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SEMICONDUCTOR DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a semiconductor device, and particularly to a semiconductor device including: a semiconductor element having electrodes; a film circuit having a plurality of external electrodes and lead wirings for connecting the external electrodes to the electrodes of the semiconductor element; and a radiating member including a heat spreader for promoting radiation of the semiconductor element from a bottom surface thereof and a reinforcing body disposed in such a manner as to surround the semiconductor element for reinforcing the film circuit; wherein the lead wirings of the film circuit are bonded to the electrodes of the semiconductor element; connecting portions between the semiconductor element and the film circuit are sealed; and the heat spreader portion is adhesively bonded on the bottom surface of the semiconductor element and the reinforcing body portion is adhesively bonded on a bottom surface of the film circuit.

Figs. 7A and 7B are sectional views each showing a related art semiconductor device in which a semiconductor element is mounted using a film circuit and a radiating member is provided for enhancing radiation of the

semiconductor element. In these figures, reference numeral 1 indicates a semiconductor element; 2 is an electrode pad disposed on a peripheral portion of the semiconductor element 1; and 3 is a film circuit used for mounting the semiconductor element 1. The film circuit 3 includes an insulating film 4 on one surface (lower surface) of which are formed inner leads 5 and on the other surface of which are formed solder balls 6 connected to surfaces of the inner leads 5 through openings. The solder balls 6 constitute external electrodes of the semiconductor device.

Tips of the inner leads 5 are bonded to the electrode pads 2 of the semiconductor element 1, whereby the film circuit 3 is assembled to the semiconductor element 1. Reference numeral 7 indicates a resin for sealing connecting portions between the semiconductor element 1 and the film circuit 3.

Reference numeral 8a indicates a radiating member which is composed of an aluminum made heat spreader 9 and an aluminum made reinforcing plate 10 separately from the heat spreader 9. The heat spreader 9 is a rectangular sheet (thickness: for example, 0.3 mm), and the reinforcing plate 10 is a rectangular frame shaped sheet (thickness: for example, 0.5 mm) bonded on the surface of the heat spreader 9 with an adhesive 11. The radiating member 8a in

the related art semiconductor device is thus formed into one-body by adhesively bonding the reinforcing plate 10 to the heat spreader 9 with the adhesive 11.

The back surface of the semiconductor element 1 is adhesively bonded by means of the adhesive 11 on the surface of a portion of the heat spreader 9 surrounded by the reinforcing plate 10. Then, the back surface of a peripheral portion of the film circuit 3 is adhesively bonded on the surface of the reinforcing plate 10 by means of an adhesive 13. In this way, the radiating member 8a is mounted to the semiconductor element 1. In addition, reference numeral 14 in Fig. 7B indicates an external ring which constitutes part of the film circuit 3.

The related art semiconductor device, however, has problems. Firstly, there is a limitation in reducing a radiation resistance of the semiconductor device due to the radiating member 8a. This is because, in the radiating member 8a, the adhesive 11 interposed between the heat spreader 9 and the reinforcing plate 10 separately formed has a heat resistance which is very larger than that of a material for forming the radiating member 8a such as aluminum.

Secondly, since the radiating member 8a is obtained by separately forming the heat spreader 9 and the

reinforcing plate 10 and then adhesively bonding them to each other by the adhesive 11, the formation of the radiating member 8a requires many steps, resulting in the increased cost. This becomes one factor of obstructing a reduction in fabrication cost of a semiconductor device.

Thirdly, since the heat spreader 9 constituting an essential portion of the radiating member 8a is required to be made as thin as 0.3 mm to meet requirements of a semiconductor device such as thinning or lightweightness and thereby it is liable to be deformed, heights of the solder balls 6 tend to be made uneven. This may cause a bonding failure when the solder balls 6 are bonded to a wiring film of a printed circuit board.

Fourthly, when the semiconductor device having been assembled is put in a reflow furnace to form the solder balls 6 into dome shapes, gas (for example, moisture) discharged from the adhesive resin 11 and the sealing resin 7 into gaps 15 between the semiconductor element 1 and the radiating member 8a is thermally expanded, with a result that there may occur such a failure that the adhesive 11 between the heat spreader 9 and the reinforcing plate 10 is peeled due to the expansion pressure or the sealing effect is reduced.

SUMMARY OF THE INVENTION

An object of the present invention is to enhance the radiation characteristic of a radiating member, to reduce the formation cost of the radiating member, to obstruct the deformation of the radiating member by enhancing its rigidity thereby preventing a reduction in connection between external terminals of the semiconductor device and other members such as a printed wiring board, and to prevent gas, which is generated from resins for sealing and the like at the reflow step for shaping solder balls and is accumulated and expanded in gaps between the radiating member and the semiconductor element, from being thermally expanded, thereby preventing air-tightness from being eliminated or reduced by peeling of the adhesive due to the increased expansion pressure of the gas.

To achieve the above object, according to a first aspect of the present invention, there is provided a semiconductor device including: a semiconductor element having electrodes; a film circuit having a plurality of external electrodes and lead wirings for connecting the external electrodes to the electrodes of the semiconductor element; and a radiating member including a heat spreader for promoting radiation of the semiconductor element from a bottom surface thereof and a reinforcing body disposed in

such a manner as to surround the semiconductor element for reinforcing the film circuit, the reinforcing body being formed integrally with the heat spreader; wherein the lead wirings of the film circuit are bonded to the electrodes of the semiconductor element; connecting portions between the semiconductor element and the film circuit are sealed; and the heat spreader portion is adhesively bonded on the bottom surface of the semiconductor element and the reinforcing body portion is adhesively bonded on a bottom surface of the film circuit.

With this configuration, since the radiating member is composed of the head spreader and the reinforcing plate formed integrally with each other, any material having a large heat resistance such as an adhesive is not interposed between the heat spreader and reinforcing plate. As a result, the heat which is generated from the semiconductor element and transmitted to the heat spreader of the radiating member is effectively radiated to the exterior not only through the heat spreader but also through the reinforcing body, to thereby make the radiation characteristic higher than that of the related art semiconductor device.

Since the radiating member is composed of the heat spreader and the reinforcing body formed integrally with

each other, it is possible to eliminate the necessity of assembling the radiating member. This makes it possible to reduce the number of steps of forming the radiating member and lower the formation cost thereof, and hence to lower the fabrication cost of the semiconductor device. In particular, since the radiating member can be significantly simply obtained by die-forming a metal powder using a forming die by the powder metallurgical process, it is possible to significantly reduce the formation cost of the radiating member.

Since the radiating member is composed of the heat spreader and the reinforcing body formed integrally with each other, the heat spreader is reinforced by the reinforcing body, to thereby increase the rigidity of the radiating member. Accordingly, the radiating member is less deformed, to prevent a reduction in connection between external terminals of the semiconductor device to other members such as a printed wiring board.

According to a second aspect of the present invention, there is provided a semiconductor device including: a semiconductor element having electrodes; a film circuit having a plurality of external electrodes and lead wirings for connecting the external electrodes to the electrodes of the semiconductor element; a radiating member

including a heat spreader for promoting radiation of the semiconductor element from a bottom surface thereof and a reinforcing body disposed in such a manner as to surround the semiconductor element for reinforcing the film circuit, the reinforcing body being formed integrally with the heat spreader; and vent holes formed in the radiating member in such a manner as to communicate gaps between the radiating member and the semiconductor element to an external surface of the radiating member; wherein the lead wirings of the film circuit are bonded to the electrodes of the semiconductor element; connecting portions between the semiconductor element and the film circuit are sealed; and the heat spreader portion is adhesively bonded on the bottom surface of the semiconductor element and the reinforcing body portion is adhesively bonded on a bottom surface of the film circuit.

With this configuration, since gas (for example, moisture) discharged from a resin used as an adhesive into gaps between the semiconductor element and the radiating member is released to the exterior through the vent holes, there is no possibility that the gas is thermally expanded at the reflow step for shaping the solder balls and the air-tightness of the semiconductor device is eliminated or reduced by peeling of the adhesive due to the increased

expansion pressure of the gas.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A and 1B are views showing a first embodiment of a semiconductor device of the present invention, wherein Fig. 1A is a plan view, and Fig. 1B is an enlarged sectional view taken on line B-B of Fig. 1A;

Fig. 2 is a sectional view of a radiating member of the first embodiment;

Figs. 3A to 3E are sectional views showing a method of fabricating the semiconductor device shown in Figs. 1A and 1B in the order of fabrication steps;

Fig. 4 is a sectional view of a second embodiment of the semiconductor device of the present invention;

Fig. 5 is a view showing a state in which the semiconductor device of the present invention is mounted on a printed wiring board;

Fig. 6 is a view showing an electronic equipment using the semiconductor device of the present invention; and

Figs. 7A and 7B are sectional views each showing a related art semiconductor device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Prior to description of preferred embodiments of the present invention, there will be described features of the present invention.

A semiconductor device according to a first invention is characterized by providing a radiating member composed of a heat spreader and a reinforcing body formed integrally with each other, wherein electrodes of a semiconductor element are bonded on leads of a film circuit; connecting portions between the semiconductor element and the film circuit are sealed; and the heat spreader is adhesively bonded on a bottom surface of the semiconductor element and the reinforcing body is adhesively bonded on a bottom surface of the film circuit. In the film circuit, an insulating layer is made from a resin such as a polyimide or epoxy resin; the inner leads are made from, for example copper; and the external terminals are formed by nickel plating and solder plating and are shaped in dome shapes at the reflow step. The film circuit surrounds the semiconductor element, and may have or have not an external ring for reinforcing and electrostatically shielding the film circuit.

The radiating member, which is composed of the heat spreader and the reinforcing body formed integrally with

each other, can be obtained by die-forming a powder of a metal having a high thermal conductivity such as aluminum or copper using a forming die by a power metallurgical process.

A second semiconductor device according to a second invention is characterized by providing vent holes in the radiating member in such a manner as to communicate gaps between the radiating member and the semiconductor element to an external surface of the radiating member. The vent holes are provided, for example, in the vicinities of four corners of the rectangular semiconductor element, and a diameter of each vent hole is set at a value, for example, in a range of 0.3 to 1.0 mm.

Hereinafter, the present invention will be described in detail by way of preferred embodiments with reference to the accompanying drawings.

Figs. 1A and 1B are sectional views showing a first embodiment of a semiconductor device of the present invention. In the figures, reference numeral 1 indicates a semiconductor element; 2 is an electrode pad disposed on a peripheral portion of the semiconductor element 1; and 3 is a film circuit used for mounting the semiconductor element 1. The film circuit 3 has an insulating film 4 on one surface (lower surface) of which are formed inner leads 5

and on the other surface of which are formed solder balls 6 connected to surfaces of the inner leads 5 through openings. The solder balls 6 constitute external electrodes of the semiconductor device, and are formed by electroplating with the inner leads 5 taken as a backing layer. In this embodiment, nickel plating is performed, followed by solder plating, to form the solder balls 6 having a double layer structure. Each solder ball 6 has a height of 0.5 mm and a width of 0.6 mm. The solder balls 6 are arranged with a pitch of, for example, 1.0 mm. In addition, reference numeral 14 indicates an external ring having a thickness of about 150 μm.

Tips of the inner leads 5 are bonded to the electrode pads 2 of the semiconductor element 1, whereby the film circuit 3 is assembled to the semiconductor element 1. Reference numeral 7 indicates a resin for sealing connecting portions between the semiconductor element 1 and the film circuit 3.

Reference numeral 8 indicates a radiating member which is, as shown in Fig. 2, composed of a heat spreader 9 and a reinforcing plate 10 formed integrally with each other. To be more specific, the radiating member 8 is obtained by die-forming a metal having a high thermal conductivity such as aluminum or copper using a powder

metallurgical process. Although a boundary between the heat spreader 9 and the reinforcing plate 10 is indicated by a two-dot chain line in Fig. 2, such a boundary is conceptual, that is, actually not present because the heat spreader 9 and the reinforcing plate 10 are formed integrally with each other. The thickness of a peripheral portion of the radiating member 8, that is, the total thickness of the heat spreader 9 and the reinforcing plate 10 is set at a value in a range of 0.5 to 2.0 mm. The thickness of the reinforcing plate 10 is set to be equal to or thicker, about less than 0.2 mm, than the thickness of the semiconductor chip 1.

Reference numeral 20 indicates a vent hole formed in the heat spreader 9 of the radiating member 8. The diameter of the vent hole is set at a value in a range of 0.3 to 1.0 mm. The vent holes 20 are formed in portions slightly outward from four corners of the rectangular semiconductor element 1 in such a manner as to communicate gaps 15 between the semiconductor element 1 and the radiating member 8 to an external surface of the radiating member 8. The vent holes 20 function to prevent gas in the resin 7 or the like from being accumulated and expanded in the gaps 15 at the subsequent reflow step for shaping the solder balls 6.

In a bottom surface portion of the heat spreader 9 of the radiating member 20 are formed grooves 21, each having a depth in a range of 0 to 0.2 mm, with a pitch of 0 to 1.0 mm. The grooves 21 are formed for increasing the surface area of the bottom surface of the heat spreader 9, thereby enhancing the radiation characteristic thereof. In addition, reference numeral 22 indicates a groove for indicating one pin mask or the like, which is identical in depth to that of the groove 21 but is different in width and shape from the groove 21. The grooves 21 and 22 are formed simultaneously with die-forming of the radiating member 8 using the powder metallurgical process.

The back surface of the semiconductor element 1 is adhesively bonded on the surface of a portion of the heat spreader 9 surrounded by the reinforcing plate 10 with a thermally conductive adhesive (conductive paste) 23 or an adhesive (polyolefin based adhesive sheet or epoxy/nitrile based adhesive, thickness: 20-100 μm) 13. Meanwhile, the back surface of a peripheral portion of the film circuit 3 is adhesively bonded on the front surface of the reinforcing plate 10 with the adhesive 13. In this way, the radiating member 8 is mounted on the semiconductor element 1.

In the case where the semiconductor element 1 is

adhesively bonded to the radiating member 8 with the thermally conductive adhesive 23, the adhesive 23 functions to make smaller the heat resistance between the semiconductor element 1 and the radiating member 8. To be more specific, silver paste for die bonding is used as the adhesive 23. Reference numeral 24 indicates a conductive paste for electrically connecting the external ring 14 to the radiating member 8. The conductive paste 14 functions to earth the external ring 14 and hence to allow the external ring 14 to exhibit an electrostatic shield function. Accordingly, it is possible to enhance an anti-radio noise characteristic.

According to the semiconductor device in this embodiment, since the radiating member 8 is composed of the head spreader 9 and the reinforcing plate 10 formed integrally with each other, any material having a large heat resistance such as an adhesive is not interposed between the heat spreader 9 and reinforcing plate 10. As a result, the heat which is generated from the semiconductor element 1 and transmitted to the heat spreader 9 of the radiating member 8 is effectively radiated to the exterior not only through the heat spreader 9 but also through the reinforcing plate 10, to thereby make the radiation characteristic higher than that of the related art

semiconductor device.

Since the radiating member 8 is composed of the heat spreader 9 and the reinforcing plate 10 formed integrally with each other, it is possible to eliminate the necessity of assembling the radiating member 8. This makes it possible to reduce the number of steps of forming the radiating member 8 and lower the formation cost thereof, and hence to lower the fabrication cost of the semiconductor device. In particular, since the radiating member 8 can be significantly simply obtained by die-forming a metal powder using a forming die by the powder metallurgical process, it is possible to significantly reduce the formation cost of the radiating member 8.

Since the radiating member 8 is composed of the heat spreader 9 and the reinforcing plate 10 formed integrally with each other, the heat spreader 9 is reinforced by the reinforcing plate 10, to thereby increase the rigidity of the radiating member 8. Accordingly, the radiating member 8 is less deformed, to prevent a reduction in connection between external terminals of the semiconductor device to other members such as a printed wiring board due to deformation of the radiating member 8.

Further, since the vent holes 20 for communicating gaps 15 between the radiating member 8 and the

semiconductor element 1 to an external surface of the radiating member 8 are formed in the radiating member 8, gas (for example, moisture) discharged from the resins 7 and 13 for adhesive bonding, sealing and the like into the gaps 15 is released to the exterior through the vent holes 20. As a result,there is no possibility that the gas is thermally expanded at the reflow step for shaping the solder balls 6 and the air-tightness of the semiconductor device is eliminated or reduced by peeling of the adhesive due to the increased expansion pressure of the gas.

Figs. 3A to 3E are sectional views showing one example of a method of fabricating the semiconductor device shown in Figs. 1A and 1B in the order of fabrication steps.

As shown in Fig. 3A, there is prepared a film circuit 3 forming a lead frame on which leads corresponding to a plurality of semiconductor devices are integrally formed. At this step, solder balls 6 for forming external terminals of the film circuit 3 are left as being plated, that is, not formed in ball shapes because they are not subjected to reflow treatment.

As shown in Fig. 3B, bumps 5a formed at tips of inner leads 5 of the film circuit 3 are bonded to electrode pads 2 of the semiconductor element 1. In the case where the bumps 5a are made from aluminum, they must be bonded by

single point bonding; while in the case where the bumps 5a are made from gold, they can be collectively bonded by gang bonding.

As shown in Fig. 3C, the surface of the semiconductor element 1 and connecting portions between the semiconductor element 1 and the film circuit 3 are sealed with a sealing resin 7.

As shown in Fig. 3D, a radiating member 8 (composed of a heat spreader 9 and a reinforcing plate 10 formed integrally with each other) is adhesively bonded by means of adhesives 13 and 23 on a bottom surface of the semiconductor element 1 and a bottom surface of the film circuit 3 at portions where the solder balls are formed.

As shown in Fig. 3E, the solder balls 6 are formed into dome shapes by reflow treatment, followed by cutting the film circuit 3 into parts corresponding to the semiconductor devices. Then, an external ring 14 is connected to the radiating member 8 with a conductive paste 24 for allowing the external ring 14 to exhibit an electrostatic shield function. Fig. 3E shows a state after connection of the external ring 14 using the conductive paste 24.

Although the reflow treatment is performed at a temperature at which the solder balls 6 are melted and

thereby gas is discharged from the resins 7 and 13, the gas is prevented from being accumulated and expanded in the gaps between the semiconductor element 1 and the radiating member 8. This is because the gaps 15 are communicated to the external surface of the radiating member 8 through the vent holes 20, and thereby the gas is released through the vent holes 20.

Fig. 4 shows another embodiment of the present invention. While the semiconductor device in the first embodiment, shown in Figs. 1A and 1B, is realized by applying the present invention to the semiconductor device shown in Fig. 7A, the semiconductor device in this embodiment is realized by applying the present invention to the semiconductor device shown in Fig. 7B and is different in only the type of the semiconductor device from the semiconductor device in the first embodiment.

Fig. 5 is a view showing a state in which the semiconductor device of the present invention is mounted on a printed wiring board, and Fig. 6 is a view showing one example of an electronic equipment using the semiconductor device of the present invention.

The above semiconductor device in which the radiation characteristic is improved and the deformation of the radiating member is reduced can be desirably connected

to electrodes of the printed wiring board, and is most suitable to be mounted on various electronic equipment such as a portable telephone as shown in Fig. 6.

While the preferred embodiments of the present invention have been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the present invention.

What is Claimed is:

1. A semiconductor device comprising:

a semiconductor element having electrodes;

a film circuit having a plurality of external electrodes and lead wirings for connecting said external electrodes to said electrodes of said semiconductor element; and

a radiating member including a heat spreader for promoting radiation of said semiconductor element from a bottom surface thereof and a reinforcing body disposed in such a manner as to surround said semiconductor element for reinforcing said film circuit, said reinforcing body being formed integrally with said heat spreader;

wherein said lead wirings of said film circuit are bonded to said electrodes of said semiconductor element;

connecting portions between said semiconductor element and said film circuit are sealed; and

said heat spreader portion is adhesively bonded on the bottom surface of said semiconductor element and said reinforcing body portion is adhesively bonded on a bottom surface of said film circuit.

2. A semiconductor device comprising:

a semiconductor element having electrodes;

a film circuit having a plurality of external

electrodes and lead wirings for connecting said external electrodes to said electrodes of said semiconductor element;

a radiating member including a heat spreader for promoting radiation of said semiconductor element from a bottom surface thereof and a reinforcing body disposed in such a manner as to surround said semiconductor element for reinforcing said film circuit, said reinforcing body being formed integrally with said heat spreader; and

vent holes formed in said radiating member in such a manner as to communicate gaps between said radiating member and said semiconductor element to an external surface of said radiating member;

wherein said lead wirings of said film circuit are bonded to said electrodes of said semiconductor element;

connecting portions between said semiconductor element and said film circuit are sealed; and

said heat spreader portion is adhesively bonded on the bottom surface of said semiconductor element and said reinforcing body portion is adhesively bonded on a bottom surface of said film circuit.

3. A semiconductor device according to claim 1 or 2, wherein said radiating member is a metal body formed by a power metallurgical process.

4. An electronic equipment on which a wiring board is mounted, comprising said semiconductor device according to claim 1, wherein said external electrodes of said semiconductor device are connected to electrodes on said wiring board.

5. An electronic equipment on which a wiring board is mounted, comprising said semiconductor device according to claim 2, wherein said external electrodes of said semiconductor device are connected to electrodes on said wiring board.