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METHOD OF PRODUCTION OF LEAD FRAME, LEAD FRAME, AND SEMICONDUCTOR DEVICE

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of production of a lead frame, a lead frame, and a semiconductor device.

2. Description of the Related Art

The increasing compactness of electronic equipment in recent years has led to demands for increasing compactness of the semiconductor devices mounted in such electronic equipment. There are various types of semiconductor devices. One of them is the type comprised of a semiconductor chip mounted on a lead frame. A cross-section of a semiconductor device of this type is shown in FIG. 5A as one related art.

In a semiconductor device 30 of the related art, a semiconductor chip 34 is fastened to a die pad 31a of a lead frame 31. Electrode terminals (not shown) of the semiconductor chip 34 and leads 31b of the lead frame 31 are bonded by bonding wires 32. A sealant 33 is used to seal the semiconductor chip 34 and bonding wires 32.

As illustrated, the leads 31b of the lead frame 31 are not bent into gull wings, but merely project out slightly from the outer circumference of the sealant 33. A semiconductor device provided with such leads 31b is called a "quad flat non-lead" (QFN) type semiconductor device. In a QFN type semiconductor device, as mentioned above, the leads are not bent into gull wings and also do not project outside much, so it is possible to bring the size of the device down close to the size of the semiconductor chip.

In this semiconductor device 30, the back surface of the die pad 31a, that is, the surface where the semiconductor chip 34 is not fastened, is exposed to

the outside without being sealed. With this structure, there is the advantage that the heat generated at the semiconductor chip 34 is efficiently radiated to the outside, but moisture is liable to enter between the die pad 31a and the sealant 33 causing the semiconductor chip 34 to stop functioning normally. In addition, if the die pad 31a touches the terminals of the mother board or other board, the terminals will short circuit, so the board has to be designed so that the terminals do not come under the die pad 31a. Therefore, the inconvenience arises of having to impose limits on the design of the board.

To avoid this inconvenience, in the past the semiconductor device shown in FIG. 5B has been proposed. In this semiconductor device 35, the support bars (not shown) connecting the lead frame proper and the die pad were bent so as to raise the die pad 31a upward and allow the sealant 33 to enter to the back surface of the die pad 31a and thereby prevent the die pad 31a from being exposed to the outside. With this structure, however, the new inconvenience arose of the thickness t of the semiconductor device 35 becoming greater by the amount of the depth of the bending of the support bars.

To avoid this inconvenience, the semiconductor device shown in FIG. 5C has further been proposed. In this semiconductor device 36, the support bars are not bent. Rather, the back surface of the die pad 31a is half etched to thin the die pad 31a, and the back surface was covered by the sealant 33 to prevent the die pad 31a from being exposed to the outside. Half etching, however, is generally expensive, so the further problem arises of a higher cost of manufacture of the semiconductor device.

Therefore, it may be considered to thin the die pad 31a by coining instead of half etching. With coining, however, the material spreads by the amount of thinning, so if the wide area of the die pad 31a is coined, the amount of spread will become great and the further

problem will arise of strain caused in the lead frame as a whole.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method of production of a lead frame eliminating strain caused in the lead frame even when thinning the die pad by coining and a lead frame and a semiconductor device made using the same.

To achieve the above object, according to a first aspect of the present invention, there is provided a method of production of a lead frame comprising the a processing step of forming leads, a die pad, and a plurality of support bars formed integrally with the die pad in a metal strip, a dividing step of dividing the die pad formed integrally with the support bars for each support bar so as to obtain a plurality of spaced apart pieces of the die pad, and a coining step of coining at least one main surface of each of the plurality of pieces of the die pad to thin the plurality of pieces of the die pad.

The processing step and the dividing step are preferably performed simultaneously.

In the dividing step, preferably the plurality of pieces of the die pad are shaped as substantial rectangles, and one diagonal line of the two diagonal lines of each rectangle is on a virtual extension of the support bar.

In the dividing step, alternatively the plurality of pieces of the die pad are shaped as substantial right angle triangles, and one side of the two sides forming the right angle of each right angle triangle is on a virtual extension of the support bar.

According to a second aspect of the present invention, there is provided a semiconductor device provided with a lead frame produced by a method of production of a lead frame of the first aspect of the present invention, a semiconductor chip fastened to an

opposite surface to a main surface of the plurality of pieces of the die pad, bonding wires electrically connecting electrode terminals of the semiconductor chip and leads, and a sealant sealing at least the main surfaces of the plurality of pieces of the die pads.

According to a third aspect of the present invention, there is provided a lead frame provided with leads, a die pad divided into a plurality of pieces, and a plurality of support bars formed integrally with the divided die pad, the die pad being thinner than the support bars.

Preferably, the plurality of pieces of the die pad are shaped as substantial rectangles, and one diagonal line of the two diagonal lines of each rectangle is on a virtual extension of the support bar.

Alternatively, preferably the plurality of pieces of the die pad are shaped as substantial right angle triangles, and one side of the two sides forming the right angle of each right angle triangle is on a virtual extension of the support bar.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become clearer from the following description of the preferred embodiments given with reference to the attached drawings, wherein:

FIGS. 1A and 1B are plan views of a method of production of a lead frame according to an embodiment of the present invention, while FIG. 1C is a sectional view along the line A-A of FIG. 1B;

FIG. 2A is a plan view of a semiconductor device comprised of a semiconductor chip mounted on a lead frame produced by the method of the present invention, FIG. 2B is a sectional view along the line B-B of FIG. 2A, and FIG. 2C is a sectional view along the line C-C of FIG. 2A;

FIG. 3A is a plan view of an embodiment of the present invention in the case where the pieces of the die

pad are shaped as substantial triangles, while FIG. 3B is an enlarged plan view of a substantial triangular piece of the die pad;

FIGS. 4A and 4B are plan views explaining the advantages of an embodiment of the present invention in the case where the pieces of the die pad are shaped as substantial triangles; and

FIGS. 5A, 5B, and 5C are sectional views of semiconductor devices of the related art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to the method of production of a lead frame of the first aspect of the present invention, the processing step forms leads, a die pad, and a plurality of support bars formed integrally with the die pad in a metal strip. Next, the dividing step divides the die pad formed integrally with the support bars for each support bar to obtain a plurality of spaced apart pieces of the die pad. Next, the coining step coins at least one main surfaces of the plurality of pieces of the die pad to thin the plurality of pieces of the die pad.

In the coining step, the material spreads by the amount of thinning, but in the present invention, since the die pad has already been divided into a plurality of pieces spaced apart from each other in the dividing step, even if coining the die pad in the coining step, the spread of the die pad is accommodated in the spaces between the pieces of the die pad, so no strain occurs in the lead frame.

Further, if the processing step and the dividing step are performed simultaneously, there is the advantage that the process of manufacture of the lead frame can be shortened.

Further, the plurality of pieces of the die pad may be shaped as substantial right angle triangles, and one side of the two sides forming the right angle of each right angle triangle made to be on a virtual extension of the support bar. By doing this, the spread of the die pad

due to the coining step occurs in a direction where the pieces of the die pad are not close to each other, so the risk of the pieces of the die pad interfering with each other due to the spread is lessened. Due to this, there is no longer a need to strictly control the precision of processing in the coining step.

According to the semiconductor device of the second aspect of the present invention, provision is made of such a produced lead frame, a semiconductor chip fastened to an opposite surface to main surfaces of the plurality of pieces of the die pad, bonding wires electrically connecting electrode terminals of the semiconductor chip and leads, and a sealant sealing at least the main surfaces of the pieces of the die pad. With this structure, the die pad is not exposed at the outside of the semiconductor device, so there is no risk of moisture entering between the die pad and the sealant and no limitation imposed on the design of the board.

Preferred embodiments of the present invention will be described in detail below while referring to the attached figures.

FIGS. 1A and 1B are plan views of the method of production of a lead frame according to an embodiment of the present invention.

First, as shown in FIG. 1A, leads 12, a die pad 13, and support bars 11 formed integrally with the die pad 13 are formed in a metal strip 10. This step is performed by punching by a press. The metal strip 10 is for example made of copper.

As illustrated, the die pad 13 is divided into a plurality of pieces for each support bar 11 formed integrally with it. The step for dividing the die pad 13 may be performed simultaneously with the above processing step or may be performed separately by a press after the processing step. If performed simultaneously, there is the advantage that the manufacturing process can be shortened.

In the illustrated example, each of the plurality of pieces of the die pad 13 is shaped as a substantial rectangle. One diagonal line 13a of the two diagonal lines of each rectangle lies on a virtual extension of the support bar 11.

Next, as shown in FIG. 1B, a coining area shown by hatching is coined. Here, a die (not shown) is pressed against the entire coining area so that the die pad 13 becomes thinner than the support bars 11. This coining step is performed to thin the die pad 13, so the coining area need only encompass all of the divided die pad 13. As illustrated, the front end positions of the support bars 11 may also be coined.

The coining area spreads by exactly the amount of thinning by the coining, but since the die pad 13 is already divided and the pieces spaced apart from each other, the spread can be accommodated in the space S between the pieces of the die pad 13 and no strain will occur in the die pad 13 or the support bars 11.

Further, since the die pad 13 is thinned by the inexpensive coining rather than the expensive half etching, there is the advantage that the cost of manufacturing the lead frame can be reduced.

FIG. 1C is a sectional view along the line A-A of FIG. 1B. The coining area originally having a thickness of about 0.2 mm is thinned to about 0.05 to 0.10 mm by the coining. The present invention is not however limited to such values. The thickness of the metal strip 10 and the depth of processing by the coining may be freely set in consideration of the situation.

Further in the illustrated example, a die is pressed against one main surface 13c of the two main surfaces 13c and 13d of the pieces of the die pad 13 to coin only the main surfaces 13c, but sometimes both main surfaces 13c and 13d may be coined.

Next, the necessary locations are plated or otherwise processed by known processes to complete the

lead frame according to the present embodiment.

The method of dividing the die pad 13 is not limited to the above. If dividing it for each support bar 11, the die pad 13 may be made any shape. For example, it may be the shape illustrated in FIG. 3A. In the example of FIG. 3A, each of the plurality of pieces of the die pad 13 is shaped as a substantial right angle triangle. One side 13b of the two sides 13b and 13e forming the right angle R of each right angle triangle lies approximately on the virtual extension of the support bar 11. Here, refer to FIG. 3B for an explanation of the meaning of "one side 13b ... lies approximately on the virtual extension of the support bar 11". FIG. 3B is an enlarged plan view of a piece of the die pad 13 of FIG. 3A after the coining step. As shown there, the piece of the die pad 13 spreads due to the coining. Further, due to the expansion, one side 13b of each piece of the die pad 13 shifts from the virtual extension of the support bar 11. The amount of the shift, however, is small. That one side 13b is located in proximity to the virtual extension, so is "approximately" on the virtual extension. That is, the above "side 13b ... lies approximately on the virtual extension of the support bar 11" does not mean that the side 13b must be precisely on the virtual extension of the support bar 11, but may be shifted to some degree from the virtual extension by the coining.

If the pieces of the die pad 13 are substantial right angle triangles as shown in FIG. 3A, compared with the shapes shown in FIG. 1B, the advantage is obtained that there is no longer a need to strictly control the precision of processing in the coining step. This will be explained with reference to FIGS. 4A and 4B.

FIG. 4A shows the case where the pieces of the die pads 13 are shaped as substantial rectangles, that is, the shapes shown in FIG. 1B. In this case, the coining step results in the die pad 13 spreading in the directions of the arrows of the figure. As clear from the

illustration, the pieces of the die pad 13 spread in directions approaching each other.

On the other hand, FIG. 4B shows the case where the pieces of the die pad 13 are shaped as substantial right angle triangles, that is, the shapes shown in FIG. 3A. In this case, the coining step results in the die pad 13 spreading in the directions of the arrows A, B, and C in the figure. Among these, the arrows B and C show the spread in directions where the pieces of the die pad 13 approach each other, while the arrow A shows the direction where the pieces of the die pad 13 do not approach each other. In this way, some of the spread of the die pad 13 includes spread in a direction where the pieces of the die pad 13 do not approach each other as shown by the arrow A. Due to this, the risk of the pieces of the die pad interfering with each other due to the spreading is lessened, so there is no longer a need to strictly control the precision of processing in the coining step.

After completing the lead frame, a known process is used to complete a semiconductor device 14 as shown in FIG. 2A. FIG. 2A is a plan view of a semiconductor device 14 comprised of a semiconductor chip 15 mounted on a lead frame produced by the above method of production.

As shown in FIG. 2A, in this semiconductor device 13, a semiconductor chip 15 is bonded on to the divided die pad 13. This is performed for example through a silver paste etc.

FIG. 2B is a sectional view along the line B-B of FIG. 2A. As shown here, the electrode terminals (not shown) of the semiconductor chip 15 are electrically connected with the front end portions of the leads 12 through bonding wires 16. The bonding wires 16 are made of for example gold wires. The semiconductor chip 15 and bonding wires 16 are sealed by a sealant 17 to prevent them from being exposed to the outside air. The sealant 17 is for example a resin, ceramic, etc.

Further, taking note of the leads 12, one of their main surfaces is exposed at the back surface of the semiconductor device 14 without bending. The exposed main surfaces are used as external connection terminals of the semiconductor device 14. Due to these features, the semiconductor device 14 is a so-called QFN type semiconductor device, but of course the present invention is not limited to a QFN type and may also be applied to for example a quad flat package (QFP) type semiconductor device.

FIG. 2C is a sectional view along the line C-C of FIG. 2A. As shown here, a semiconductor chip 15 is fastened on a main surface 13d of the uncoined side among the two main surfaces 13c and 13d of the die pads 13. Further, the main surface 13c of the coined side is sealed by the sealant 17, so the die pad is not exposed to the outside of the semiconductor device 14. With this structure, there is the advantage that moisture will not enter from between the die pad 13 and the sealant 17 and the advantage that no limitation is imposed on the design of the mother board or other board (not shown).

As explained above, according to the method of production of a lead frame of the first aspect of the present invention, the processing step forms leads, a die pad, and a plurality of support bars formed integrally with the die pad in a metal strip. Next, the dividing step divides the die pad formed integrally with the support bars for each support bar to obtain a plurality of spaced apart pieces of the die pad. Next, the coining step coins at least one main surface of each of the plurality of pieces of die pad to thin the plurality of pieces of the die pad.

According to this, since the die pad has already been divided into a plurality of pieces spaced apart from each other in the dividing step, even if coining the die pads in the coining step, the spread of the die pad is accommodated in the space between the pieces of the die

pad, so no strain occurs in the lead frame.

In particular, if the plurality of pieces of the die pad are shaped as substantial right angle triangles, and one side of the two sides forming the right angle of each right angle triangle is made to be on a virtual extension of the support bar, there is no longer a need to strictly control the precision of processing in the coining step.

Further, according to the semiconductor device of the second aspect of the present invention, provision is made of such a produced lead frame, a semiconductor chip bonded to an opposite surface to a main surface of a plurality of pieces of the die pad, bonding wires electrically connecting electrode terminals of the semiconductor chips and leads, and a sealant sealing at least the main surfaces of the die pads. With this structure, the die pad is not exposed at the outside of the semiconductor device, so there is no risk of moisture entering between the die pad and the sealant and no limitation imposed on the design of the board.

While the invention has been described with reference to specific embodiments chosen for purpose of illustration, it should be apparent that numerous modifications could be made thereto by those skilled in the art without departing from the basic concept and scope of the invention.

The present disclosure relates to subject matter contained in Japanese Patent Application No. 2001-156789, filed on May 25, 2001, the disclosure of which is expressly incorporated herein by reference in its entirety.

WHAT IS CLAIMED IS

1. A method of production of a lead frame comprising:

a processing step of forming leads, a die pad, and a plurality of support bars formed integrally with the die pad in a metal strip,

a dividing step of dividing the die pad formed integrally with the support bars for each support bar so as to obtain a plurality of spaced apart pieces of the die pad, and

a coining step of coining at least one main surface of each of the plurality of pieces of the die pad to thin the plurality of pieces of the die pad.

2. A method of production of a lead frame as set forth in claim 1, comprising performing the processing step and the dividing step simultaneously.

3. A method of production of a lead frame as set forth in claim 1, wherein, in the dividing step, the plurality of pieces of the die pad are shaped as substantial rectangles, and one diagonal line of the two diagonal lines of each rectangle is on a virtual extension of the support bar.

4. A method of production of a lead frame as set forth in claim 1, wherein, in the dividing step, the plurality of pieces of the die pad are shaped as substantial right angle triangles, and one side of the two sides forming the right angle of each right angle triangle is on a virtual extension of the support bar.

5. A semiconductor device provided with:

a lead frame produced by the method of production of a lead frame of any one of claims 1 to 4,

a semiconductor chip bonded to an opposite surface to a main surface of said plurality of pieces of die pads,

bonding wires electrically connecting electrode terminals of the semiconductor chip and said leads, and

a sealant sealing at least the main surfaces of the plurality of pieces of the die pads.

6. A lead frame provided with:

leads,

a die pad divided into a plurality of pieces; and

a plurality of support bars formed integrally with the divided die pad,

the die pad being thinner than the support bars.

7. A lead frame as set forth in claim 6, wherein the plurality of pieces of the die pad are shaped as substantial rectangles, and one diagonal line of the two diagonal lines of each rectangle is on a virtual extension of the support bar.

8. A lead frame as set forth in claim 6, wherein the plurality of pieces of the die pad are shaped as substantial right angle triangles, and one side of the two sides forming the right angle of each right angle triangle is on a virtual extension of the support bar.