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(54) **LIGHT EMITTING DIODE AND METHOD OF MAKING THE SAME**

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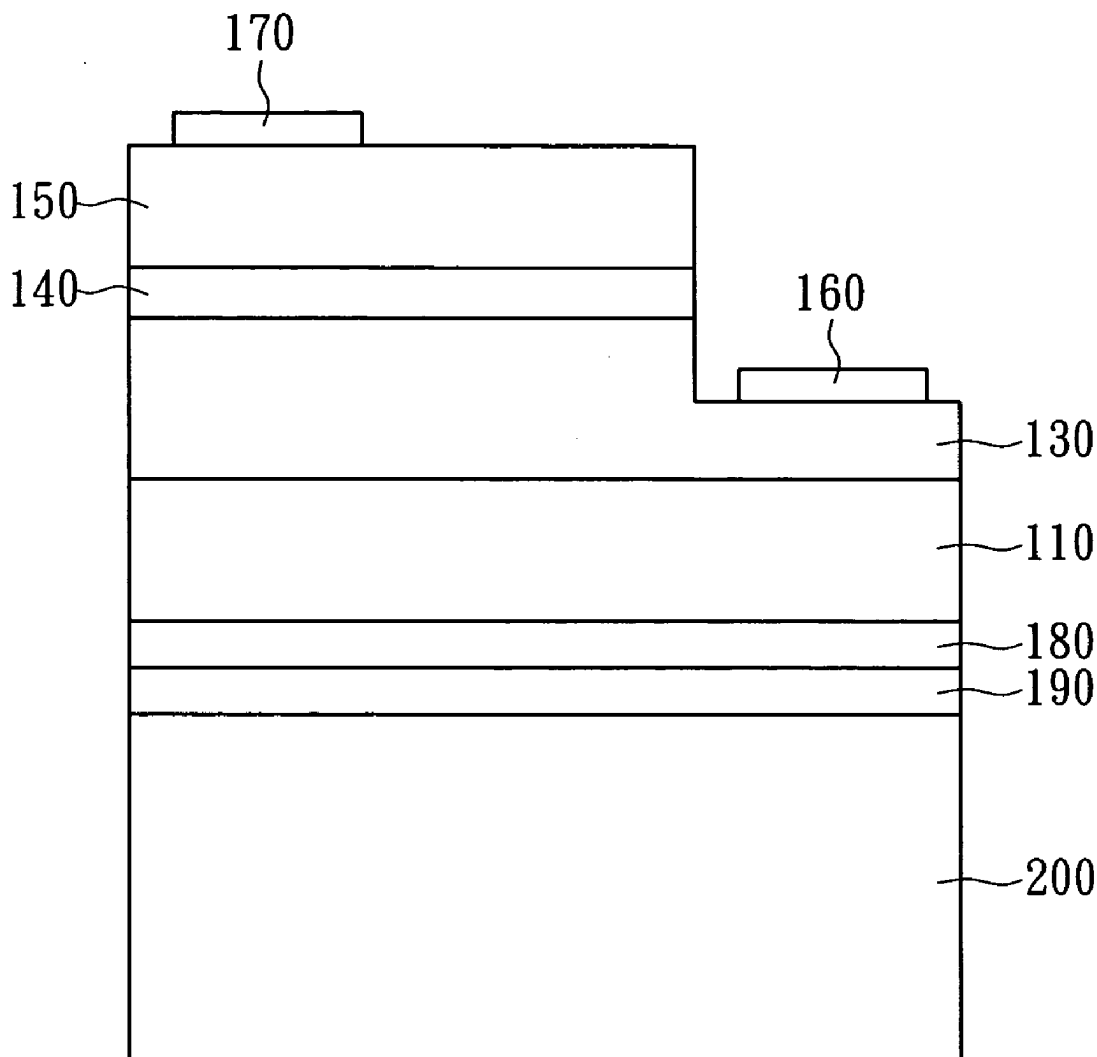
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(57) **ABSTRACT**

A light emitting diode (LED) and a method of making the same are disclosed. The present invention is featured in that the LED comprises a transparent heat-conductive glue, a reflective layer, and a carrier, etc, wherein the transparent heat-conductive glue is used to adhere the epitaxial structure and the carrier of the LED; the reflective layer can make the light emitted by the epitaxial structure to be reflected more efficiently; and the carrier is used to enhance the heat-dissipation effect of the LED. Moreover, the transparent heat-conductive glue and the reflective layer can be replaced with one single adhesive reflective layer having functions of adhesion and reflection simultaneously.



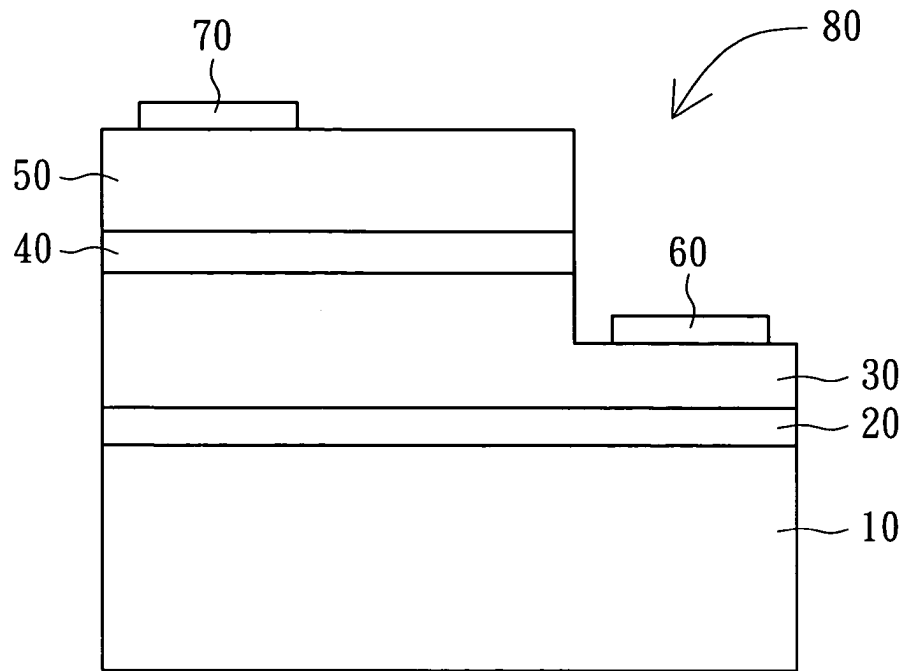


FIG. 1(PRIOR ART)

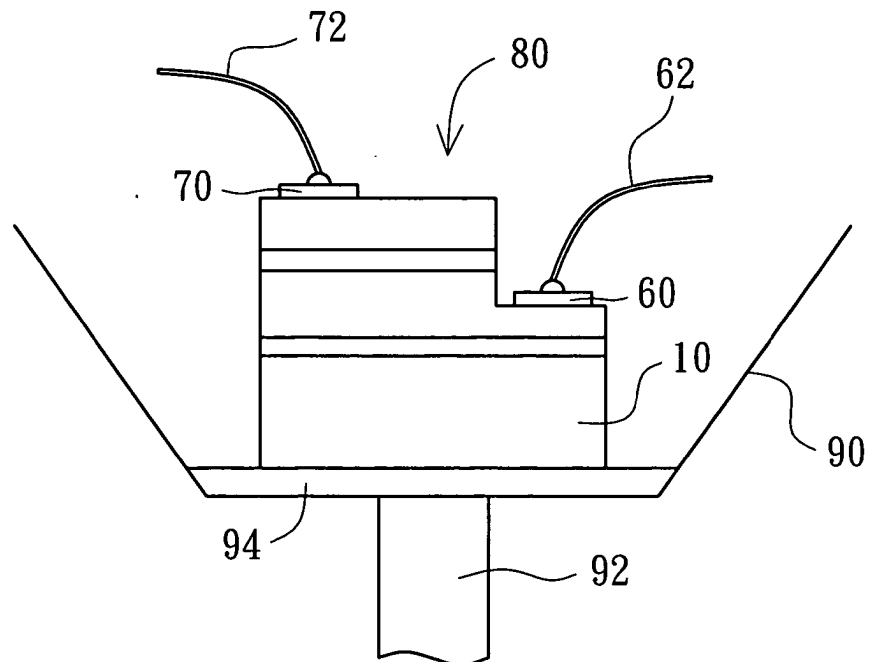


FIG. 2(PRIOR ART)

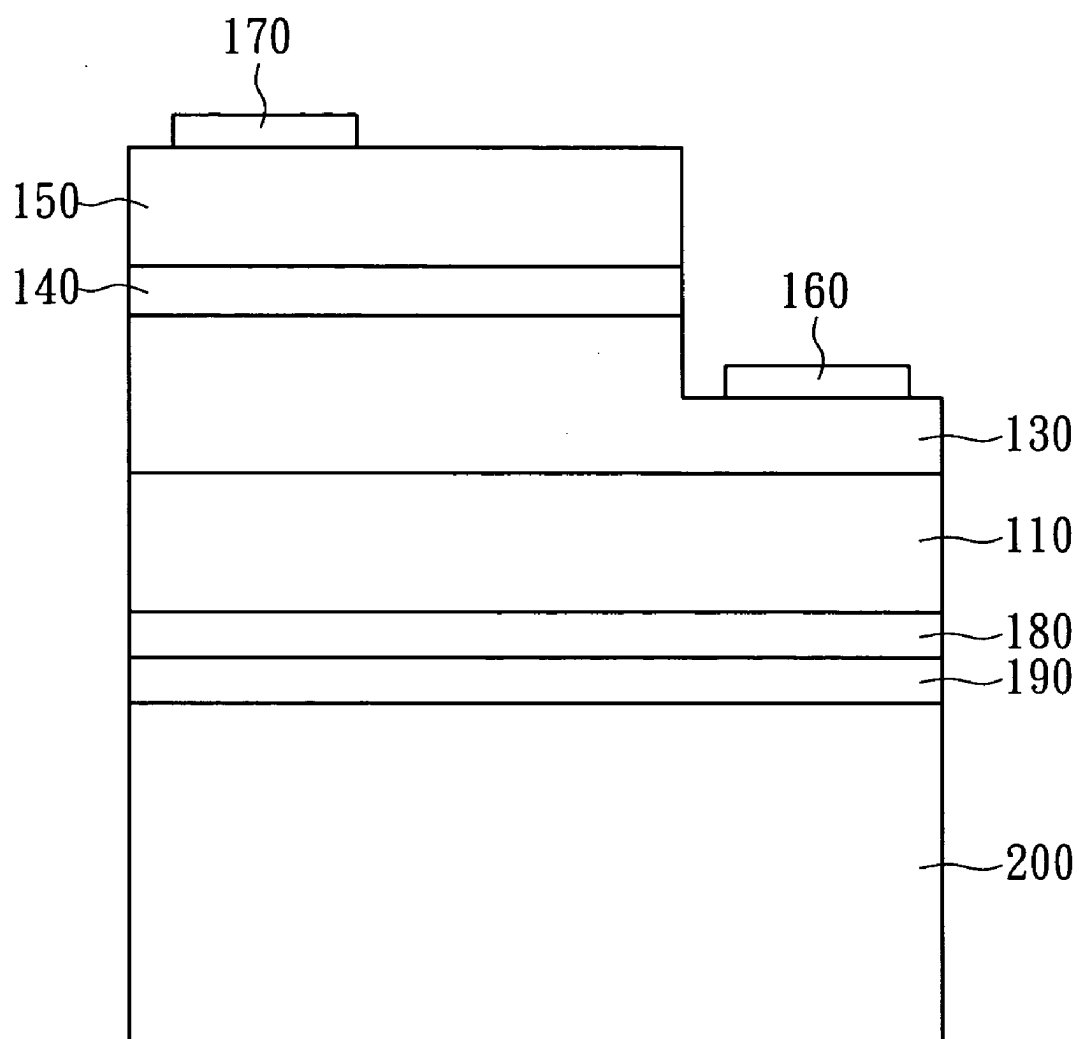


FIG. 3A

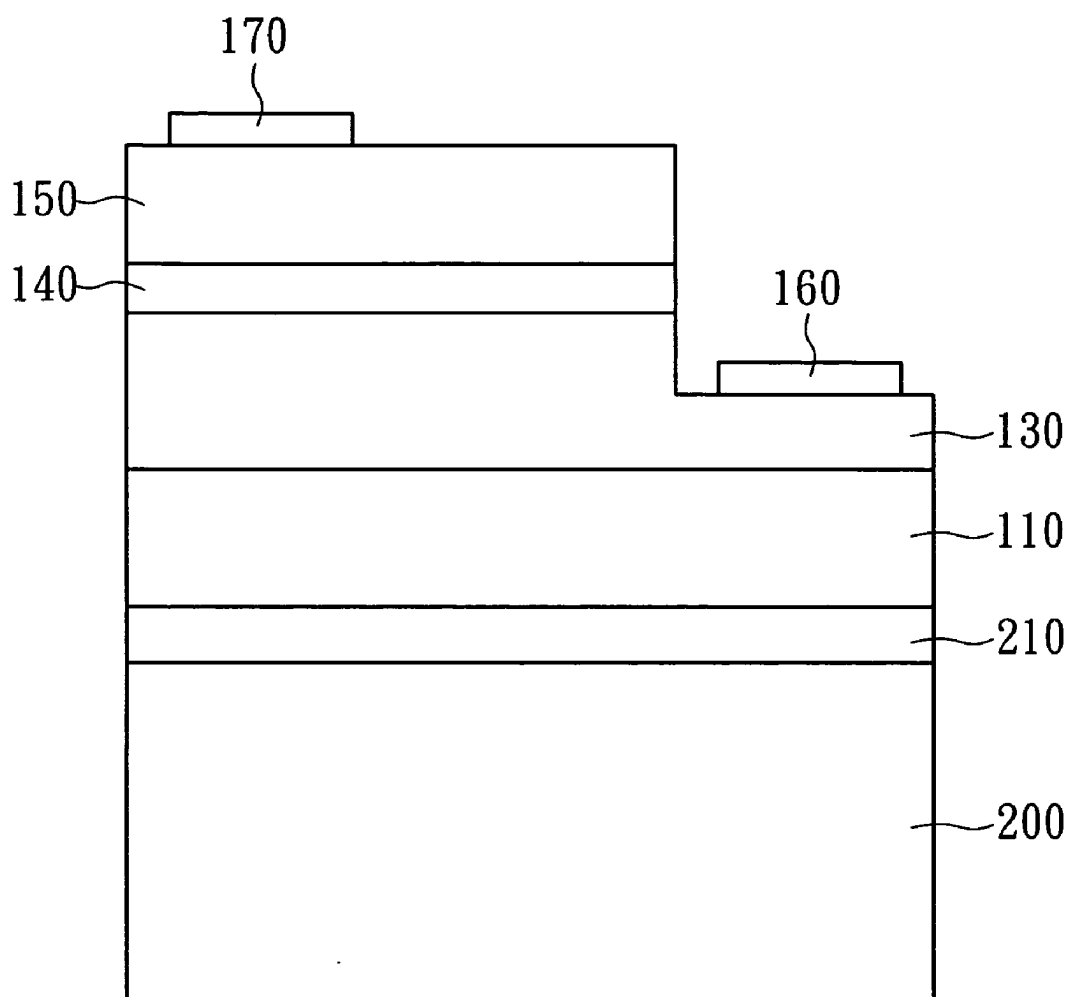


FIG. 3B

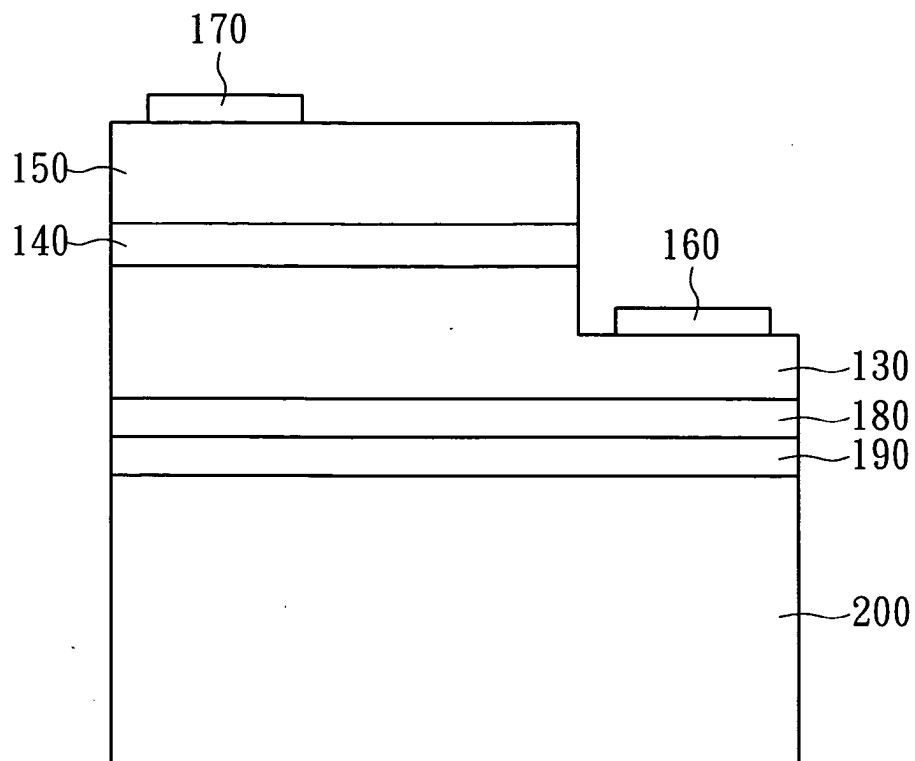


FIG. 4

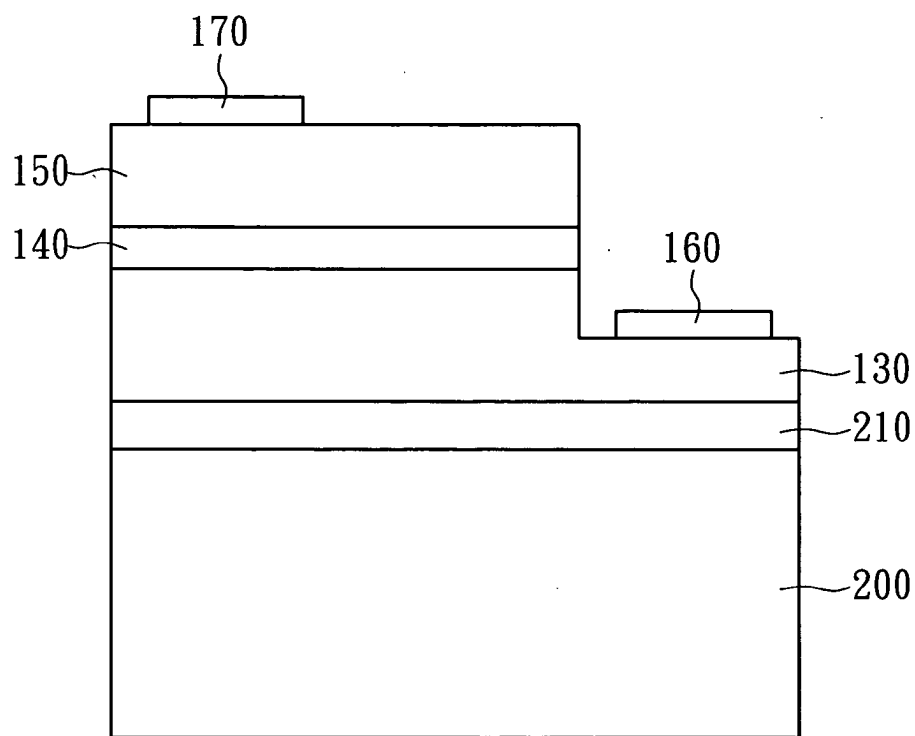


FIG. 5

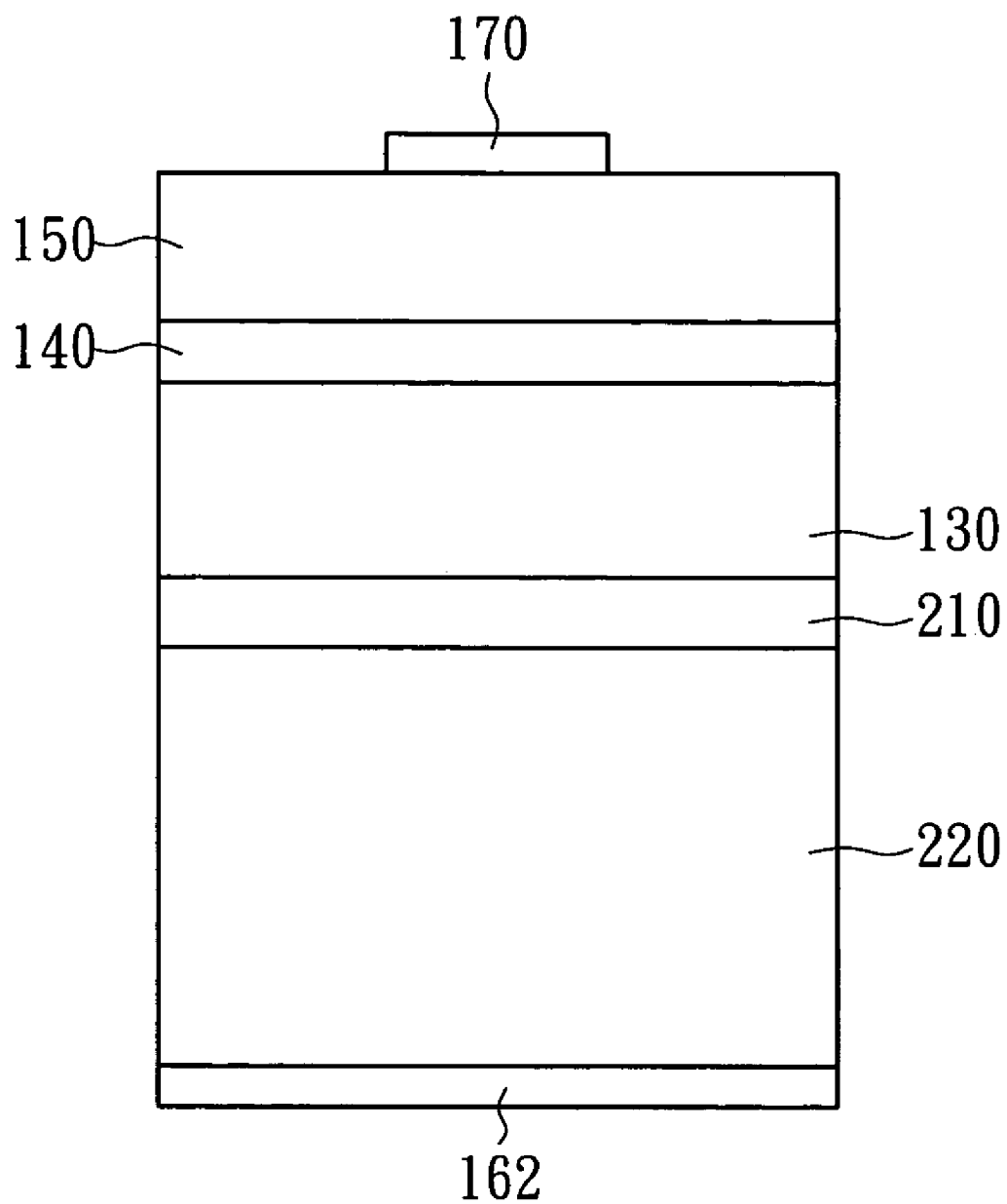


FIG. 6

## LIGHT EMITTING DIODE AND METHOD OF MAKING THE SAME

### FIELD OF THE INVENTION

[0001] The present invention relates to a light emitting diode (LED) and a method of making the same, and more particularly, to a LED having a carrier that can enhance heat-dissipation effect and a method of making the LED.

### BACKGROUND OF THE INVENTION

[0002] In recent years, a great deal of attention has been directed to the light-emitting device utilizing gallium nitride-based semiconductors such as GaN, AlGa<sub>N</sub>, InGa<sub>N</sub>, and AlInGa<sub>N</sub>, etc. Usually, most of the light-emitting devices of the aforementioned type are grown on an electrically insulating substrate such as sapphire, GaN, AlN, etc., that are different from other light-emitting devices utilizing conductive substrates. Since the sapphire substrate is an insulator, the electrodes cannot be directly formed on the substrate, and has to directly contact the P-type semiconductor layer and the N-type semiconductor layer individually so as to complete the manufacturing of the light-emitting device formed on the sapphire substrate.

[0003] Please refer to **FIG. 1** showing the cross section of the conventional nitride LED. A LED **80** shown in **FIG. 1** can be formed via the following steps. Firstly, a nucleation layer **20** is formed on a substrate **10**, wherein the material of the substrate **10** is such as sapphire, GaN, AlN, etc. Then, a semiconductor layer **30** of a first polarity, a multi quantum well structure **40**, and a semiconductor layer **50** of a second polarity are sequentially epitaxially grown on the nucleation layer **20**. Afterwards, the aforementioned epitaxial layers are etched, thereby exposing a portion of the semiconductor layer **30** of the first polarity. Then, an electrode **60** of the first polarity and an electrode **70** of the second polarity are deposited respectively on the exposed portion of the semiconductor layer **30** of the first polarity and the semiconductor layer **50** of the second polarity via thermal evaporation, e-beam evaporation, or sputtering, etc.

[0004] The aforementioned substrate **10** can be made of material such as sapphire, GaN, AlN, etc. The thermal conductivity of sapphire is about 35~40 W/(m·K), that will cause poor conducting effect to the heat generated by the LED **80** when it emits light, make the heat resistance of one single chip too large, and therefore cause poor light emitting efficiency to high current application.

[0005] Please refer to **FIG. 2** showing packaging of the conventional nitride LED. As shown in **FIG. 2**, a welding wire **62** and a welding wire **72** are connected to the electrode **60** of the first polarity and the electrode **70** of the second polarity of the LED **80** respectively, thereby making the LED **80** to be electrically connected to an external power or other elements. When the LED chip is packaged and fixed, the wood glue **94** pervious to light is always used to adhere the LED **80** onto a metal cup **90** and the metal cup **90** is connected to a base **92** since the substrate **10** made of material such as sapphire etc. is pervious to light, thereby enabling the light below to be reflected by the metal cup **90** and thus enhancing light emitting effect. However, the thermal conductivity of the general wood glue **94** is still not good. Moreover, when the wood glue **94** is replaced by

silver paste, it is possible for silver paste or solder to absorb light; therefore the usage of the LED **80** is limited.

[0006] Furthermore, the hardness of the sapphire material is very large, therefore the related process such as cutting cannot be performed easily. Besides, since sapphire is an insulator, therefore it is necessary to dispose the electrodes on the same side of the LED, causing that the design of LED faces the problem that the light emitting area is occupied; at the same time, the aforementioned issue is not convenient for subsequent test and packaging.

[0007] One of the conventional solutions to the aforementioned AlInGa<sub>N</sub> LED is flip chip; however, the processes of such as reflective layer and flip chip, etc. in this method have certain difficulties.

[0008] Consequently, since the LEDs in the future will be developed toward application market needing higher brightness, therefore the operating current and power of a single LED will be in the range of several times to several hundred times as much as the present ones. At the same time, that how to apply and solve the light generated by LED and the heat produced subsequently effectively will be a very important and measurable problem.

### SUMMARY OF THE INVENTION

[0009] Consequently, an objective of the present invention is to provide a LED and a method of making the same, wherein the thickness of the substrate is shortened and even eliminated completely, thereby reducing the heat resistance of LED remarkably.

[0010] Another objective of the present invention is to provide a LED and a method of making the same, wherein the carrier under the epitaxial structure can take out the heat generated by the epitaxial structure, thereby reducing the heat resistance of LED remarkably.

[0011] Still another objective of the present invention is to provide a LED and a method of making the same, wherein the reflective layer above the carrier can reflect the light emitted by the epitaxial structure.

[0012] Further another objective of the present invention is to provide a LED and a method of making the same, wherein two electrodes of LED can be disposed on the upper surface of the epitaxial structure and the lower surface of the carrier respectively while the carrier is a conductor, thereby reducing the light-blocking area of the electrode.

[0013] According to the aforementioned objectives of the present invention, the present invention provides a LED, comprising: a carrier used to transfer heat generated by the LED, wherein a reflective layer is located on the carrier; and an epitaxial structure disposed on the carrier by a transparent heat-conductive glue, wherein the epitaxial structure comprises a plurality of mi-V compound semiconductor epitaxial layers, wherein light is generated when a current enters the LED.

[0014] According to the aforementioned objectives of the present invention, the present invention provides another LED, comprising: a carrier used to transfer heat generated by the LED; an adhesive reflective layer located on the carrier; and an epitaxial structure disposed on the adhesive reflective layer, wherein the epitaxial structure comprises a

plurality of m-v compound semiconductor epitaxial layers, wherein light is generated when a current enters the LED.

[0015] According to the aforementioned objectives of the present invention, the present invention provides a method of making a LED, comprising: providing a carrier used to transfer heat generated by the LED; providing an epitaxial structure comprising a plurality of III-V compound semiconductor epitaxial layers, wherein light is generated when a current enters the LED; and using an adhesive reflective layer to adhere the carrier and the epitaxial structure. Moreover, the adhesive reflective layer further comprises a reflective layer and a transparent heat-conductive glue, wherein the reflective layer is located on the carrier; and the transparent heat-conductive glue is used to adhere the carrier and the epitaxial structure.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

[0017] **FIG. 1** is a diagram showing the cross section of the conventional nitride LED;

[0018] **FIG. 2** is a diagram showing packaging of the conventional nitride LED;

[0019] **FIG. 3A** is a diagram showing the cross section of the LED according to an embodiment of the present invention;

[0020] **FIG. 3B** is a diagram showing the cross section of the LED according to another embodiment of the present invention;

[0021] **FIG. 4** is a diagram showing the cross section of the LED according to another embodiment of the present invention;

[0022] **FIG. 5** is a diagram showing the cross section of the LED according to still another embodiment of the present invention; and

[0023] **FIG. 6** is a diagram showing the cross section of the LED according to even another embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0024] The present invention relates to a LED having a carrier that can enhance heat-dissipation effect and a method of making the LED, wherein the LED comprises a plurality of semiconductor epitaxial layers made of III-V compounds such as AlInGa<sub>N</sub>, etc. Please refer to **FIG. 3A** showing the cross section of the LED according to an embodiment of the present invention. The LED as shown in **FIG. 3A** can be formed via the following process. Firstly, a substrate **110** is provided, wherein the substrate **110** can be made of material such as sapphire, GaN, or AlN, etc. Then, a semiconductor layer **130** of a first polarity, a multi quantum well structure **140**, and a semiconductor layer **150** of a second polarity are sequentially epitaxially grown on the nucleation layer **20**. Afterwards, the aforementioned epitaxial structure is etched, thereby exposing a portion of the semiconductor layer **130**

of the first polarity. Then, an electrode **160** of the first polarity and an electrode **170** of the second polarity are deposited respectively on the exposed portion of the semiconductor layer **130** of the first polarity and the semiconductor layer **150** of the second polarity via thermal evaporation, e-beam evaporation, or sputtering, etc. It is worth describing that both the first polarity and the second polarity mentioned in the present invention are mutually opposite polarities. For example, the second polarity is N type while the first polarity is P type; the second polarity is P type while the first polarity is N type.

[0025] Afterwards, the substrate **110** can be polished or etched so as to shorten the thickness of the substrate **110** to about 10  $\mu\text{m}$ ~50  $\mu\text{m}$  or even thinner. Then, a carrier **200** is provided, wherein the carrier **200** can be mainly made of metal material having high thermal conductivity, such as copper, silver, aluminum, or gold, etc. (including the compound), or other non-metal material such as silicon, GaN, AlN, diamond, or SiC, etc. (including the compound). Moreover, a reflective layer **190** is formed on the carrier **200**, wherein the reflective layer **190** is made of material having high reflectivity, such as silver, gold, or aluminum, etc., thereby making the light emitted by the above epitaxial structure to be reflected more efficiently by the reflective layer **190**. Afterwards, a heat-conductive glue **180** can be used to adhere the aforementioned epitaxial structure and the substrate **110** onto the carrier **200** having the reflective layer **190**, wherein the heat-conductive glue **180** can be made of material such as silicon glue or epoxy, etc.

[0026] With the use of the aforementioned structure and process of LED of the present invention, heat resistance can be reduced remarkably since the thickness of the substrate **110** is shortened. Moreover, the carrier **200** that is adhered under the substrate **110** and that is able to transfer heat well can enable heat to be dissipated out more rapidly, thereby reducing rapidly the heat produced in the multi quantum well structure **140**. Furthermore, in addition to wood glue, solder such as silver paste, indium, or tin, etc. can be used to perform adherence in subsequently packaging and fixing of chip under the carrier **200**, thereby enabling this kind of LED to be used in wider range more extensively.

[0027] Please refer to **FIG. 3B** showing the cross section of the LED according to another embodiment of the present invention. The difference between **FIG. 3B** and **FIG. 3A** is that the transparent heat-conductive glue **180** and the reflective layer **190** shown in **FIG. 3A** can be replaced with one single adhesive reflective layer **210** having functions of adhesion and reflection simultaneously as shown in **FIG. 3B**, thereby being used in larger range, wherein the adhesive reflective layer **210** can be made of material such as metal.

[0028] Please refer to **FIG. 4** showing the cross section of the LED according to another embodiment of the present invention. The difference between **FIG. 4** and **FIG. 3A** is that in **FIG. 4**, there is no substrate **110** as shown in **FIG. 3A** since the substrate has been eliminated completely via polishing, etching, or removing in the present embodiment. Consequently, the heat resistance of LED in the present invention can be reduced further; and thus the light emitting efficiency can be heightened.

[0029] Please refer to **FIG. 5** showing the cross section of the LED according to still another embodiment of the present invention. The difference between **FIG. 5** and **FIG.**

4 is that the transparent heat-conductive glue 180 and the reflective layer 190 shown in FIG. 4 can be replaced with one single adhesive reflective layer 210 having functions of adhesion and reflection simultaneously as shown in FIG. 5, thereby being used in larger range, wherein the adhesive reflective layer 210 can be made of material such as metal.

[0030] In the aforementioned embodiments as shown in FIG. 3A to FIG. 5, the carrier 200 can be a conductor having high thermal conductivity or an insulator having high thermal conductivity. If the carrier 200 is a conductor having high thermal conductivity, the present invention can be changed further like the even another embodiment as shown in FIG. 6. In FIG. 6, the carrier 220 is a conductor; and therefore the two electrodes of LED can be disposed on the upper surface of the epitaxial structure and the lower surface of the carrier 220 respectively. That is, the electrode 162 of the first polarity of LED is located on the lower surface of the carrier 220; and the electrode 170 of the second polarity is located on the upper surface of the epitaxial structure, thereby reducing the light-blocking area of the electrode.

[0031] To sum up, an advantage of the present invention is to provide a LED and a method of making the same, wherein the thickness of the substrate is shortened and even eliminated completely, thereby reducing the heat resistance of LED remarkably.

[0032] Another advantage of the present invention is to provide a LED and a method of making the same, wherein the carrier under the epitaxial structure can take out the heat generated by the epitaxial structure, thereby reducing the heat resistance of LED remarkably.

[0033] Still another advantage of the present invention is to provide a LED and a method of making the same, wherein the reflective layer above the carrier can reflect the light emitted by the epitaxial structure.

[0034] Further another advantage of the present invention is to provide a LED and a method of making the same, wherein two electrodes of LED can be disposed on the upper surface of the epitaxial structure and the lower surface of the carrier respectively while the carrier is a conductor, thereby reducing the light-blocking area of the electrode.

[0035] As is understood by a person skilled in the art, the foregoing preferred embodiments of the present invention are illustrations of the present invention rather than limitations of the present invention. It is intended to cover various modifications and similar arrangements comprised within the spirit and scope of the appended claims, the scope of which should be accorded the broadest interpretation so as to encompass all such modifications and similar structure.

What is claimed is:

1. A light emitting diode (LED), comprising:

a carrier used to transfer heat generated by the LED, wherein a reflective layer is located on the carrier; and

an epitaxial structure disposed on the carrier by a transparent heat-conductive glue, wherein the epitaxial structure comprises a plurality of III-V compound semiconductor epitaxial layers, wherein light is generated when a current enters the LED.

2. The LED according to claim 1, wherein the material of the carrier is selected from a group consisting of copper, silver, aluminum, and gold.

3. The LED according to claim 1, wherein the material of the carrier is selected from a group consisting of silicon, GaN, AlN, diamond, and SiC.

4. The LED according to claim 1, wherein the material of the reflective layer is selected from a group consisting of silver, gold, and aluminum.

5. The LED according to claim 1, further comprising a substrate located between the epitaxial structure and the transparent heat-conductive glue.

6. The LED according to claim 5, wherein the thickness of the substrate is less than 50  $\mu\text{m}$ .

7. A LED, comprising:

a carrier used to transfer heat generated by the LED;

an adhesive reflective layer located on the carrier; and

an epitaxial structure disposed on the adhesive reflective layer, wherein the epitaxial structure comprises a plurality of III-V compound semiconductor epitaxial layers, wherein light is generated when a current enters the LED.

8. The LED according to claim 7, wherein the adhesive reflective layer is made of metal.

9. The LED according to claim 7, wherein the material of the carrier is selected from a group consisting of copper, silver, aluminum, and gold.

10. The LED according to claim 7, wherein the material of the carrier is selected from a group consisting of silicon, GaN, AlN, diamond, and SiC.

11. The LED according to claim 7, further comprising a substrate located between the epitaxial structure and the adhesive reflective layer.

12. The LED according to claim 11, wherein the thickness of the substrate is less than 50  $\mu\text{m}$ .

13. A method of making a LED, comprising:

providing a carrier used to transfer heat generated by the LED;

providing an epitaxial structure comprising a plurality of III-V compound semiconductor epitaxial layers, wherein light is generated when a current enters the LED; and

using an adhesive reflective layer to adhere the carrier and the epitaxial structure.

14. The method of making the LED according to claim 13, wherein the step of providing the epitaxial structure further comprises providing a substrate, wherein a portion of a thickness of the substrate is polished or etched; the epitaxial structure is located on the substrate; and afterwards, the substrate is located between the epitaxial structure and the adhesive reflective layer.

15. The method of making the LED according to claim 14, wherein the thickness of the substrate is less than 50  $\mu\text{m}$ .

16. The method of making the LED according to claim 13, wherein the material of the carrier is selected from a group consisting of silicon, GaN, AlN, diamond, and SiC.

17. The method of making the LED according to claim 13, wherein the material of the carrier is selected from a group consisting of copper, silver, aluminum, and gold.

18. The method of making the LED according to claim 13, wherein the adhesive reflective layer is made of metal.

**19.** The method of making the LED according to claim 13, wherein the adhesive reflective layer further comprises a reflective layer and a transparent heat-conductive glue; the reflective layer is located on the carrier; and the transparent heat-conductive glue is used to adhere the carrier and the epitaxial structure.

**20.** The method of making the LED according to claim 19, wherein the material of the reflective layer is selected from a group consisting of silver, gold, and aluminum.

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