

Description

COINING PUNCH FOR LEAD FRAME MACHINING,
PRODUCTION METHOD THEREOF, AND LEAD FRAME

Technical Field

The present invention relates to a coining punch for lead frame machining, a method for producing the coining punch, and a lead frame, in particular, to a coining technology of forming a concave groove having V- or U-shaped configuration in cross section onto a lead frame in order to prevent solder from spreading during the soldering of semiconductor components.

Background Art

In the case of the die pad of a conventional IC lead frame, as shown in Fig. 5 for example, the concave groove 42 is formed in the shape of a rectangular ring along the periphery on the surface of the die pad 41. The semiconductor chip 43 is soldered to the die pad 41 inside the concave groove 42 formed in the shape of the rectangular ring. The role of the concave groove 42 is to prevent molten solder from flowing out from the joint and spreading at the time of the soldering. Here, in the figure, the reference characters w and h represent the width and depth, respectively, of the groove.

The concave groove 42 is formed in the forming

process of a lead frame by coining it with a press to which such a coining punch 44 as shown in Fig. 6 for example is attached. A coining portion (protruding portion) 46, which has a configuration conforming to the width and depth of the rectangular-ring-shaped concave groove 42 to be formed on the die pad 41, is formed around the periphery on the tip face 45 of the coining punch 44, a flat face 47 that touches the surface of the die pad 41 is formed inside the coining portion 46, and resultantly the concave groove forming portion 48 is composed of them. Here, the reference numeral 49 shows a hole for releasing air pressure imposed at the time of coining. Meanwhile, cemented carbide is mainly used as the material of the coining punch 44.

In the meantime, due to the recent requirements for downsizing and weight reduction of semiconductor devices, semiconductor chips and lead frames become smaller, the region of the concave groove formed on a die pad (bonding region) also becomes smaller accordingly, and, as a result, the projected shape of the concave groove is required to be preciser. In other words, a certain bonding region in the die pad of a semiconductor chip still has to be secured even when downsizing advances and, in order to do so, it is necessary not only to form the corners of the rectangular ring of a concave groove so that the radius R of the corners is as small as possible to the extent of forming a right angle but also to reduce the width of the concave

groove. In the case of reducing the width of the concave groove, it is necessary to increase the sectional area of the concave groove in order to receive leaking solder and resultantly prevent the solder from spreading at the time of soldering. In order to increase the sectional area of the concave groove, it is necessary to increase the groove depth to the degree corresponding to the reduction of the groove width. For the above reasons, it is necessary to change the sectional shape of a concave groove from a V shape to a U shape and also from a shallow groove to a deep groove. For example, since there is a limit in the reduction of a groove width in order to prevent solder from spreading, it is necessary to increase the groove depth from 0.20 to 0.3-0.35 mm. As a consequence, a concave groove having a certain depth and the section of a U shape is required.

Meanwhile, when a concave groove having a smaller corner radius R of the concave groove ring and a certain depth and a U shape in cross section as stated above is formed on the die pad of a lead frame, the tip of the coining punch that coins such a concave groove (corresponding to the concave groove forming portion) takes the shape of a coining portion (protruding portion) 50 which has a configuration conforming to the width and depth of the rectangular-ring-shaped concave groove to be formed on the die pad as shown in a partially enlarged manner in Fig. 7. That is, the corner portion 53 formed at the

intersection between one side 51 and the other side 52 of the rectangle has a smaller corner radius R than before and also the corner portion formed at the intersection between the flat face 54, which touches the surface of a die pad, inside the coining portion 50 and the upright wall of the coining portion 50 has a very small corner radius r .

When a concave groove 42 is formed by coining a die pad 41 with a coining punch 44 having the shape of such a concave groove forming portion 48 as mentioned above, the groove forming portion 48 of the coining punch 44 undergoes a large reaction force. The reaction force causes stress concentration at the corner portion 53 of the coining portion 50, in particular at the portion 55 where the corner radius R between the sides 51 and 52 and the corner radius r between the flat face 54 and the upright wall of the coining portion 50 intersect with each other, and the large stress concentration produces the origins of cracks and resultantly causes some parts of the coining portion 50 of the concave groove forming portion 48 to fall off. In particular, when the width of the coining portion 50 is narrower, the height thereof is higher and further the corner radii R and r are smaller, the coining portion 50 tends to crack and the aforementioned requirements for a concave groove having a deeper depth and a U shape in cross section cannot be satisfied accordingly. Incidentally, when the depth and width of the concave groove 42 are defined as h and w respectively, for example, whereas a

coining punch having a groove depth h of 0.20 mm and a ratio h/w of not more than one withstands the coining of several hundreds of thousands times, a coining punch having a groove depth h of 0.27 mm and a ratio h/w of more than one cracks even in the coining of some dozen times.

The present invention has been established to solve the above problems. The first object of the present invention is to provide: a coining punch for lead frame machining that does not crack and can withstand the forming of a concave groove even when the depth of the concave groove increases and the width thereof decreases; and a method for producing the coining punch. Further, the second object thereof is to provide a lead frame having on the surface of the die pad a concave groove the depth of which is larger than the width thereof.

Disclosure of the Invention

In order to attain the aforementioned first object, a coining punch for lead frame machining according to the present invention (claim 1), the coining punch being used for forming a concave groove on the surface of a lead frame: comprises a punch inner component having a punch tip portion that touches the surface of the lead frame at the time of coining and a hollow punch body having a coining portion that forms the concave groove on the lead frame at the time of coining and a hollow portion in the axial direction of the punch; and is assembled by fitting the

punch inner component into the hollow portion of the hollow punch body.

With the above configuration, since the punch tip portion that touches the surface of the lead frame at the time of coining is incorporated into the punch inner component, the coining portion (protruding portion) that forms, for example, a ring-shaped concave groove on the lead frame at the time of coining is incorporated into the hollow punch body, and thus the punch inner component and the hollow punch body are separated from each other, the corner of radius r is not formed, thus the stress concentration imposed on the corner of radius r is eliminated, and resultantly it is possible to apply coining without the cracking and falling off of the coining portion even when the ratio h/w of the concave groove is one or larger. Note that, according to experiments, though the results vary in accordance with the quality and thickness of copper alloy, the width w of a concave groove and others, in an ordinary case, it is possible to apply coining without cracking as long as a ratio h/w of the concave groove is about two or less.

Further, it is preferable that the coining punch for lead frame machining according to claim 1 is configured so that both the hollow portion of the hollow punch body and the punch inner component are formed so as to reduce the sectional areas thereof gradually toward the tip of the punch (claim 2). By adopting such a configuration, it

becomes possible not only to firmly fit the punch inner component into the hollow portion of the hollow punch body but also to facilitate adjusting the protruding length of the protrusion of the coining portion in accordance with the depth h of the concave groove. Note that, in the case where the punch inner component and the hollow punch body are divided from each other along a straight line on a cross section containing the axes thereof, it is possible to firmly fit the punch inner component into the hollow punch body by inserting a spacer.

Furthermore, in order to attain the aforementioned first object, a method for producing a coining punch for lead frame machining according to the present invention (claim 3), the coining punch being used for forming a concave groove on the surface of a lead frame, comprises the processes of: producing a material rod having a profile of the coining punch product; separating the material rod in the axial direction into a central member (corresponding to the punch inner component) and a hollow member (corresponding to the hollow punch body) in such a manner that a protrusion having the width corresponding to the width of the concave groove to be formed on the surface of the lead frame is formed on the tip face of the material rod; and inserting the central member into the hollow portion that passes through in the axial direction of the hollow member in such a manner that the protrusion from the tip face of the central member has at least the length

corresponding to the depth of the concave groove to be formed on the surface of the lead frame.

By the above production method, it becomes possible to produce a coining punch for lead frame machining according to claim 1 relatively easily. Further, by applying wire electric discharge machining particularly to the separation of the central member and the hollow member (claim 4), it becomes possible to carry out the separation with a high degree of accuracy and moreover to easily produce a coining punch having the configuration defined in claim 2.

Yet further, a lead frame according to the present invention (claim 5) is the one that has on the surface of the die pad a ring-shaped concave groove the depth of which is larger than the width thereof.

In this way, by the invention of a coining punch for lead frame machining according to claim 1, it has become possible to: stably produce a lead frame having on the surface of the die pad, for example, a ring-shaped concave groove the depth h of which is larger than the width w thereof (the ratio h/w being one or larger); by so doing, solder a semiconductor chip without the spread of the solder even when the size of the die pad is reduced; and, as a result, satisfy the requirements for the downsizing and weight reduction of a semiconductor device.

Brief Description of the Drawings

Fig. 1 is composed of explanatory views of a coining punch for lead frame machining according to the present invention; Fig. 1 (a) is a sectional view thereof in the axial direction and Fig. 1 (b) a view taken from the direction indicated by the arrow A in Fig. 1 (a).

Fig. 2 is composed of explanatory views showing the outline of the procedures in the production of a coining punch for lead frame machining according to the present invention; Fig. 2 (a) is a view showing the profile of a material rod, Fig. 2 (b) a view showing the state of electric discharge machining, Fig. 2 (c) a view taken from the direction indicated by the arrow B in Fig. 2 (b), and Fig. 2 (d) a view showing the profile of a central member.

Fig. 3 is composed of explanatory views of a lead frame according to the present invention; Fig. 3 (a) is a front view thereof and Fig. 3 (b) a sectional view taken on line C-C of Fig. 3 (a).

Fig. 4 is a sectional view of a coining punch for lead frame machining in the axial direction thereof in another embodiment according to the present invention.

Fig. 5 is composed of explanatory views of a conventional lead frame; Fig. 5 (a) is a front view thereof and Fig. 5 (b) a sectional view taken on line D-D of Fig. 5 (a).

Fig. 6 is composed of explanatory views of a conventional coining punch for lead frame machining; Fig. 6 (a) is a sectional view thereof in the axial direction and

Fig. 6 (b) a view taken from the direction indicated by the arrow E in Fig. 6 (a).

Fig. 7 is an enlarged perspective view showing the tip portion of a coining punch for lead frame machining in the state of cutting off the front part thereof.

Best Mode for Carrying Out the Invention

The embodiments according to the present invention are hereunder explained on the basis of the drawings. Fig. 1 is composed of explanatory views of a coining punch for lead frame machining according to the present invention; Fig. 1 (a) is a sectional view thereof in the axial direction and Fig. 1 (b) a view taken from the direction indicated by the arrow A in Fig. 1 (a). The reference numeral 1 is a coining punch for lead frame machining, 2 a punch inner component, and 3 a hollow punch body.

The punch inner component 2 is a solid rod rectangular in cross section and, at the tip thereof, has a punch tip portion 6 that touches the surface 5 of a lead frame (die pad) 4 at the time of coining.

The hollow punch body 3 has the same shape as a conventional punch in outer appearance, is a rod rectangular in cross section having a tapered portion 7 between the tip and the center thereof in the axial direction in the case of the present embodiment, and has at the tip thereof a coining portion 9 that forms a ring-shaped concave groove 8 on the lead frame 4 at the time of

coining. Further, it also has at the center of the coining punch 1 a hollow portion 10 extending from the coining portion 9 to the other end opposite the coining portion 9 in the axial direction of the punch.

Then, the coining punch for lead frame machining 1 is constructed by fitting the punch inner component 2 into the hollow portion 10 of the hollow punch body 3 with a spacer 11 interposed in between.

With a coining punch for lead frame machining 1 having the aforementioned configuration, since the punch tip portion 6 of the punch inner component 2 is separated from the coining portion 9 of the hollow punch body 3, the corner of radius r , which has conventionally been formed, is not formed, and thus the stress concentration imposed on the corner of radius r is eliminated, it is possible to coin a die pad without the cracking and falling off of the coining portion 9 even when the ratio h/w of the concave groove is one or larger.

Fig. 2 is composed of explanatory views showing the outline of the procedures in the production of a coining punch for lead frame machining having the aforementioned configuration. In the production of the coining punch for lead frame machining having the aforementioned configuration, firstly a material rod 12 formed into the product shape of the coining punch 1 in appearance is produced and then an air releasing hole 13 is pierced at the center of the material rod 12 (refer to Fig. 2 (a)).

Successively, the material rod 12 is cut in the axial direction thereof separably into a central member (corresponding to the punch inner component) 16 and the hollow member (corresponding to the hollow punch body) 17 by inserting a wire 14 for electric discharge machining through the air releasing hole 13 and then moving the electric discharge machining wire 14 as indicated by the arrow 15 in Fig. 2 (c) so as to form a rectangle in cross section (refer to Figs. 2 (b) to 2 (d)). In the cutting process, the electric discharge machining is applied so that the wall thickness at the tip of the hollow member 17 is identical with the width of the ring-shaped concave groove formed on the surface of a lead frame.

A coining punch for lead frame machining 1 is produced by using the central member 16 and the hollow member 17 that are cut separably through electric discharge machining as stated above and fitting the central member 16 into the hollow portion 18 of the hollow member 17 formed by cutting off the central member 16 with a spacer 11 interposed in between as shown in Fig. 1. The coining portion (protruding portion) having the shape conforming to the width and depth of the concave groove is formed by firmly fitting the central member 16 in the manner of, at the time of the fitting, retracting the tip face 19 of the central member 16 by the distance corresponding to the depth of the ring-shaped concave groove to be formed on the surface of the lead frame.

Fig. 3 is composed of explanatory views of a lead frame according to the present invention and only the expanded views of a die pad are shown. On the surface 5 of the lead frame (die pad) 4, a concave groove 8 formed so that the ratio (h/w) of the depth h and width w of the groove is two ($w = 0.2$ mm and $h = 0.4$ mm) is formed in a rectangular ring shape along the periphery of the die pad 4. The lead frame 4 is produced by coining a copper alloy lead frame material with a coining punch for lead frame machining 1 shown in Fig. 1, the coining punch being produced in the manner shown in Fig. 2 and having a coining portion 9 conforming to the concave groove 0.2 mm in width w and 0.4 mm in depth h . In the coining with the coining punch thus produced, no cracks are observed at the coining portion 9 of the coining punch for lead frame machining 1 even when several hundreds of thousands times of coining are applied and thus the coining punch is far more excellent in durability than conventional punches.

Fig. 4 is a sectional view of a coining punch for lead frame machining in the axial direction thereof in another embodiment according to the present invention.

The coining punch for lead frame machining 21 shown in Fig. 4 is produced by: cutting off the central member 16 from the hollow member 17 in the production manner shown in Fig. 2 so that the cross sectional area of the central member 16 increases toward the bottom end thereof in the manner of forming a taper; then producing the punch inner

component 22 by cutting off the tip portion of the central member 16 by the length corresponding to the depth of the concave groove; using the hollow member 17 having a hollow portion 24 formed into the tapered shape as the hollow punch body 23; fitting the punch inner component 22 into the hollow portion 24 of the hollow punch body 23; placing the spacer 25 at the bottom end of the punch inner component 22; and further applying the retaining means 26.

Even with a coining punch for lead frame machining 21 having the aforementioned configuration, in the same way as the coining punch for lead frame machining 1 shown in Fig. 1, since the punch tip portion 6 of the punch inner component 22 is separated from the coining portion 9 of the hollow punch body 23, the corner of radius r , which has conventionally been formed, is not formed, and thus the stress concentration imposed on the corner of radius r is eliminated, it is possible to apply coining without the cracking and falling off of the coining portion 9 even when the ratio h/w of the concave groove is one or larger.

Though the above explanations are done on the basis of the above embodiments in the case where the concave groove 8 is formed into a ring shape, the same effects can be obtained even in the case where the concave groove 8 is formed into an L-shape or a U-shape.

Industrial Applicability

As explained above, with a coining punch for lead

frame machining according to the present invention, since the corner of radius r at the intersection between the flat face, which touches the surface of a die pad, inside the coining portion and the upright wall of the coining portion is not formed and thus the stress concentration imposed on the corner of radius r is eliminated, it is possible to coin the die pad without the cracking and falling off of the coining portion even when the ratio h/w of the concave groove to be formed on the lead frame is one or larger.

Further, by the method for producing a coining punch for lead frame machining according to the present invention, it is possible to produce a coining punch for lead frame machining according to the present invention comparatively easily. In particular, by applying wire electric discharge machining in separating the punch inner component from the hollow punch body, the separation can be done with a high degree of accuracy.

Furthermore, since a lead frame according to the present invention has on the surface of a die pad a ring-shaped concave groove the depth of which is larger than the width thereof, it is possible to apply soldering with the solder prevented from spreading even when the sizes of semiconductor chips and lead frames are reduced and the radius R of the corners of the rectangular-ring-shaped concave groove and the width of the concave groove are reduced accordingly to cope with the requirements for the downsizing and weight reduction of semiconductor devices.

CLAIMS

1. A coining punch for lead frame machining, said coining punch being used for forming a concave groove on the surface of a lead frame, wherein: said coining punch comprises a punch inner component having a punch tip portion that touches the surface of said lead frame at the time of coining and a hollow punch body having a coining portion that forms said concave groove on said lead frame at the time of coining and a hollow portion in the axial direction of said punch; and said punch inner component is fit into said hollow portion of said hollow punch body.

2. A coining punch for lead frame machining according to claim 1, wherein both said hollow portion of said hollow punch body and said punch inner component are formed so as to reduce the sectional areas thereof gradually toward the tip of said coining punch for lead frame machining.

3. A method for producing a coining punch for lead frame machining, said coining punch being used for forming a concave groove on the surface of a lead frame, comprising the processes of: producing a material rod having a profile of the coining punch product; separating said material rod in the axial direction thereof into a central member and a hollow member in such a manner that a protrusion having the width corresponding to the width of said concave groove to

be formed on the surface of said lead frame is formed on the tip face of said material rod; and inserting said central member into said hollow portion that passes through in the axial direction of said hollow member in such a manner that said protrusion from the tip face of said central member has at least the length corresponding to the depth of said concave groove to be formed on the surface of said lead frame.

4. A method for producing a coining punch for lead frame machining according to claim 3, wherein wire electric discharge machining is applied in the separation of said central member and said hollow member.