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(54) STAMPED LEAD FRAME FOR SEMICONDUCTOR PACKAGES

(71) We, PLESSEY INCORPORATED, a Corporation organised under the laws of New York, United States of America, having a place of business at 767 fifth Avenue, New York, New York 10022, United States of America do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates in general to packages for semiconductive devices. More particularly, the invention relates to semiconductor packages that include lead frames. The invention is specifically adapted to, and will be described in connection with, a 40-lead dual-in-line ceramic package, or Cer-Dip, but it is not so limited; the invention can, in fact, be applied to substantially any lead frame used in ceramic packages.

Ceramic semiconductor packages have three essential parts. A ceramic substrate has a central cavity or depression that is metallized and plated to receive the semiconductive device or "chip". In Dip packages, the substrate is rectangular, and in "quad" packages, the substrate is square. The lead frame is secured to the upper surface of the substrate and includes a plurality of metal leads extending from the edge of the cavity to and beyond the edges of the substrate. In Dip packages, the leads extend to the two long sides of the rectangular substrate and are there bent down to form two parallel lines of leads that are adapted for insertion into printed circuit boards. In quad packages, the leads extend over the edges on all four sides. Lastly, and after the chip has been bonded in the depression and wired to the leads, a ceramic cover is secured over the top to hermetically seal the chip.

During manufacture, the other ends of the leads are all integral with a surrounding frame which holds them in place (hence the name "lead frame") and there may also be intermediate tie-bars between the leads assisting in the same function. At some point after the lead frame is secured to the substrate the frame and tie bars are cut away.

Lead frames are made by either stamping or etching. Etching is a relatively slow process, but it is advantageous in that required photomasks are not expensive. Etching is thus preferred for low-volume production, particularly where complicated patterns are involved. Stamping is very rapid, but requires a very substantial investment in tooling, because as many as 15 progressive steps may be involved. Stamping is thus preferred for high-volume production.

Lead frames are manufactured out of so-called glass-sealing alloys, which are alloys specifically designed to have a coefficient of thermal expansion about the same as the glass they will ultimately be embedded in. Kovar (trademark) is one such alloy and contains iron, cobalt and nickel. Alloy 42 is similar. Kovar is preferred for etched frames and Alloy 42 is preferred for stamping. These alloys are difficult to bond wires directly to, accordingly, the alloy may be provided with a stripe of vapor-deposited aluminium which covers the lead tips, or a dot of gold may be applied over the lead tips by selective plating.

The progress of microelectronics has been miniaturization, putting more and more electronic functions on a single chip. Whereas a few years ago, a 14-lead Dip was practically standard, today 40 and even 64-lead packages are commonplace. The chip itself and the cavity in the substrate have remained about the same size (roughly 1/4 in. square), however, so the leads have had to become progressively finer and be more closely spaced. In a 40 lead package, for example, the leads (at the tip) may be 0.012 in. wide and spaced 0.012 in. apart. Because no tie bars can be placed on the portions of the leads to be embedded in the glass, the very fine leads can move about, particularly during the embedding operation, and one short circuit — e.g. two leads touching, will ruin the entire package.

Accurate lead positioning is even more

important and in fact it is absolutely essential — when automatic equipment is used to insert and wire bond the chip.

It is a general aim of the present invention is to provide an improved lead frame for semiconductor packages.

Accordingly this invention provides a lead frame for semiconductor packages including a plurality of leads integral with a surrounding frame and extending to a central opening around which the inner tips of the leads converge, at least some of the leads being integral with one or more tabs, and the tabs being weakened across a break-off line to facilitate removal of same.

The tabs may be upwardly-bent along the break-off line at a suitable angle to further facilitate removal of same.

Preferably, the package is a rectangular dual-in-line package, the opening is substantially square, and the tabs are integral with the leads having their tips parallel to the short side of the rectangle.

The lead frame may include smaller leads more closely spaced than has heretofore been possible. Also, the lead frame may include large numbers of closely spaced leads that can be manufactured in high volume and at a low cost with a high yield of acceptable parts.

The lead frame may include a ceramic substrate having a cavity on its upper surface corresponding to the opening, the substrate underlying the lead frame with the inner tips converging on the cavity and the outer ends of the leads, and the frame, extending beyond the edges of said substrate, and a layer of glass on the upper surface having overlying portions of the leads embedded therein.

The lead frame may be one in which the opening is substantially square, there are four of the tabs, each integral with leads on one side of the opening, and each tab is upwardly-bent at a suitable angle to further facilitate removal of same.

Preferably, the break-off line extends across the inner tips of the leads and into same to approximately one-half their thickness.

The invention further provides a stamped lead frame for a dual-in-line semiconductor package comprising a rectangular ring having a plurality of leads integral with the long sides thereof extending interiorly from the ring and converging at their inner tips on a substantially square central opening, at least some of the leads on the sides of the opening having inner tips parallel to the short sides of the rectangle being integral with break-off tabs interior of the central opening, and the inner tips integral with the tabs being weakened along a score line to facilitate removal of the tabs.

The lead frame may include at least 40 of the leads. Usually the lead frame will be one in which there are longer leads and shorter leads, and in which the leads that are integral with the tab or tabs are the longer leads.

Then present invention still further provides a partially-assembled dual-in-line semiconductor package comprising a stamped lead frame, and a rectangular ceramic substrate having a central cavity corresponding to the opening and a glass layer on the remainder of the upper surface thereof, the leads being embedded in the glass layer over the upper surface and extending beyond the edges of the long sides of the substrate, and the extending leads being bent downwardly in a dual-in-line configuration.

The present invention yet further provides a process for making lead frames for semiconductor packages from strip stock in a progressive stamping operation, the frames including a plurality of leads integral with a surrounding frame and extending to a central unstamped area around which the inner tips of the leads converge and which are integral therewith, which process comprises:

(a) stamping the unstamped area to form a central opening including only one or more tabs integral with at least the inner tips of some of the leads;

(b) weakening the inner tips along a break-off line to facilitate removal of same; and

(c) bending the tabs upwardly along the break-off line to further facilitate removal of same.

Preferably, steps (a), (b) and (c) are carried out as an integral part of the stamping operation. The process may include coining the inner lead tips simultaneously with the bending step.

Embodiments of the invention will now be described solely by way of example and with reference to the accompanying drawings in which:

Figure 1 is an enlarged, partial plan view of a small portion of a lead frame embodying the invention;

Figures 2 and 3 are cross sectional elevations, taken along line 2—2 of Figure 1, and illustrating weakening and bending of tabs in accordance with the invention;

Figure 4 is a plan view, greatly enlarged, of one-quarter of a completed 40-lead Dip lead frame in accordance with the invention;

Figure 5 is a plan view of an alternate embodiment of the invention, wherein all leads are tab-supported; and

Figures 6 and 7 are elevation views of the Figure 4 lead frame, taken along lines 6—6 and 7—7 respectively.

Stamping of complex lead frames is carried out in progressive carbide dies. That is, the raw material is fed through a stamping press having successive punch and die sets at a number of stations, where successive stamping operations are carried out. The material is indexed forward one station between each

stamping blow. Typically, index holes are punched at the first station, and the various leads are formed at successive stations. FIGURE 1 shows the tips of 20 leads of a 40-lead frame. The configuration shown results after ten stamping operations. FIGURE 4 shows one-fourth of an entire device, including frame 11 integral with the outer ends of all leads.

As is more clearly shown in FIGURE 4, leads 10, 12 are very short, and are bent over the side of ceramic substrate 14 a small distance from the tip, because their tips are parallel with the long side of the substrate. Furthermore, they are spaced relatively widely from each other. Even leads 16, 18, while longer than leads 10, 12, are not so long that motion or shorting is a problem, even though their tips are parallel to the short side of the substrate. Leads 20 are the longest, their unsupported length being such that they could not survive stamping, much less embedment, without internal support.

In accordance with the invention, then, in the tenth operation, the metal holding all the lead tips is cut away except for the tabs 22 holding leads 20. At this point, however, tabs 22 are not distinct from internal tie bars found in the prior art.

At the next station the sides of the leads are bent down into two parallel rows 23, in FIGURE 7 (which is one reason Dip packages are preferred by the industry over other types: they can continue to be handled in automatic equipment after lead bending).

The next station is particularly important in the present invention, and attention is directed to FIGURE 2. Leads 20 are here supported on a die 24, and a punch 26 weakens tabs 22 about one-half way through its thickness. The weakened tabs 22 are known in the art as scored tabs and the score line is shown in phantom at 28 in FIGURE 1.

The next and final station in the stamping process is also novel and important to the present invention. In a conventional lead frame process, this stage involves coining the lead tips to insure flatness, and this is done in the present invention as well. More particularly, in moving from the scoring to the coining station, the bent strip is raised a few thousandths on spring-mounted supports. With reference to FIGURE 3, a coining punch 30 then presses down, coining lead tips 20 (as well as tips of leads 10, 12, 16, 18) against die block 24 over the area 31 (FIGURE 4). As coining punch 30 pushes the frame down (and the spring-mounted supports give way), tabs 22 impinge against a slope-sided die block 32, bending tabs 22 upward at a suitable angle, 30—45°. When coining punch 30 retracts, the spring supports raise the frame over block 32, and the finished strip of frames moves on to cutting and stacking.

Processing from this point on is substantially conventional. Ceramic substrate 14 having central cavity 34 and a screen-printed glass coating is positioned on a fixture so that the lead tips reach the edge of cavity 34 and tabs 22 extend thereover. The glass is a low-melting composition, and heat is quickly applied to melt same, while a ram (similar to coining die 30 but covering all of the horizontal leads) presses the leads into the glass and quickly cools the assembly. After the glass is solidified, tabs 22, having served their function during the embedment process, are broken off, leaving lead tips 20 exposed and in precise spatial relation.

It will be appreciated that while the invention is particularly adapted for stamped lead frames, it could be embodied in an etched part. More particularly, such a part would include tabs 22, and they would thereafter be scored and bent as described above but on a separate machine.

Other variations are possible, and one is illustrated in FIGURE 5: In quad packages or very large packages, it may be desirable to support all leads 36, in which case the stamping (or etching) leaves four tabs 38, which can be scored and bent in precisely the same manner as described hereinabove in connection with tabs 22.

Various other changes in the details, steps, materials, and arrangements of parts, which have been herein described and illustrated to explain the nature of the invention, may be made by those skilled in the art, within the principle and scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS: —

1. A lead frame for semiconductor packages including a plurality of leads integral with a surrounding frame and extending to a central opening around which the inner tips of the leads converge, at least some of the leads being integral with one or more tabs, and the tabs being weakened across a break-off line to facilitate removal of same.

2. A lead frame according to Claim 1 in which the tabs are upwardly-bent along the break-off line at a suitable angle to further facilitate removal of same.

3. A lead frame according to Claim 1 or Claim 2 in which the package is a rectangular dual-in-line package, the opening is substantially square, and the tabs are integral with the leads having their tips parallel to the short side of the rectangle.

4. A lead frame according to any one of the preceeding claims including a ceramic substrate having a cavity on its upper surface corresponding to the opening, the substrate underlying the lead frame with the inner tips converging on the cavity and the outer ends of the leads, and the frame, extending beyond the edges of said substrate, and a layer of

stamping blow. Typically, index holes are punched at the first station, and the various leads are formed at successive stations. FIGURE 1 shows the tips of 20 leads of a 40-lead frame. The configuration shown results after ten stamping operations. FIGURE 4 shows one-fourth of an entire device, including frame 11 integral with the outer ends of all leads.

As is more clearly shown in FIGURE 4, leads 10, 12 are very short, and are bent over the side of ceramic substrate 14 a small distance from the tip, because their tips are parallel with the long side of the substrate. Furthermore, they are spaced relatively widely from each other. Even leads 16, 18, while longer than leads 10, 12, are not so long that motion or shorting is a problem, even though their tips are parallel to the short side of the substrate. Leads 20 are the longest, their unsupported length being such that they could not survive stamping, much less embedment, without internal support.

In accordance with the invention, then, in the tenth operation, the metal holding all the lead tips is cut away except for the tabs 22 holding leads 20. At this point, however, tabs 22 are not distinct from internal tie bars found in the prior art.

At the next station the sides of the leads are bent down into two parallel rows 23, in FIGURE 7 (which is one reason Dip packages are preferred by the industry over other types: they can continue to be handled in automatic equipment after lead bending).

The next station is particularly important in the present invention, and attention is directed to FIGURE 2. Leads 20 are here supported on a die 24, and a punch 26 weakens tabs 22 about one-half way through its thickness. The weakened tabs 22 are known in the art as scored tabs and the score line is shown in phantom at 28 in FIGURE 1.

The next and final station in the stamping process is also novel and important to the present invention. In a conventional lead frame process, this stage involves coining the lead tips to insure flatness, and this is done in the present invention as well. More particularly, in moving from the scoring to the coining station, the bent strip is raised a few thousandths on spring-mounted supports. With reference to FIGURE 3, a coining punch 30 then presses down, coining lead tips 20 (as well as tips of leads 10, 12, 16, 18) against die block 24 over the area 31 (FIGURE 4). As coining punch 30 pushes the frame down (and the spring-mounted supports give way), tabs 22 impinge against a slope-sided die block 32, bending tabs 22 upward at a suitable angle, 30—45°. When coining punch 30 retracts, the spring supports raise the frame over block 32, and the finished strip of frames moves on to cutting and stacking.

Processing from this point on is substantially conventional. Ceramic substrate 14 having central cavity 34 and a screen-printed glass coating is positioned on a fixture so that the lead tips reach the edge of cavity 34 and tabs 22 extend thereover. The glass is a low-melting composition, and heat is quickly applied to melt same, while a ram (similar to coining die 30 but covering all of the horizontal leads) presses the leads into the glass and quickly cools the assembly. After the glass is solidified, tabs 22, having served their function during the embedment process, are broken off, leaving lead tips 20 exposed and in precise spatial relation.

It will be appreciated that while the invention is particularly adapted for stamped lead frames, it could be embodied in an etched part. More particularly, such a part would include tabs 22, and they would thereafter be scored and bent as described above but on a separate machine.

Other variations are possible, and one is illustrated in FIGURE 5: In quad packages or very large packages, it may be desirable to support all leads 36, in which case the stamping (or etching) leaves four tabs 38, which can be scored and bent in precisely the same manner as described hereinabove in connection with tabs 22.

Various other changes in the details, steps, materials, and arrangements of parts, which have been herein described and illustrated to explain the nature of the invention, may be made by those skilled in the art, within the principle and scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS: —

1. A lead frame for semiconductor packages including a plurality of leads integral with a surrounding frame and extending to a central opening around which the inner tips of the leads converge, at least some of the leads being integral with one or more tabs, and the tabs being weakened across a break-off line to facilitate removal of same.

2. A lead frame according to Claim 1 in which the tabs are upwardly-bent along the break-off line at a suitable angle to further facilitate removal of same.

3. A lead frame according to Claim 1 or Claim 2 in which the package is a rectangular dual-in-line package, the opening is substantially square, and the tabs are integral with the leads having their tips parallel to the short side of the rectangle.

4. A lead frame according to any one of the preceeding claims including a ceramic substrate having a cavity on its upper surface corresponding to the opening, the substrate underlying the lead frame with the inner tips converging on the cavity and the outer ends of the leads, and the frame, extending beyond the edges of said substrate, and a layer of

glass on the upper surface having overlying portions of the leads embedded therein.

5. A lead frame according to Claim 1 in which the opening is substantially square, there are four of the tabs, each integral with leads on one side of the opening, and each tab is upwardly-bent at a suitable angle to further facilitate removal of same.

6. A lead frame according to any one of the preceeding claims in which the break-off line extends across the inner tips of the leads and into same to approximately one-half their thickness.

7. A stamped lead frame for a dual-in-line semiconductor package comprising a rectangular ring having a plurality of leads integral with the long sides thereof extending interiorly from the ring and converging at their inner tips on a substantially square central opening, at least some of the leads on the sides of the opening having inner tips parallel to the short sides of the rectangle being integral with break-off tabs interior of the central opening, and the inner tips integral with the tabs being weakened along a score line to facilitate removal of the tabs.

8. A lead frame according to Claim 7, in which the tabs are upwardly bent at a suitable angle along the break-off line to further facilitate removal of same.

9. A lead frame according to Claim 7 or Claim 8 and including at least 40 of the leads.

10. A lead frame according to anyone of the preceding claims in which there are longer leads and shorter leads, and in which the leads that are integral with the tab or tabs are the longer leads.

11. A partially-assembled dual-in-line semiconductor package comprising a stamped lead frame as claimed in any one of Claims 7 to 9, and a rectangular ceramic substrate having a central cavity corresponding to the opening and a glass layer on the remainder of the upper surface thereof, the leads being embedded in the glass layer over the upper surface and extending beyond the edges of the long sides of the substrate, and the extending leads being bent downwardly in a dual-in-line configuration.

12. A partially-assembled dual-in-line semiconductor package according to claim 11 in which there are longer leads and shorter leads, and in which the leads that are integral with the break-off tabs are the longer leads.

13. A process for making lead frames for semiconductor packages from strip stock in a progressive stamping operation, the frames including a plurality of leads integral with a surrounding frame and extending to a central unstamped area around which the inner tips of the leads converge and which are integral therewith, which process comprises:

(a) stamping the unstamped area to form a central opening including only one or more tabs integral with at least the inner tips of some of the leads;

(b) weakening the inner tips along a break-off line to facilitate removal of same; and

(c) bending the tabs upwardly along the break-off line to further facilitate removal of same.

14. A process according to Claim 13, wherein steps (a), (b) and (c) are carried out as an integral part of the stamping operation.

15. A process as claimed in Claim 13 or Claim 14 and including coining the inner lead tips simultaneously with the bending step.

16. A lead frame for semiconductor packages, substantially as herein described with reference to the accompanying drawings.

17. Semiconductor packages whenever including a lead frame as claimed in any one of Claims 1 to 10 and 16.

18. A process for making lead frames for semiconductor packages, substantially as herein described.

19. Lead frames for semiconductor packages whenever produced by the process claimed in any one of Claims 13 to 15 and 18.

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