SEMICONDUCTOR DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2016-012709; filed on January 26, 2016; the entire contents of which are incorporated herein by reference.

FIELD

Embodiments described herein relate generally to a semiconductor device including a light emitting layer.

BACKGROUND

A photo coupler includes an LED and a light receiving element which are contained one IC package, and is used for transmitting signals by using photo coupling.

In the photo coupler, the LED and the light receiving element are disposed so as to face each other with a distance, and the periphery of the LED and the light receiving element is covered by an inner mold resin portion through which light from the LED transmits.

An LED for a photo coupler generally emits infrared light. The LED which emits the infrared light has a cross-section structure in which a light emitting layer is disposed, for example, a GaAs substrate. In a structure in which the light emitting layer comes into direct contact with the inner mold resin portion, the light emitting layer is stressed from the inner mold resin portion, and thereby the light emitting layer is cracked and heated. Accordingly, there is possibility that light intensity or light emission lifetime of the LED is reduced.

For this reason, in the related art, the periphery of a light emitting layer is covered by an encapsulation resin portion, and an inner mold resin portion is disposed in the periphery. The encapsulation resin portion is formed by thermally curing a thermosetting resin material after potting of the thermosetting resin material which uses silicone as a material is made in the periphery of the light emitting layer. Multiple LED chips which are formed on a wafer are separated from each other, bonding wires are bonded to the LED chips, and thereafter, the encapsulation resin portions are formed in the respective chips. Due to this, not only there is a problem that workability is reduced, but also forming of the encapsulation resin portion is omitted, or there is a possibility that failure occurs due to the fact that the encapsulation resin portion is formed on a light receiving element side by a mistake.

An example of related art includes Japanese Patent No. 3141373.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a semiconductor device according to a first embodiment.

FIG. 2 is a view illustrating a detailed cross-section structure of an LED in a photo coupler of FIG. 1.

FIG. 3 is a plan view in which the LED of FIG. 2 is viewed from top.

FIG. 4 is a view illustrating a cross-section structure of an LED in a semiconductor device according to a second embodiment.

DETAILED DESCRIPTION

[0007]Embodiments are to provide a semiconductor device whose fabrication processes are not complicated and which can prevent light intensity and light emission lifetime of a light emitting layer from being reduced.

[0008]In general, according to one embodiment, a semiconductor device includes a light emitting element; and a light receiving element which is disposed on a propagation path of light that is emitted from the light emitting element. The light emitting element includes a light emitting layer which is disposed on a more internal side than a periphery portion on a substrate; an electrode which is disposed in a part of an upper surface of the light emitting layer; and a first insulating layer which is disposed over an upper surface of the substrate in the periphery portion, a side surface of the light emitting layer, and a part of an upper surface of the light emitting layer, and has a single layer that contains an organic material or a lamination structure.

[0010]Hereinafter, exemplary embodiments will be described in detail.

First Embodiment

[0011]Fig. 1 is a sectional view of a semiconductor device according to a first embodiment. The semiconductor device of FIG. 1 is an example of a photo coupler 1. The photo coupler 1 of FIG. 1 includes a light emitting element (LED) 2 and a light receiving element 3 which is disposed so as to face the LED 2. The LED 2 is connected to a first lead frame 5 by a bonding wire 4, and the light receiving element 3 is connected to a second lead frame 6 by another bonding wire 4.

[0012]The LED 2 emits, for example, infrared light. A cross-section structure of the LED 2 will be described below. The light receiving element 3 receives light from the LED 2 and converts the light into an electric signal.

[0013]The LED 2, the light receiving element 3, and a part of the first and second lead frames 5 and 6 are covered by an inner mold resin portion (second insulating layer) 7. The inner mold resin portion 7 has a property of transmitting light from the LED 2. The inner mold resin portion 7 is a resin which is formed by using, for example, epoxy and filler as base materials.

[0014]The inner mold resin portion 7 is covered by an outer mold resin portion 8. The outer mold resin portion 8 is formed by using a black resin with a light transmitting property as a material. The outer mold resin portion 8 is a package member which is shown in the outside of the photo coupler 1 of Fig. 1. A part of the first lead frame 5 and the second lead frame 6 protrudes from two outer wall surfaces, which face each other, of the outer mold resin portion 8.

[0015]FIG. 2 is a view illustrating a detailed cross-section structure of the LED 2 in the photo coupler 1 of FIG. 1. As illustrated in FIG. 2, the LED 2 includes a lamination body in which a GaAs substrate 11, an n-type clad layer 12, an active layer 13, a p-type clad layer 14, a current diffusion layer 15, and a contact layer 16 are sequentially laminated in this order. There is a case where a buffer layer, a current block layer, or the like is laminated in the lamination body, but these are omitted in FIG. 2.

[0016]A conductivity type of the GaAs substrate 11 may be a p type or an n type. In the present embodiment, an example in which the GaAs substrate 11 is used, but a substrate including other compound semiconductors such as GaP may be used.

[0017]The n-type clad layer 12 is, for example, AlxGa1-xAs (0 < x < 1). The p-type clad layer 14 is, for example, AlyGa1-yAs (0 < y < 1). The active layer 13 includes, for example, an InAlGaP-based MQW layer. The contact layer 16 is, for example, a GaAs-based semiconductor layer. Materials which form the respective layers that configure the lamination body may be arbitrarily changed.

[0018]A p-type electrode 17 is disposed on an upper surface of the contact layer 16, and an n-type electrode 18 is disposed on a rear surface side of the GaAs substrate 11. The n-type electrode 18 may be disposed on the same side as the p-type electrode 17.

[0019]In the present specification, a lamination structure which is configured by the n-type clad layer 12, the active layer 13, the p-type clad layer 14, the current diffusion layer 15, and the contact layer 16 is collectively referred to as a light emitting layer 21.

[0020]The light emitting layer 21 is disposed on a more inner side than a peripheral portion on the GaAs substrate 11. That is, a side surface of the light emitting layer 21 is disposed on a more inner side than a side surface of the GaAs substrate 11, as illustrated in FIG. 2. Here, the inner side is on a more central side than the peripheral portion on an upper surface of the substrate.

[0021]A first insulating layer 22 is disposed over a part of a side surface of the light emitting layer 21 and an upper surface of the light emitting layer 21 from an upper surface of the GaAs substrate 11 between a side surface of the light emitting layer 21 and a side surface of the GaAs substrate 11.

[0022]The first insulating layer 22 is, for example, a resin layer (polyimide layer) containing polyimide. In a structure in which the inner mold resin portion 7 comes into direct contact with the upper surface and the side surface of the light emitting layer 21, the light emitting layer 21 can be cracked by stress of the inner mold resin portion 7. If the light emitting layer is cracked, the cracked portion has large resistance and is heated when power is applied thereto. Accordingly, the light emitting layer is degraded, light intensity is reduced, and light emission lifetime is shortened.

[0023]In contrast to this, in a case of the present embodiment, a part of an upper surface and a side surface of the light emitting layer 21 are covered by the first insulating layer 22, as illustrated in FIG. 2. Accordingly, the light emitting layer 21 does not come into direct contact with the inner mold resin portion 7, and thereby the light emitting layer 21 is barely affected by stress from the inner mold resin portion 7. Thus, it is possible to prevent the light intensity and light emission lifetime from being reduced. In this way, the first insulating layer 22 functions as a stress mitigation layer which mitigates the stress from the inner mold resin portion 7.

[0024]As described above, the light emitting layer 21 is a lamination body which is configured by multiple layers, and particularly, the active layer 13 of the light emitting layer 21 is easily affected by the stress from the inner mold resin portion 7. The active layer 13 is provided in a central layer of the light emitting layer 21 having a lamination structure, and does not come into the inner mold resin portion 7 on an upper side of the active layer 13. Hence, the active layer 13 is barely affected by the stress from the inner mold resin portion 7 which is disposed on an upper side thereof. However, if there is no the first insulating layer 22, the side surface of the active layer 13 comes into contact with the inner mold resin portion 7, and the active layer 13 is easily affected by the stress from the inner mold resin portion 7 on a side surface thereof. In the present embodiment, as described above, the side surface of the active layer 13 is covered by the first insulating layer 22, and thereby the side surface of the active layer 13 does not come into contact with the inner mold resin portion 7. Hence, the upper surface and the side surface of the active layer 13 are also barely affected by the stress from the inner mold resin portion 7.

[0025]FIG. 3 is a plan view in which the LED 2 of FIG. 2 is viewed from top. The p-type electrode 17 of a ring type is disposed in the central portion of the LED 2, and multiple thin wire electrodes 19 are disposed on periphery thereof. Shapes and sizes of the p-type electrode 17 and the thin wire electrode 19 of FIG. 3 are just an example, and arbitrary shapes and sizes can be taken. Light from an upper surface side of the LED 2 is emitted from a gap between the p-type electrode 17 and the thin wire electrode 19. The light from the LED 2 is emitted not only from the upper surface side but also from the side surface of the light emitting layer 21.

[0026]In the example of FIG. 3, a slight gap 25 is formed on a periphery portion of the p-type electrode 17, and the entire upper surface on an outer side of the gap 25 is covered by the first insulating layer 22. The bonding wire 4 which is not illustrated is coupled to an approximately central portion of the p-type electrode 17, but the upper surface of the p-type electrode 17 may be covered by the first insulating layer 22, except for a portion coupled to the bonding wire 4.

[0027]The light emitting layer 21 is not disposed in a predetermined range 26 on a periphery portion of an upper surface of the GaAs substrate 11. Accordingly, the first insulating layer 22 comes into contact with the GaAs substrate 11 in the predetermined range 26.

[0028]In this way, in the first embodiment, the side surface of the light emitting layer 21 which is disposed on the GaAs substrate 11 of the LED 2 is disposed on a more internal side than a periphery portion of the GaAs substrate 11, and the region from the upper surface of the GaAs substrate 11 to the side surface of the light emitting layer 21 and a part of the upper surface of the light emitting layer 21 is covered by the first insulating layer 22. Accordingly, the upper surface and the side surface of the light emitting layer 21 do not come into contact with the inner mold resin portion 7, and thereby the light emitting layer 21 is barely affected by the stress from the inner mold resin portion 7. Hence, it is possible to prevent the light intensity and light emission lifetime of the light emitting layer 21 from being reduced.

[0029]The first insulating layer 22 can be collectively formed in a wafer in which multiple chips of the LED 2 are formed, and thus, fabrication processes of the LED can be simplified. In order to cover the periphery of the light emitting layer 21 with an encapsulation resin portion, each chip of the LED 2 is separated from the wafer, the bonding wires 4 are bonded to each chip, and thereafter, potting of a thermosetting resin needs to be made for each chip. Accordingly, not only workability is reduced, but also potting can be omitted. In contrast to this, according to the present embodiment, the first insulating layers 22 are collectively formed on a wafer, and thus, the fabrication processes thereof can be considerably reduced, and there is no possibility that the first insulating layer 22 is omitted.

Second Embodiment

[0030]There is a case where the first insulating layer 22 does not have good adhesion to the GaAs substrate 11. If adhesion between the first insulating layer 22 and the GaAs substrate 11 is bad, a gap is formed between the first insulating layer 22 and the GaAs substrate 11. Then, moisture or the like is introduced into the first insulating layer 22 through the gap, and thereby light intensity or light emission lifetime is reduced, and peeling can occur.

[0031]Hence, in a second embodiment, the first insulating layer 22 has a double-layered structure, and a material having good adherence to the GaAs substrate 11 is disposed on a side which comes into contact with the GaAs substrate 11.

[0032]FIG. 4 is a view illustrating a cross-section structure of the LED 2 in a semiconductor device according to the second embodiment. The LED 2 of FIG. 4 has a lamination structure of a first layer 23 and a second layer 24, instead of the first insulating layer 22 of the LED 2 of FIG. 1.

[0033]The first layer 23 covers an upper surface of the GaAs substrate 11, a side surface of the light emitting layer 21, and a part of an upper surface of the light emitting layer 21. The first layer 23 is an oxide film such as SiO2, or a nitride film such as SiN. The second layer 24 is disposed on the first layer 23, and contains an organic material. The second layer 24 is, for example, a polyimide layer.

[0034]a material having a good adherence to the GaAs substrate 11 is used for the first layer 23. Accordingly, there is no possibility that a gap occurs between the first layer 23 and the GaAs substrate 11. In addition, the second layer 24 comes into contact with the inner mold resin portion 7, and functions as a stress mitigation layer which mitigates the stress from the inner mold resin portion 7. Furthermore, for example, the second layer may have a function to block metal ions on the first layer 23.

[0035]In this way, in the second embodiment, the first insulating layer 22 has a double-layered layer, the first layer having good adherence to the GaAs substrate 11 is disposed on a side which comes into contact with the GaAs substrate 11, and the second layer 24 which functions as a stress mitigation layer is disposed on a side which comes into contact with the inner mold resin portion 7. Accordingly, the light emitting layer 21 is not affected by the stress from the inner mold resin portion 7, and adherence between the light emitting layer 21 and the first insulating layer 22 can be increased.

[0036]In the first and second embodiments described above, an example in which a semiconductor device is applied to the photo coupler 1 is described, but the semiconductor device is not limited to the photo coupler 1. For example, the semiconductor device can be applied to an infrared light sensor which emits infrared light, an interrupter sensor, or the like. In a case where the semiconductor device is applied to an infrared light sensor or an interrupter sensor, the light receiving element 3 illustrated in FIG. 1 is not required.

[0037]While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

WHAT IS CLAIMED IS:

1. A semiconductor device comprising:

a light emitting element; and

a light receiving element which is disposed on a propagation path of light that is emitted from the light emitting element,

wherein the light emitting element includes

a light emitting layer which is disposed on a more internal side than a periphery portion on a substrate;

an electrode which is disposed in a part of an upper surface of the light emitting layer; and

a first insulating layer which is disposed over an upper surface of the substrate in the periphery portion, a side surface of the light emitting layer, and a part of an upper surface of the light emitting layer, and has a single layer that contains an organic material or a lamination structure.

2. The device according to Claim 1, wherein the first insulating layer contains polyimide as the organic material.

3. The device according to Claim 1 or 2, wherein the first insulating layer includes

a first layer which is disposed over the upper surface of the substrate, the side surface of the light emitting layer, and a part of the upper surface of the light emitting layer, and contains oxide or nitride; and

a second layer which is disposed on an upper surface of the first layer, and contains an organic material.

4. The device according to any one of Claims 1 to 3, further comprising:

a second insulating layer which is disposed so as to cover the electrode and an entire surface of the first insulating layer, and causes light that is emitted from the light emitting layer to be transmitted.

5. The device according to Claim 4, wherein the second insulating layer covers a periphery of the light receiving element.

6. The device according to any one of Claims 1 to 5,

wherein the substrate contains a compound semiconductor, and

wherein light which is emitted from the light emitting layer is infrared light.

ABSTRACT

According to one embodiment, a semiconductor device includes a light emitting element; and a light receiving element which is disposed on a propagation path of light that is emitted from the light emitting element. The light emitting element includes a light emitting layer which is disposed on a more internal side than a periphery portion on a substrate; an electrode which is disposed in a part of an upper surface of the light emitting layer; and a first insulating layer which is disposed over an upper surface of the substrate in the periphery portion, a side surface of the light emitting layer, and a part of an upper surface of the light emitting layer, and has a single layer that contains an organic material or a lamination structure.