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Lee(10) **Pub. No.: US 2009/0315050 A1**(43) **Pub. Date: Dec. 24, 2009**(54) **SEMICONDUCTOR LIGHT EMITTING
DEVICE**(75) Inventor: **Sang Youl Lee**, Gwangju (KR)

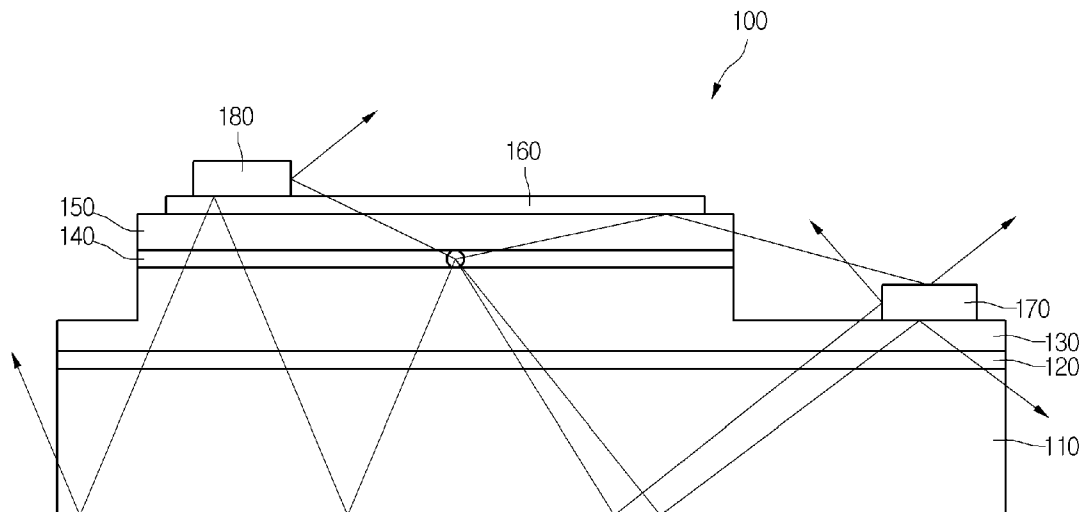
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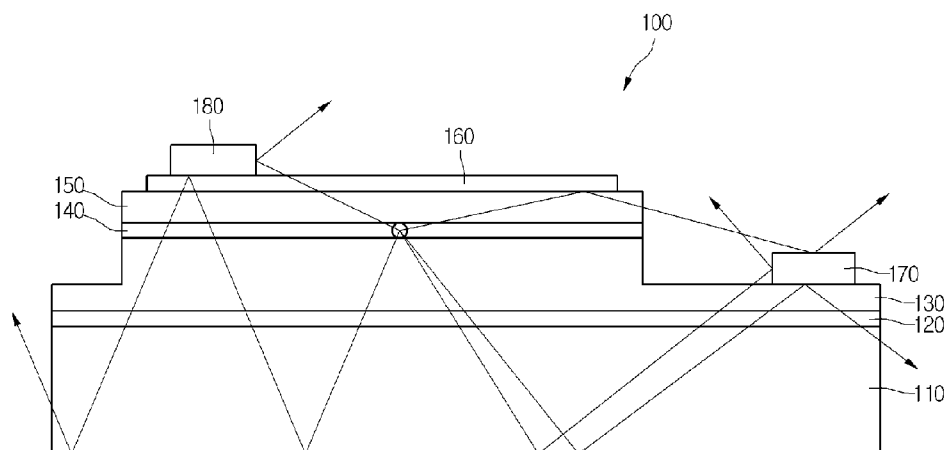
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257/E33.067**(57) **ABSTRACT**

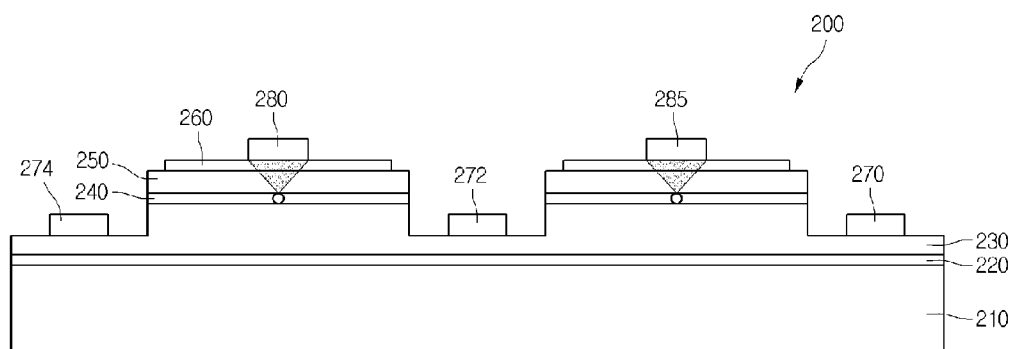
Disclosed is a semiconductor light emitting device. The semiconductor light emitting device comprises a first semiconductor layer, a second semiconductor layer, an active layer formed between the first semiconductor layer and the second semiconductor layer, a first reflective electrode on the first semiconductor layer to reflect incident light, and a second reflective electrode on the second semiconductor layer to reflect the incident light.



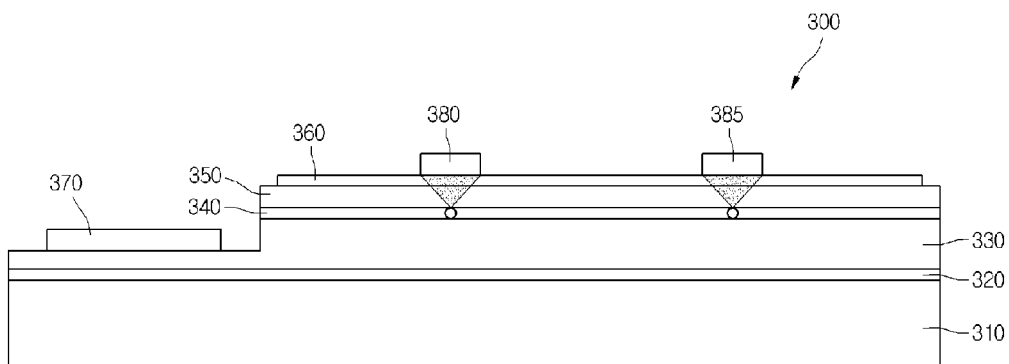
[Fig. 1]



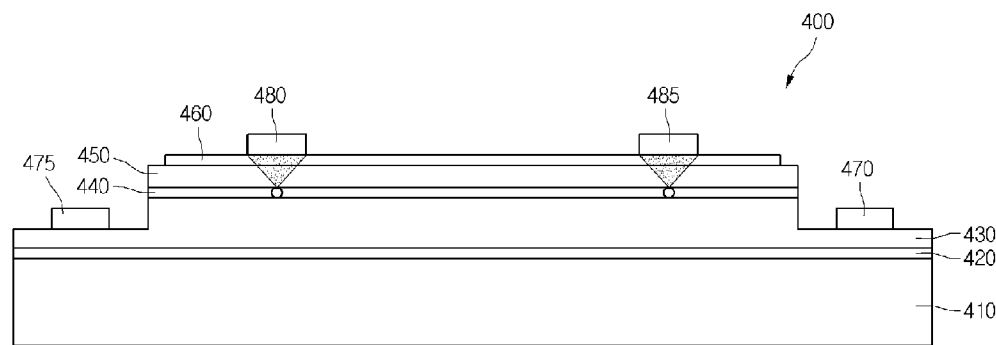
[Fig. 2]



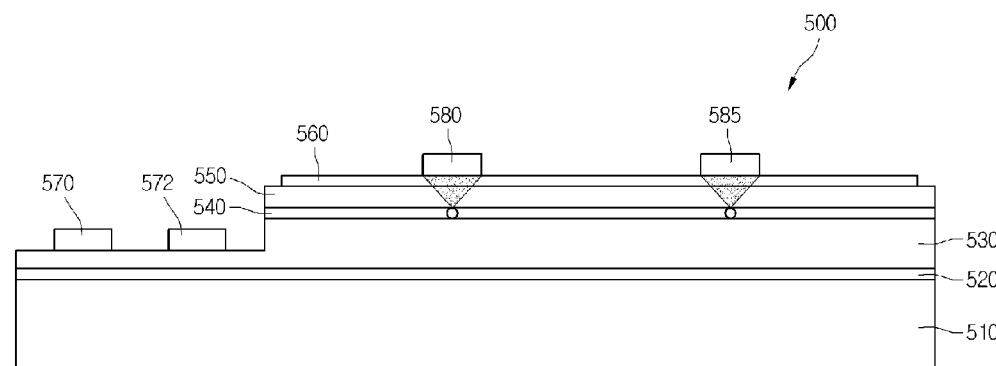
[Fig. 3]



[Fig. 4]



[Fig. 5]



SEMICONDUCTOR LIGHT EMITTING DEVICE

TECHNICAL FIELD

[0001] The embodiment relates to a semiconductor light emitting device.

BACKGROUND ART

[0002] A semiconductor light emitting device comprises an LED (light emitting diode), an LD (laser diode) and the like. A semiconductor light emitting device is used to convert electrical signals into infrared rays, visible rays and the like by using the characteristics of a compound semiconductor and to exchange the converted signals.

[0003] In general, an LED has been widely used for household electrical appliances, remote controllers, electric light boards, indicators, and various automation devices, and is largely classified as an IRED (infrared emitting diode) and a VLED (visible light emitting diode).

[0004] In general, an LED having a small size is fabricated in the form of a surface mount device so that the LED is directly mounted on a PCB (printed circuit board). Accordingly, an LED lamp used as a display device is also fabricated in the form of a surface mount device. Such a surface mount device can replace an existing simple lighting lamp and is used as a lighting indicator producing various colors, a character indicator, an image indicator and the like.

[0005] As described above, such a semiconductor light emitting device has been used for various fields, for example, electric lights for daily life, electric lights for outputting rescue signals and the like. Further, demand for a high brightness semiconductor light emitting device has increased more and more. Thus, a high-power light emitting device has been actively developed.

DISCLOSURE OF INVENTION

Technical Problem

[0006] The embodiment provides a semiconductor light emitting device capable of improving the total light emitting efficiency by preventing light generated from an active layer from being absorbed by electrodes.

Technical Solution

[0007] An embodiment provides a semiconductor light emitting device comprising: a first semiconductor layer; a second semiconductor layer; an active layer formed between the first semiconductor layer and the second semiconductor layer; a first reflective electrode on the first semiconductor layer to reflect incident light; and a second reflective electrode on the second semiconductor layer to reflect the incident light.

[0008] An embodiment provides a semiconductor light emitting device comprising: a first semiconductor layer; a second semiconductor layer; an active layer formed between the first semiconductor layer and the second semiconductor layer; a first electrode on the first semiconductor layer; and a second electrode on the second semiconductor layer, wherein

at least one of the first electrode and the second electrode is divided into a plurality of electrodes.

ADVANTAGEOUS EFFECTS

[0009] According to the embodiment, light generated from an active layer is prevented from being absorbed by electrodes, so that the total light emitting efficiency can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a sectional view schematically showing the stack structure of a semi-conductor light emitting device according to a first embodiment;

[0011] FIG. 2 is a sectional view schematically showing the stack structure of a semi-conductor light emitting device according to a second embodiment;

[0012] FIG. 3 is a sectional view schematically showing the stack structure of a semi-conductor light emitting device according to a third embodiment;

[0013] FIG. 4 is a sectional view schematically showing the stack structure of a semi-conductor light emitting device according to a fourth embodiment; and

[0014] FIG. 5 is a sectional view schematically showing the stack structure of a semi-conductor light emitting device according to a fifth embodiment.

MODE FOR THE INVENTION

[0015] In the description of an embodiment, 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 substrate, 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.

[0016] Hereinafter, embodiments will be described with reference to the accompanying drawings.

[0017] FIG. 1 is a sectional view schematically showing the stack structure of a semi-conductor light emitting device according to a first embodiment.

[0018] As shown in FIG. 1, the semiconductor light emitting device 100 according to the first embodiment comprises a substrate 110, a buffer layer 120, a first semiconductor layer for example, an n-type semiconductor layer 130, an active layer 140, a second semiconductor layer for example, a p-type semiconductor layer 150, a transparent electrode 160, a first reflective electrode for example, an n-type reflective electrode 170, and a second reflective electrode for example, a p-type reflective electrode 180.

[0019] First, the substrate 110 is formed of one selected from the group consisting of Al_2O_3 , Si, SiC, GaAs, ZnO, MgO or a compound thereof.

[0020] The buffer layer 120 may have a stack structure such as AlInN/GaN , $\text{In}_x\text{Ga}_{1-x}\text{N}/\text{GaN}$, $\text{Al}_x\text{In}_y\text{Ga}_{1-x-y}\text{N}/\text{In}_x\text{Ga}_{1-x}\text{N}/\text{GaN}$ and the like.

[0021] The n-type semiconductor layer 130 and the p-type semiconductor layer 150 may comprise nitride semiconductor layers, respectively.

[0022] The active layer 140 is formed between the n-type semiconductor layer 130 and the p-type semiconductor layer 150. The active layer 140 may have a single quantum well structure or a multi-quantum well structure.

[0023] The transparent electrode 160 is formed on the p-type semiconductor layer 150. The transparent electrode

160 comprises materials that have superior light transmittance and increase diffusion of electric current. The transparent electrode **160** may be formed of transparent conductive oxide layer, such as ITO, CTO, SnO_2 , ZnO, RuO_x , TiO_x , IrO_x or Ga_xO_y .

[0024] The p-type reflective electrode **180** is formed on the transparent electrode **160**, and the n-type reflective electrode **170** is formed on the n-type semiconductor layer **130**.

[0025] The p-type reflective electrode **180** and the n-type reflective electrode **170** comprise metal containing reflective material to serve as a bonding pad. The p-type reflective electrode **180** and the n-type reflective electrode **170** comprise reflective material such as Ag or Al to have a single layer structure or a multi-layer structure.

[0026] Further, the transparent electrode **160** and the n-type reflective electrode **170** serve as an ohmic contact layer.

[0027] For example, the n-type reflective electrode **170** can be formed with an ohmic contact layer by using reflective material such as Al. Further, the n-type reflective electrode **170** can be formed with an ohmic contact layer by using Ti, Cr and the like. Furthermore, the n-type reflective electrode **170** may have a thickness less than several nm in order to increase the reflectivity of a reflective layer.

[0028] Further, the transparent electrode **160** is located below the p-type reflective electrode **180**. The transparent electrode **160** serves as an ohmic contact layer. Accordingly, the p-type reflective electrode **180** can serve as a reflective layer. In addition, the p-type reflective electrode **180** can be prepared in the form of a bonding pad, in which an ohmic contact layer is formed by Ti or Cr having a thickness less than several nm and a reflective layer is additionally formed.

[0029] According to the semiconductor light emitting device **100** of the first embodiment as described above, the n-type and p-type reflective electrodes **170** and **180** are provided thereto, so that the light generated from the active layer **140** can be prevented from being absorbed by the n-type and p-type reflective electrodes **170** and **180**. The light generated from the active layer **140** is reflected from the side or bottom surfaces of the n-type and p-type reflective electrodes **170** and **180** instead of being absorbed by the n-type and p-type reflective electrodes **170** and **180**.

[0030] Accordingly, the semiconductor light emitting device **100** of the first embodiment can improve the brightness thereof. Further, the semiconductor light emitting device **100** of the first embodiment can be applied to a low-power semiconductor light emitting device as well as a high-power semiconductor light emitting device.

[0031] Meanwhile, the embodiment proposes a scheme for dividing a reflective electrode in order to further improve the brightness of the semiconductor light emitting device. FIGS. 2 to 5 show an example of the semiconductor light emitting device comprising divided reflective electrodes.

[0032] As shown in FIGS. 2 to 5, when dividing a reflective electrode, either an n-type reflective electrode or a p-type reflective electrode can be divided, or both the n-type reflective electrode and the p-type reflective electrode can also be divided. Further, the divided n-type reflective electrodes are electrically interconnected, and the divided p-type reflective electrodes are also electrically interconnected. For example, the divided n-type reflective electrodes can be patterned on the same plane and the divided p-type reflective electrodes can also be patterned on the same plane.

[0033] FIG. 2 is a sectional view schematically showing the stack structure of a semiconductor light emitting device according to a second embodiment.

[0034] As shown in FIG. 2, the semiconductor light emitting device **200** according to the second embodiment comprises a substrate **210**, a buffer layer **220**, an n-type semiconductor layer **230**, an active layer **240**, a p-type semiconductor layer **250**, a transparent electrode **260**, p-type reflective electrodes **280** and **285**, and n-type reflective electrodes **270**, **272** and **274**.

[0035] According to the semiconductor light emitting device **200** of the second embodiment, two p-type reflective electrodes **280** and **285** and three n-type reflective electrodes **270**, **272** and **274** are formed.

[0036] The two p-type reflective electrodes **280** and **285** formed through division are electrically interconnected. According to one example, the two p-type reflective electrodes **280** and **285** can be patterned on the same plane in the form of a substantial '⌐' shape.

[0037] Further, the three n-type reflective electrodes **270**, **272** and **274** formed through division are electrically interconnected. The three n-type reflective electrodes **270**, **272** and **274** can be patterned on the same plane.

[0038] The two p-type reflective electrodes **280** and **285** are formed on the transparent electrode **260**, and the three n-type reflective electrodes **270**, **272** and **274** are formed on the n-type semiconductor layer **230**.

[0039] As described above, the two p-type reflective electrodes **280** and **285** and the three n-type reflective electrodes **270**, **272** and **274** are formed through division, so that various light paths can be ensured even when an area, in which the reflective electrodes are formed in the second embodiment, is equal to that in which the reflective electrodes are formed in the first embodiment. Accordingly, the light generated from the active layer **240** can be more efficiently emitted to the upward direction. As a result, the brightness of the semiconductor light emitting device comprising the divided reflective electrodes can be increased more and more.

[0040] The second embodiment shows an example in which the electrodes formed through division are reflective electrodes. However, the electrodes formed through division may be typical electrodes, other than the reflective electrodes, which are applied to fields related to a semiconductor light emitting device.

[0041] FIG. 3 is a sectional view schematically showing the stack structure of a semiconductor light emitting device according to a third embodiment.

[0042] As shown in FIG. 3, the semiconductor light emitting device **300** according to the third embodiment comprises a substrate **310**, a buffer layer **320**, an n-type semiconductor layer **330**, an active layer **340**, a p-type semiconductor layer **350**, a transparent electrode **360**, p-type reflective electrodes **380** and **385**, and an n-type reflective electrode **370**.

[0043] According to the semiconductor light emitting device **300** of the third embodiment, two p-type reflective electrodes **380** and **385** and one n-type reflective electrode **370** are formed.

[0044] The two p-type reflective electrodes **380** and **385** formed through division are electrically interconnected. According to one example, the two p-type reflective electrodes **380** and **385** can be patterned on the same plane in the form of a substantial '⌐' shape.

[0045] The two p-type reflective electrodes 380 and 385 are formed on the transparent electrode 360, and the one n-type reflective electrode 370 is formed on the n-type semiconductor layer 330.

[0046] As described above, the two p-type reflective electrodes 380 and 385 are formed through division, so that various light paths can be ensured and the light generated from the active layer 340 can be more efficiently emitted to the upward direction. Accordingly, the brightness of the semiconductor light emitting device comprising the divided reflective electrodes can be increased more and more.

[0047] The third embodiment shows an example in which the electrodes formed through division are reflective electrodes. However, the electrodes formed through division may be typical electrodes, other than the reflective electrodes, which are applied to fields related to a semiconductor light emitting device.

[0048] FIG. 4 is a sectional view schematically showing the stack structure of a semi-conductor light emitting device according to a fourth embodiment.

[0049] As shown in FIG. 4, the semiconductor light emitting device 400 according to the fourth embodiment comprises a substrate 410, a buffer layer 420, an n-type semiconductor layer 430, an active layer 440, a p-type semiconductor layer 450, a transparent electrode 460, p-type reflective electrodes 480 and 485, and n-type reflective electrodes 470 and 475.

[0050] According to the semiconductor light emitting device 400 of the fourth embodiment, two p-type reflective electrodes 480 and 485 and two n-type reflective electrodes 470 and 475 are formed.

[0051] The two p-type reflective electrodes 480 and 485 formed through division are electrically interconnected. According to one example, the two p-type reflective electrodes 480 and 485 can be patterned on the same plane in the form of a substantial 'C' shape.

[0052] The two n-type reflective electrodes 470 and 475 formed through division are electrically interconnected. The two n-type reflective electrodes 470 and 475 can be patterned on the same plane in the form of a substantial 'C' shape.

[0053] The two p-type reflective electrodes 480 and 485 are formed on the transparent electrode 460, and the two n-type reflective electrodes 470 and 475 are formed on the n-type semiconductor layer 430.

[0054] As described above, the two p-type reflective electrodes 480 and 485 and the two n-type reflective electrodes 470 and 475 are formed through division, so that various light paths can be ensured and the light generated from the active layer 440 can be more efficiently emitted to the upward direction. Accordingly, the brightness of the semiconductor light emitting device comprising the divided reflective electrodes can be increased more and more.

[0055] The fourth embodiment shows an example in which the electrodes formed through division are reflective electrodes. However, the electrodes formed through division may also comprise typical electrodes, other than the reflective electrodes, which are applied to fields related to a semiconductor light emitting device.

[0056] FIG. 5 is a sectional view schematically showing the stack structure of a semi-conductor light emitting device according to a fifth embodiment.

[0057] As shown in FIG. 5, the semiconductor light emitting device 500 according to the fifth embodiment comprises a substrate 510, a buffer layer 520, an n-type semi-conductor

layer 530, an active layer 540, a p-type semiconductor layer 550, a transparent electrode 560, p-type reflective electrodes 580 and 585, and n-type reflective electrodes 570 and 572.

[0058] According to the semiconductor light emitting device 500 of the fifth embodiment, two p-type reflective electrodes 580 and 585 and two n-type reflective electrodes 570 and 572 are formed.

[0059] The two p-type reflective electrodes 580 and 585 formed through division are electrically interconnected. According to one example, the two p-type reflective electrodes 580 and 585 can be patterned on the same plane in the form of a substantial 'C' shape.

[0060] The two n-type reflective electrodes 570 and 572 formed through division are electrically interconnected. The two n-type reflective electrodes 570 and 572 can be patterned on the same plane in the form of a substantial 'C' shape.

[0061] The two p-type reflective electrodes 580 and 585 are formed on the transparent electrode 560, and the two n-type reflective electrodes 570 and 572 are adjacently formed on the n-type semiconductor layer 530.

[0062] As described above, the two p-type reflective electrodes 580 and 585 and the two n-type reflective electrodes 570 and 572 are formed through division, so that various light paths can be ensured and the light generated from the active layer 540 can be more efficiently emitted to the upward direction. Accordingly, the brightness of the semiconductor light emitting device comprising the divided reflective electrodes can be increased more and more.

[0063] The fifth embodiment shows an example in which the electrodes formed through division are reflective electrodes. However, the electrodes formed through division may be typical electrodes, other than the reflective electrodes, which are applied to fields related to a semiconductor light emitting device.

[0064] According to the embodiments as described above, the number of the reflective electrodes formed through division is two or three. However, the number of the reflective electrodes formed through division can be varied according to the design thereof.

[0065] Further, the embodiments show an example of the P-N junction semiconductor light emitting device in which the p-type semiconductor layer is formed on the n-type semiconductor layer. However, the embodiment can be applied to an N-P-N junction semi-conductor light emitting device in which an n-type semiconductor layer is additionally formed on the p-type semiconductor layer. The N-P-N junction semiconductor light emitting device denotes a semiconductor light emitting device in which both first and second electrode layers are provided as n-type semiconductor layers, and a p-type semiconductor layer is formed between the n-type semiconductor layers. At this time, a first electrode is formed on the first electrode layer, which is the n-type semiconductor layer, while making contact with the first electrode layer. A second electrode is formed on the second electrode layer, which is the n-type semiconductor layer, while making contact with the second electrode layer.

[0066] Any reference in this specification to "one embodiment", "an embodiment", "example embodiment", etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is

described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments.

[0067] 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

[0068] According to the embodiments as described above, the semiconductor light emitting device comprises a plurality of divided reflective electrodes as electrodes, so that the light generated from the active layer can be transmitted in the upward direction through gaps between the electrodes or reflected from the electrodes instead of being absorbed by the electrodes. Consequently, the total light emitting efficiency of the semiconductor light emitting device can be improved.

1. A semiconductor light emitting device comprising:
 - a first semiconductor layer;
 - a second semiconductor layer;
 - an active layer formed between the first semiconductor layer and the second semiconductor layer;
 - a first reflective electrode on the first semiconductor layer to reflect incident light; and
 - a second reflective electrode on the second semiconductor layer to reflect the incident light.
2. The semiconductor light emitting device as claimed in claim 1, comprising a transparent electrode formed between the second semiconductor layer and the second reflective electrode, and wherein the first semiconductor layer is a n-type semiconductor layer and the second semiconductor layer is a p-type semiconductor layer.
3. The semiconductor light emitting device as claimed in claim 2, wherein the transparent electrode is formed of transparent conductive oxide layer.
4. The semiconductor light emitting device as claimed in claim 2, wherein the transparent electrode comprises material selected from the group consisting of ITO, CTO, SnO_2 , ZnO, RuO_x , TiO_x , IrO_x and Ga_xO_y .
5. The semiconductor light emitting device as claimed in claim 1, wherein the first reflective electrode comprises a plurality of divided electrodes.
6. The semiconductor light emitting device as claimed in claim 5, wherein the divided electrodes are electrically interconnected and formed on the same plane.
7. The semiconductor light emitting device as claimed in claim 1, wherein the first reflective electrode is formed on the first semiconductor layer that is formed at the both sides of the second semiconductor layer, or the first reflective electrode is

formed on the first semiconductor layer that is formed at the both sides of the second semiconductor layer and at the divided portion of the second semiconductor layer.

8. The semiconductor light emitting device as claimed in claim 1, wherein the second reflective electrode comprises a plurality of divided electrodes.

9. The semiconductor light emitting device as claimed in claim 8, wherein the divided electrodes are electrically interconnected.

10. The semiconductor light emitting device as claimed in claim 8, wherein the divided electrodes are formed of '⌌' shape.

11. The semiconductor light emitting device as claimed in claim 1, wherein at least one of the first reflective electrode and the second reflective electrode is formed in the form of a single layer comprising Ag or Al, or a multi-layer comprising Ag or Al.

12. The semiconductor light emitting device as claimed in claim 1, wherein light generated from the active layer is emitted in an upward direction toward the first reflective electrode and the second reflective electrode.

13. A semiconductor light emitting device comprising:

- a first semiconductor layer;
 - a second semiconductor layer;
 - an active layer formed between the first semiconductor layer and the second semiconductor layer;
 - a first electrode on the first semiconductor layer; and
 - a second electrode on the second semiconductor layer,
- wherein at least one of the first electrode and the second electrode is divided into a plurality of electrodes.

14. The semiconductor light emitting device as claimed in claim 13, comprising a transparent electrode formed between the second semiconductor layer and the second electrode, and wherein the first semiconductor layer is a n-type semiconductor layer and the second semiconductor layer is a p-type semiconductor layer.

15. The semiconductor light emitting device as claimed in claim 14, wherein the transparent electrode is formed of transparent conductive oxide layer.

16. The semiconductor light emitting device as claimed in claim 14, wherein the transparent electrode comprises material selected from the group consisting of ITO, CTO, SnO_2 , ZnO, RuO_x , TiO_x , IrO_x and Ga_xO_y .

17. The semiconductor light emitting device as claimed in claim 13, wherein the divided first or second electrodes are electrically interconnected.

18. The semiconductor light emitting device as claimed in claim 13, wherein the first electrode is divided to two or three parts, and the second electrode is divided to two parts.

19. The semiconductor light emitting device as claimed in claim 13, wherein the first and second electrodes are formed with reflective electrodes that reflect incident light.

20. The semiconductor light emitting device as claimed in claim 13, at least one of the first electrode and the second electrode is formed in the form of a single layer comprising Ag or Al, or a multi-layer comprising Ag or Al.

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