclosure of Invention

Technical Problem

[4] The embodiment provides a semiconductor light emitting device comprising a reflective layer, in which mediums comprising different refractive indexes are alternately stacked.

[5] The embodiment provides a semiconductor light emitting device capable of adjusting the thickness of mediums and the number of pairs of the mediums in a reflective layer according to wavelength of emitted light.

[6] The embodiment provides a semiconductor light emitting device comprising a reflective layer and an ohmic layer stacked under a light emitting structure.

Technical Solution

[7] An embodiment provides a semiconductor light emitting device comprising: a light emitting structure comprising a III-V group compound semiconductor laye; a reflective layer comprising mediums, which are different from each other and alternately stacked under the light emitting structure; and a second electrode layer under the reflective layer.

[8] An embodiment provides a semiconductor light emitting device comprising: a semiconductor light emitting device comprising: a light emitting structure comprising a first conductive semiconductor layer, an active layer under the first conductive semi-

conductor layer, and a second conductive semiconductor layer under the active layer; a reflective layer comprising a first medium having a first refractive index and a second medium having a second refractive index under the light emitting structure; and a second electrode layer under the reflective layer.

Advantageous Effects

[9] The embodiment can improve reflection characteristics by adopting a reflective layer having a DBR (Distributed Bragg Reflector) structure.

[10] The embodiment can improve external light-emitting efficiency using a reflective layer under an active layer.

[11] The embodiment can maintain high reflection characteristics by adjusting the thickness of each medium in a reflective layer according to wavelength of emitted light.

Brief Description of Drawings

[12] FIG. 1 is a side sectional view illustrating a semiconductor light emitting device according to a first embodiment;

[13] FIGS. 2 to 10 are side sectional view illustrating the method of fabricating the semiconductor light emitting device according to the first embodiment;

[14] FIG. 11 is a side sectional view illustrating a semiconductor light emitting device according to a second embodiment; and

[15] FIG. 12 is a graph illustrating reflectance according to the number of AlN-GaN pairs in a reflective layer according to a first embodiment.

Best Mode for Carrying out the Invention

[16] A semiconductor light emitting device according to an embodiment will be described in detail with reference to the accompanying drawings. In the description of the embodiment, the term "on or "under of each layer will be described with reference to the accompanying drawings and thickness of each layer is not limited to thickness shown in the drawings.

[17] FIG. 1 is a side sectional view illustrating a semiconductor light emitting device according to a first embodiment.

[18] Referring to FIG. 1, the semiconductor light emitting device 100 comprises a light emitting structure 110, a reflective layer 120, an ohmic layer 140 and a conductive support member 150.

[19] The light emitting structure 110 comprises a first conductive semiconductor layer 111, a second conductive semiconductor layer 115, and an active layer 113 interposed

between the first and second conductive semiconductor layers 111 and 115.

[20] The first conductive semiconductor layer 111 can be prepared in the form of at least one semiconductor layer doped with a first conductive dopant. The first conductive semiconductor layer is a III-V group compound semiconductor and may comprise at least one selected from the group consisting of GaN, InN, AlN, InGaN, AlGaN, InAlGaN and AlInN. When the first conductive semiconductor layer 111 is an N type semiconductor layer, the first conductive dopant comprises an N type dopant such as Si, Ge, Sn, Se and Te.

[21] A first electrode 151 having a predetermined pattern is formed on the upper surface of the first conductive semiconductor layer 111. Roughness 112 may be formed on a part of the upper surface of the first conductive semiconductor layer 111, or the entire surface of the first conductive semiconductor layer 111.

[22] The active layer 113 is formed under the first conductive semiconductor layer 111. The active layer 113 has a single quantum well structure or a multi-quantum well structure. The active layer 113 is formed with the arrangement of a well layer and a barrier layer by using III-V group compound semiconductor materials. For example, the active layer 113 may be formed with the arrangement of an InGaN well layer/a GaN barrier layer or an AlGaN well layer/a GaN barrier layer.

[23] The active layer 113 comprises material having bandgap energy according to wavelength of emitted light. For example, in the case of blue light having wavelength of 460㎚ to 470㎚, the active layer 113 may have a single quantum well structure or a multi-quantum well structure at one cycle of an InGaN well layer/a GaN barrier layer. The active layer 113 may comprise material that emits chromatic light such as blue light, red light and green light.

[24] A conductive clad layer (not shown) may be formed on and/or under the active layer 113. The conductive clad layer can be prepared in the form of an AlGaN layer.

[25] The second conductive semiconductor layer 115 is formed under the active layer 113. The second conductive semiconductor layer 115 can be prepared in the form of at least one semiconductor layer doped with a second conductive dopant. The second conductive semiconductor layer 115 is a III-V group compound semiconductor and may comprise at least one selected from the group consisting of GaN, InN, AlN, InGaN, AlGaN, InAlGaN and AlInN. When the second conductive semiconductor layer 115 is a P type semiconductor layer, the second conductive dopant comprises a P type dopant such as Mg, Zn, Ca, Sr and Ba.

[26] A third conductive semiconductor layer (not shown) can be formed under the second

conductive semiconductor layer 115. When the first conductive semiconductor layer 111 is a N type semiconductor layer, the second conductive semiconductor layer 115 can be prepared in the form of an P type semiconductor layer. The third conductive semiconductor layer can be prepared in the form of a semiconductor layer doped with the N type dopant. The light emitting structure 110 may comprise at least one of an N-P junction structure, a P-N junction structure, an N-P-N junction structure and a P-N-P junction structure.

[27] The reflective layer 120 is formed under the light emitting structure 110. The reflective layer 120 is formed under the second conductive semiconductor layer 115 and comprises a DBR structure in which different mediums 121 and 131 are alternately stacked. In the DBR structure, several pairs of two transparent mediums 121 and 131 having different refractive indexes are alternately stacked.

[28] In the reflective layer 120, the first medium 121 and the second medium 131 stacked under the first medium 121 forms one pair, and the number of pairs of the first medium 121 and the second medium 131 may be 10 to 30.

[29] The first medium 121 and the second medium 131 in the reflective layer 120 may use two materials representing large difference between refractive indexes thereof among III-V group compound semiconductors. The first medium 121 may comprise an AlN layer and the second medium 131 may comprise a GaN layer. In the reflective layer 120, AlN/GaN pairs are alternately stacked. In addition, GaN/AlN pairs are alternately stacked in the reflective layer 120. The first medium 121 or the second medium 131 may comprise one selected from the group consisting of InN, InGaN, AlGaN, InAlGaN and AlInN. Further, another semiconductor layer, such as InN, InGaN, AlGaN, InAlGaN and AlInN, can be inserted between the first medium 121 and the second medium 131.

[30] In each pair structure provided in the reflective layer 120, the first medium 121 may have thickness of 35nm to 80nm and the second medium 131 may have thickness of 30nm to 75nm. Further, the first medium 121 may have thickness different from that of the second medium 131, and the first medium 121 and the second medium 131 may be formed with the same thickness.

[31] The thickness of the first medium 121 and the second medium 131 in the reflective layer 120 can be calculated using wavelength of emitted light in the active layer 113 and refractive indexes of the first medium 121 and the second medium 131 as expressed by the following Equation 1.

[32] [Equation 1]

[33] $T = \lambda/(4n)$

[34] In Equation 1, T denotes thickness of each medium, λ denotes wavelength and n denotes a refractive index of each medium.

[35] When the wavelength is 450nm, if the AlN layer has a refractive index of 2.12, the AlN layer may have thickness of 53.1nm. If the GaN layer has a refractive index of 2.44, the GaN layer may have thickness of 46.1nm.

[36] In the reflective layer 120, thickness of the first medium 121 and the second medium 131 can be optimized according to the wavelength of emitted light. The lowermost medium of the reflective layer 120 may not have a pair structure.

[37] Referring to FIG. 12, in a case in which the wavelength of emitted light is 450nm, if the number of AlN-GaN pairs in the reflective layer 120 is larger than 10, the r eflective layer 120 has reflectance larger than 94%. If the number of AlN-GaN pairs is larger than 11, the reflective layer 120 has reflectance of 95% to 99%. Accordingly, if the number of AlN-GaN pairs is larger than 10, the reflective layer 120 has higher reflectance.

[38] The thickness of the mediums and the number of pairs of the mediums in the reflective layer 120 may vary depending on the wavelength of emitted light. For example, the reflective layer 120 can efficiently reflect light having wavelength of 300nm to 700nm.

[39] The reflective layer 120 may be formed a size identical to a light emitting area of the active layer 113, so that the reflection characteristics can be maximized and external light-emitting efficiency can be improved.

[40] Also, the reflective layer 120 can be formed with a high-conductivity material and used as a part of the light emitting device.

[41] The ohmic layer 140 is formed under the reflective layer 120 and the conductive support member 150 is formed under the ohmic layer 140. The ohmic layer 140 and the conductive support member 150 serve as a second electrode layer.

[42] The ohmic layer 140 may comprise material having superior ohmic characteristics and low transmittance to reduce difference in resistance between the reflective layer 120 and the conductive support member 150. For example, the ohmic layer 140 may comprise at least one selected from the group consisting of Pt, Ni, Au, Rh and Pd or a mixture thereof. The ohmic layer 140 may not be exposed to the outer wall of a device.

[43] The conductive support member 150 may comprise copper, gold, carrier wafer (e.g. Si, Ge, GaAs, ZnO, or SiC) and the like. For example, the conductive support member 150 can be formed using plating or wafer bonding technology. The scope of the

present invention is not limited thereto.

[44] FIGS. 2 to 10 are side sectional view illustrating the method of fabricating the semiconductor light emitting device according to the first embodiment.

[45] Referring to FIG. 2, a buffer layer 103 is formed on a substrate 101. The substrate 101 may comprise material selected from the group consisting of Al_2O_3, GaN, SiC, ZnO, Si, GaP, InP and GaAs.

[46] The buffer layer 103 may comprise a III-V group compound semiconductor. For example, the buffer layer 103 may comprise one selected from the group consisting of GaN, InN, AlN, InGaN, AlGaN, InAlGaN and AlInN. The buffer layer 103 may be doped with a conductive dopant, or may not be formed.

[47] An undoped semiconductor layer (not shown) may be formed on the buffer layer 103 and may serve as a seed layer for growth of a nitride semiconductor. At least one of the buffer layer 103 and the undoped semiconductor layer may be formed or not. The scope of the present invention is not limited thereto.

[48] The first conductive semiconductor layer 111 is formed on the buffer layer 103, the active layer 113 is formed on the first conductive semiconductor layer 111, and the second conductive semiconductor layer 115 is formed on the active layer 113.

[49] The conductive clad layer (not shown) may be formed on and/or under the active layer 113. The conductive clad layer may comprise the AlGaN layer.

[50] A light emitting structure 110 comprises the first conductive semiconductor layer 111, the active layer 113 and the second conductive semiconductor layer 115. Another layer can be added thereto or can be inserted there between within the scope of the embodiment. The scope of the present invention is not limited to such a structure.

[51] The reflective layer 120 is formed on the second conductive semiconductor layer 115. The reflective layer 120 can be formed using a deposition method such as an MOCVD (Metal Organic Chemical Vapor Deposition), an MBE (Molecular Beam Epitaxy) or a HVPE (hydride Vapor Phase Epitaxy).

[52] The reflective layer 120 comprises the first medium 121 and the second medium 131. In detail, the first medium 121 is formed on the second conductive semiconductor layer 115 and the second medium 131 is formed on the first medium 121. The first medium 121 and the second medium 131, which are prepared as a pair, can be alternately stacked to form the DBR structure. The number of the pairs may be 10 to 30.

[53] The first medium 121 and the second medium 131 may use two materials representing large difference between refractive indexes thereof. The first medium 121 in the reflective layer 120 may comprise the AlN layer and the second medium 131 may

comprise the GaN layer. The reflective layer 120 may comprise the AlN-GaN pair or the GaN-AlN pair. The first medium 121 or the second medium 131 may comprise one selected from the group consisting of InN, InGaN, AlGaN, InAlGaN and AlInN. Further, another semiconductor layer, such as InN, InGaN, AlGaN, InAlGaN and AlInN, can be inserted between the first medium 121 and the second medium 131.

[54] The first medium 121 may have thickness of 35nm to 80nm and the second medium 131 may have thickness of 30nm to 75nm. Further, the first medium 121 may have thickness different from that of the second medium 131, and the first medium 121 and the second medium 131 may be formed with the same thickness.

[55] The thickness of the first medium 121 and the second medium 131 and the number of pairs of the first medium 121 and the second medium 131 in the reflective layer 120 may vary depending on the wavelength of emitted light. For example, when the wavelength of emitted light is 450nm, if the AlN layer has a refractive index of 2.12, the AlN layer may have thickness of 53.1nm. If the GaN layer has a refractive index of 2.44, the GaN layer may have thickness of 46.1nm.

[56] The thickness of the first medium 121 and the second medium 131 can be calculated based on the wavelength of emitted light, and the number of pairs of the first medium 121 and the second medium 131 can be selected based on the reflectance of the reflective layer 120.

[57] When the first medium 121 has thickness of 35nm to 80nm, the second medium 131 has thickness of 30nm to 75nm, and the number of pairs is 10 to 30, the reflective layer 120 can efficiently reflect light having wavelength of 300nm to 700nm.

[58] The reflective layer 120 may be formed with a size identical to a light emitting area of the active layer 113, so that the reflection characteristics can be maximized and external light-emitting efficiency can be improved.

[59] Referring to FIG. 3, after the reflective layer 120 is formed on the second conductive semiconductor layer 115, an outer peripheral portion Al on the substrate 101 is removed using a mesa etching process.

[60] Referring to FIG. 4, the ohmic layer 140 is formed on the reflective layer 120. The ohmic layer 140 may comprise material having superior ohmic characteristics and low transmittance. For example, the ohmic layer 140 may comprise at least one selected from the group consisting of Pt, Ni, Au, Rh and Pd or a mixture thereof.

[61] The ohmic layer 140 is formed on the upper surface of the reflective layer 120 so that the outer side of the ohmic layer 140 is not exposed to the sidewall of a device. Further, the ohmic layer 140 can be formed on the entire surface of the reflective layer

120.

[62] Referring to FIG. 5, after the ohmic layer 140 is formed, the conductive support member 150 may be formed on the ohmic layer 140. The conductive support member 150 may comprise copper, gold, carrier wafer (e.g. Si, Ge, GaAs, ZnO, SiC) and the like. For example, the conductive support member 150 may be formed using plating or wafer bonding technology. The scope of the present invention is not limited thereto. The ohmic layer 140 and the conductive support member 150 serve as the second electrode layer.

[63] Referring to FIGS. 6 and 7, if the conductive support member 150 is formed, the conductive support member 150 serves as a base, so that the substrate 101 can be removed. The substrate 101 can be removed using a physical method and/or a chemical method. According to the physical method, the substrate 101 is separated using an LLO (laser lift off) scheme of irradiating laser having predetermined wavelength onto the substrate 101. According to the chemical method, the buffer layer 103 is removed by injecting etchant solution into the buffer layer 103 so that the substrate 101 can be separated.

[64] After the substrate 101 is removed, a process of removing Ga oxide relative to the surface of the buffer layer 103 is performed. The process may not be performed.

[65] Referring to FIGS. 7 and 8, the buffer layer 103 is removed. The buffer layer 103 can be removed using a dry etching process, a wet etching process or a polishing process. At this time, if the buffer layer 103 is doped with a conductive dopant, the buffer layer 103 may not be removed.

[66] Referring to FIGS. 9 and 10, the roughness 112 may be formed on a part A2 of the upper surface of the first conductive semiconductor layer 111, or on the entire surface of the first conductive semiconductor layer 111.

[67] The roughness 112 may have a concave-convex shape using a dry etching method, and the concave-convex shape may be changed. The roughness 112 may not be formed.

[68] The first electrode 151 having a predetermined pattern is formed on the upper surface of the first conductive semiconductor layer 111.

[69] FIG. 11 is a side sectional view illustrating a semiconductor light emitting device according to a second embodiment. In the second embodiment, the description about elements and functions identical to those of the first embodiment will be omitted in order to avoid redundancy.

[70] Referring to FIG. 11, in the semiconductor light emitting device 100A, the reflective

layer 120 having a plurality of island shape is formed under the second conductive semiconductor layer 115, and the ohmic layer 140 is formed under the reflective layer 120 and the second conductive semiconductor layer 115. Herein, the reflective layer 120 may be formed with a concave-convex shape.

[71] The reflective layer 120 be formed under the second conductive semiconductor layer 115 of the light emitting structure 110, and a convex section 145 of the ohmic layer 140 is formed between the islands of the reflective layer 120.

[72] The reflective layer 120 and the convex section 145 of the ohmic layer 140 may be formed on the lower surface of the second conductive semiconductor layer 115.

[73] As disclosed above, in the embodiments, the thickness of the first medium 121 or the second medium 131 and the number of pairs of the first medium 121 and the second medium 131 are adjusted according to the wavelength of light emitted from the light emitting device, so that high reflectance can be provided. The reflective layer 120 has high reflection characteristics in a wavelength range of 300nm to 700nm.

[74] In the description of the embodiments, it will be understood that, when a layer (or film), a region, a pattern, or a structure is referred to as being "on" or "under another su bstrate, another layer (or film), another region, another pad, or another pattern, it can be "directly" or "indirectly" on the other substrate, layer (or film), region, pad, or pattern, or one or more intervening layers may also be present. Reference about the term "on" or "under" of each layer will be described with reference to the accompanying drawings.

[75] Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

Industrial Applicability

[76] The embodiment can provide a vertical semiconductor light emitting device.

[77] The embodiment can improve external light-emitting efficiency.

[78] The embodiment can improve the reliability of a semiconductor light emitting device.

Claims

[1] A semiconductor light emitting device comprising:
a light emitting structure comprising a III-V group compound semiconductor layer;
a reflective layer comprising mediums, which are different from each other and alternately stacked under the light emitting structure; and
a second electrode layer under the reflective layer.

[2] The semiconductor light emitting device as claimed in claim 1, wherein the reflective layer comprises pairs of a first medium having a first refractive index and a second medium having a second refractive index under the first medium, and a number of the pairs is at least 10.

[3] The semiconductor light emitting device as claimed in claim 1, wherein the reflective layer comprises pairs of a first medium having first thickness and a second medium having second thickness under the first medium, and a number of the pairs is at least 10.

[4] The semiconductor light emitting device as claimed in claim 1, wherein the mediums in the reflective layer comprise AlN and GaN layers, respectively.

[5] The semiconductor light emitting device as claimed in claim 1, wherein the reflective layer has an AlN-GaN pair or a GaN-AlN pair, and a number of the pair is 10 to 30.

[6] The semiconductor light emitting device as claimed in claim 4, wherein the AlN layer has thickness of 35㎚ to 80㎚ and the GaN layer has thickness of 30㎚ to 75㎚.

[7] The semiconductor light emitting device as claimed in claim 1, wherein the reflective layer is formed by stacking 30 pairs or less of two materials, which have refractive indexes different from each other and are selected from the group consisting of GaN, InN, AlN, InGaN, AlGaN, InAlGaN and AlInN.

[8] The semiconductor light emitting device as claimed in claim 1, comprising:
an ohmic layer under the reflective layer; and
a conductive support member under the ohmic layer,
wherein the ohmic layer comprises one selected from the group consisting of Pt, Ni, Au, Rh and Pd.

[9] The semiconductor light emitting device as claimed in claim 1, comprising roughness and a first electrode formed on a first conductive semiconductor layer.

[10] The semiconductor light emitting device as claimed in claim 1, wherein the reflective layer has a concave-convex shape under the light emitting structure, and the second electrode layer makes electric contact with the reflective layer and the light emitting structure under the reflective layer and the light emitting structure.

[11] The semiconductor light emitting device as claimed in claim 1, wherein the light emitting structure comprises:
a first conductive semiconductor layer having a first electrode;
an active layer under the first conductive semiconductor layer; and
a second conductive semiconductor layer between the active layer and the reflective layer.

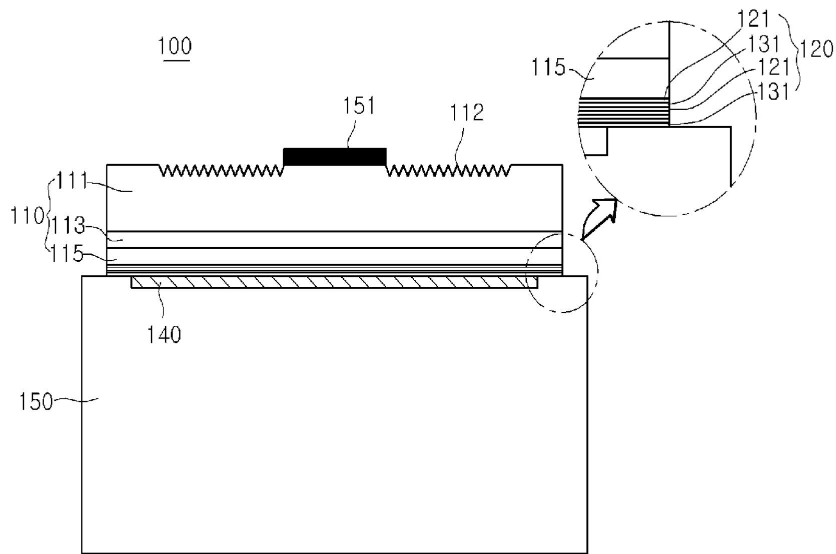
[12] A semiconductor light emitting device comprising:
a light emitting structure comprising a first conductive semiconductor layer, an active layer under the first conductive semiconductor layer, and a second conductive semiconductor layer under the active layer;
a reflective layer comprising a first medium having a first refractive index and a second medium having a second refractive index under the light emitting structure; and
a second electrode layer under the reflective layer.

[13] The semiconductor light emitting device as claimed in claim 12, wherein the first medium and the second medium of the reflective layer is formed with a conductivity material.

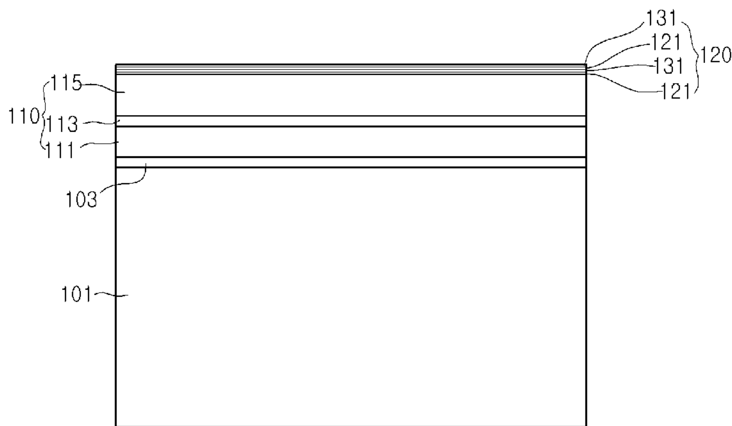
[14] The semiconductor light emitting device as claimed in claim 12, wherein the first medium has thickness of 35nm to 80nm, the second medium has thickness of 30nm to 75nm and the first medium has thickness different from thickness of the second medium.

[15] The semiconductor light emitting device as claimed in claim 12, wherein the reflective layer has a concave-convex shape or a plurality of island shape, and the second electrode layer makes electric contact with the reflective layer and the light emitting structure under the reflective layer and the light emitting structure.

[Fig. 1]

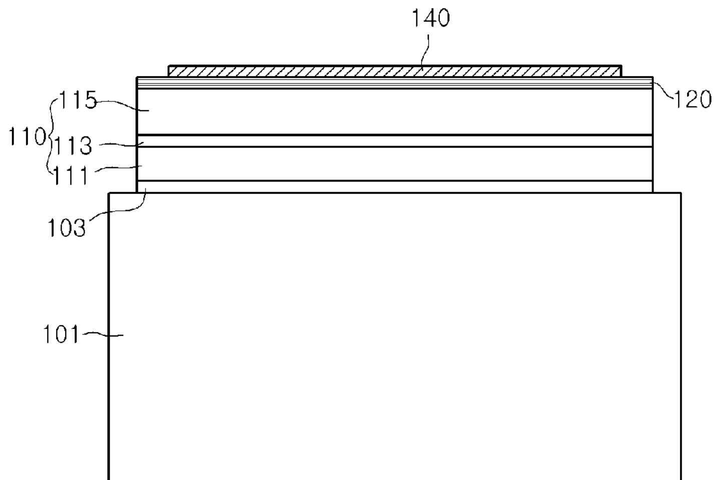


[Fig. 2]

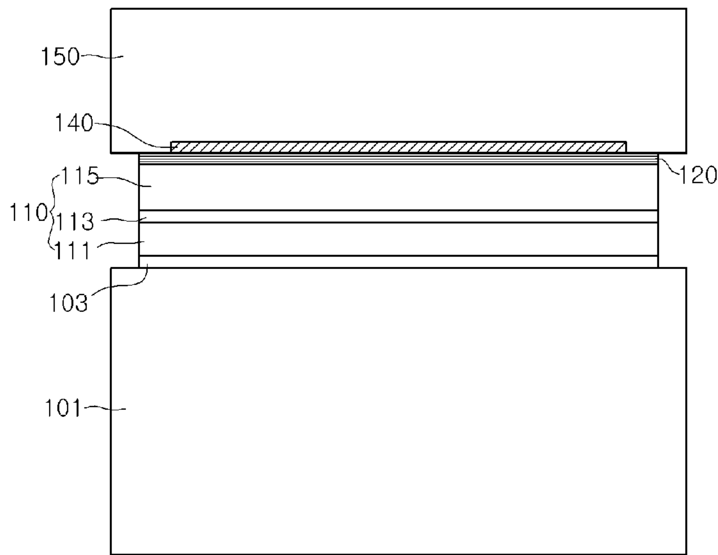


[Fig. 3]

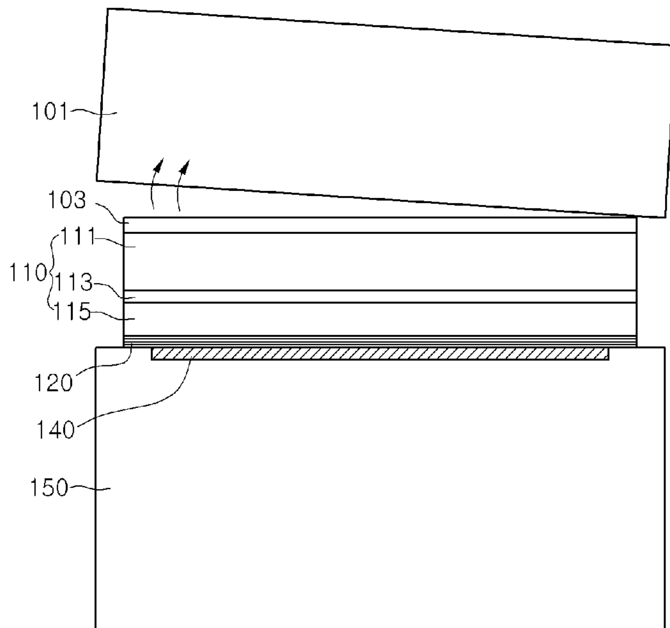
[Fig. 4]



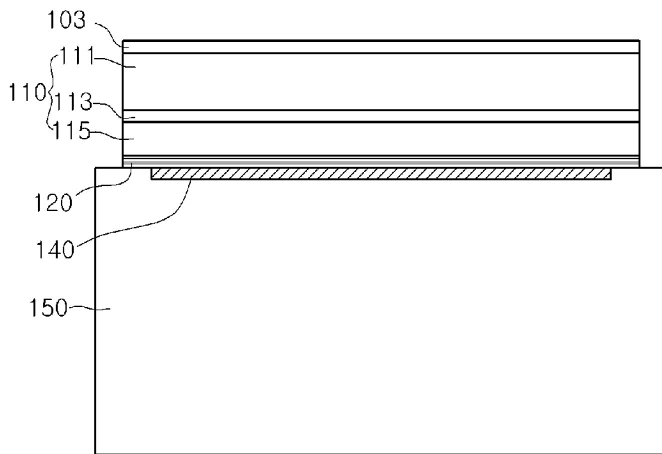
[Fig. 5]



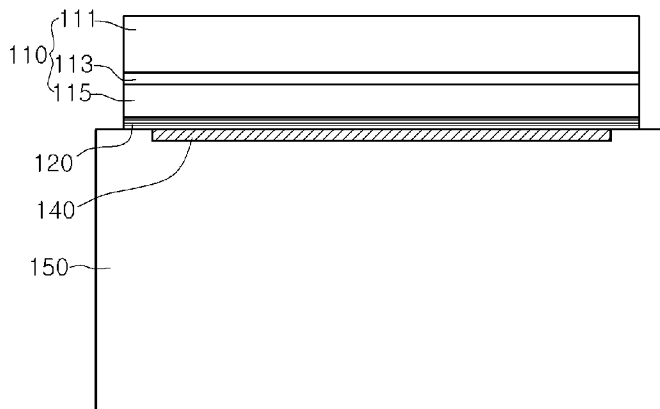
[Fig. 6]



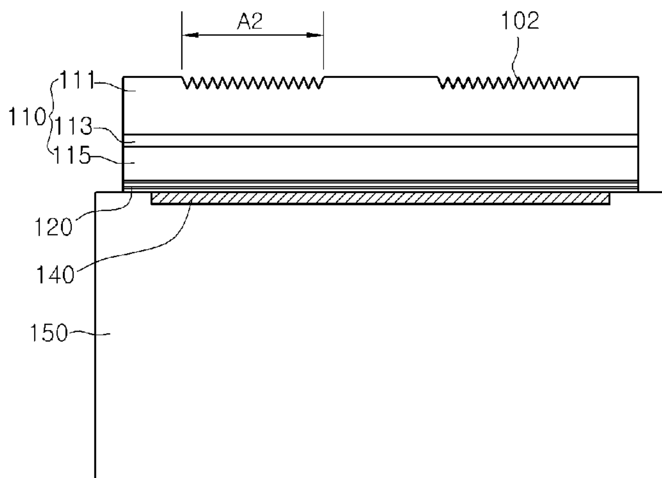
[Fig. 7]



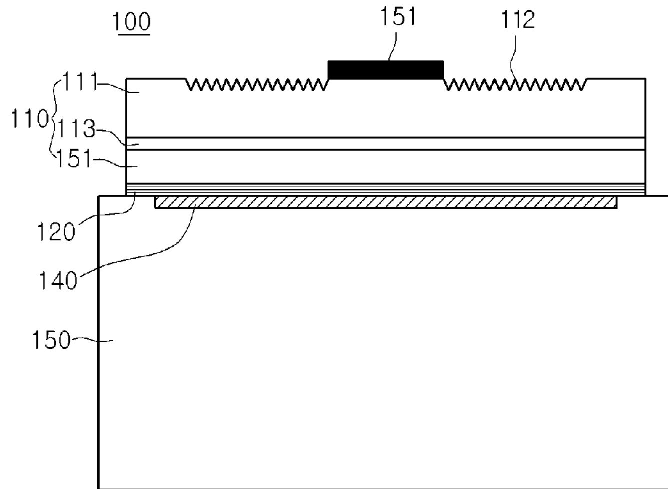
[Fig. 8]



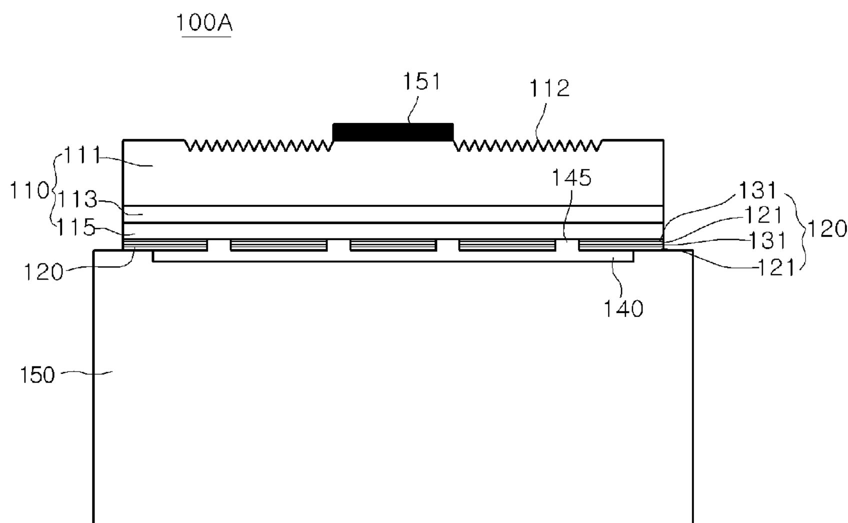
[Fig. 9]



[Fig. 10]



[Fig. 11]



[Fig. 12]