

IMPROVED PUNCH AND DIE ASSEMBLY

Field of the Invention

[0001] The present invention generally relates to punch and die assemblies, and more particularly to punch and die assemblies for semiconductor manufacturing.

Background of the Invention

[0002] Punching is a mechanical process of stamping or piercing selected portions of a work piece, for example metal sheets and strips. Typically, a punch and die assembly is used to carry out this punching process. The work piece is inserted into the punch and die assembly and punched by a cutting tool or a punch against a die insert.

[0003] In the semiconductor manufacturing industry, the punch and die assembly is used in the “dedam/dejunk” process to mechanically individualize the leads on a packaged integrated circuit (IC). Typically, the packaged IC is first formed by encapsulating an IC die coupled to a leadframe. The leadframe is generally a pre-designed metal strip that allows a number of IC dies to be mounted onto it. The plurality of IC dies are encapsulated or molded in epoxy materials to protect it from damage or contamination. After the IC dies are encapsulated, the leadframe undergoes punching and trimming processes to define the leads on the packaged IC. The leads on the encapsulated IC serve as means of electrical connection between the encapsulated IC die and the printed circuit board (PCB).

[0004] Typically, the leadframe design comprises a dambar structure to facilitate the encapsulation process and to provide additional support for the leads. During the encapsulation process, the dambar functions as a barrier to prevent leakage or “flashing” of the epoxy from the IC mold onto the leads. After encapsulation, the packaged IC undergoes the “dedam/dejunk” process to mechanically remove the dambar in order to individualize the leads. Furthermore, any epoxy trapped in the dambar, referred herein as junk, is removed.

[0005] During the “dedam/dejunk” process, an indexing mechanism moves and aligns the encapsulated IC with the leadframe onto the punch and die assembly. Thereafter, the cutting tool of the punch and die assembly is used to remove the dambar

and junk from the encapsulated IC and leadframe. Typically, the cutting tool is made of steel, which has certain drawbacks. In the large volume and high rate IC packaging process, the steel cutting tool is subjected to rapid wear and tear. Manufacturers are required to have frequent maintenance periods for the punch and die assemblies due to the relatively high rates of wear and tear in the steel punch. This leads to disadvantages of increased costs arising from higher maintenance costs, short tool life and frequent periods of down time to replace the steel cutting tool. Furthermore, the worn out steel cutting tool degrades the product quality, hence lowering the overall productivity and yield. Moreover, the implementation of additional product quality controls and inspections to monitor the product quality may consequently increase the overall manufacturing costs. Another disadvantage is “loading” on the cutting surface of the steel cutting tool, wherein plating material on the leadframe and/or the leadframe material itself sticks on cutting surface. Further, there is a problem of dambar slug suck back when a steel cutting tool is used. Subsequently, tungsten carbide materials were used for the cutting tool, which were able to reduce the wear rate and yield loss. However, the problems of “loading” and dambar slug back are still present.

[0006] The present invention overcomes the above disadvantages by utilizing ceramic cutting tools for the punch and die assembly. The ceramic cutting tools are less susceptible to wear and tear and therefore leads to longer tool life and less frequent maintenance. In particular, the ceramic cutting tool has consistent toughness at the cutting edges, and hence not easily chipped. Furthermore, the non-stick surface on the ceramic cutting tool overcomes the “loading” problem on the cutting tool surfaces, thus extending tool life. Other advantages of this invention will be apparent with reference to the detailed description.

Summary of the Invention

[0007] The present invention provides a punch and die assembly comprising ceramic cutting tools which have the advantages of a longer tool life leading to a lower cost per cut, and less frequent maintenance downtimes resulting in lower overall maintenance cost. Furthermore, the ceramic cutting tools provide consistent quality and reduce yield losses by having a longer tool life. Furthermore, the non-stick surface of the ceramic cutting tools overcomes the “loading” problem on the cutting tool surface.

[0008] Accordingly, in one aspect, the present invention provides a punch and die assembly comprising: a die block securely mounted on a base, wherein the die block supports a die; a first plate coupled to the die block, wherein the first plate is movable relative to the die block; a stripper plate disposed between the die block and the first plate, wherein the stripper plate is coupled to the first plate, wherein the stripper plate is movable relative to the first plate, the stripper plate comprising an opening, wherein a stripper component is aligned to the die and is slidable in the stripper plate opening; a punch holder block securely mounted on the first plate and slidable along an opening in the stripper plate, wherein the punch holder block is configured with at least one ceramic punch, the ceramic punch being slidable along the apertures of the stripper component; whereby the first plate moves towards the die block till the stripper component rest on the die, wherein further movement of the first plate towards the die block causes the at least one ceramic punch to protrude from the apertures of the stripper component and thereby punching the die.

[0009] In another aspect, the present invention provides A punch and die machine comprising: a die block securely mounted on a base, wherein the die block supports a die; a feeding mechanism for inserting the die into the die block; a first plate coupled to the die block, wherein the first plate is movable relative to the die block; a stripper plate disposed between the die block and the first plate, wherein the stripper plate is coupled to the first plate, wherein the stripper plate is movable relative to the first plate, the stripper plate comprising an opening, wherein a stripper component is aligned to the die and is slidable in the stripper plate opening; a punch holder block securely mounted on the first plate and slidable along an opening in the stripper plate, wherein the punch holder block is configured with at least one ceramic punch, the ceramic punch being slidable along the apertures of the stripper component; a servo motor for moving the first plate relative to the die block, wherein the first plate moves towards the die block till the stripper component rest on the die, wherein further movement of the first plate towards the die block causes the at least one ceramic punch to protrude from the apertures of the stripper component and thereby punching the die.

Brief Description of the Drawings

[0010] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0011] FIG 1 illustrates the cross-sectional end view of a punch and die assembly in accordance with one embodiment of the present invention.

[0012] FIG 2 illustrates a punch in accordance with one embodiment of the present invention.

[0013] FIG 3 illustrates an alternative view of the punch in FIG 2 looking from the direction BB.

[0014] FIG 4 illustrates the profile of the cutting edge of the punch in FIG 2 in accordance with one embodiment of the present invention.

[0015] FIG 5 illustrates the punch in accordance with one alternative embodiment of the present invention.

[0016] FIG 6 illustrates an alternative view of the punch in FIG 5 looking from the direction CC.

[0017] FIG 7 illustrates a top plan view of the molded IC bring fed into the punch and die assembly.

[0018] FIG 8 illustrates a partial top plan view of the punch aligned to the molded IC.

[0019] FIG 9 illustrates a partial top plan view of the end product with the leads individualized.

Detailed Description of the Invention

[0020] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0021] Punch and die assemblies have been used to produce a variety of stamping and piercing that are useful in the manufacture of various products. The present invention provides a punch and die assembly 1 for precision punching in the semiconductor packaging industry. In particular, the punch and die assembly 1 is utilized to fabricate/create fine pitch packaging or leads on a molded chip package. Some examples

of fine pitch packaging are Small Outline Integrated Circuit (SOIC), Shrink Small Outline Package (SSOP) and Thin Quad Flat Pack (TQFP).

[0022] Referring to FIG 1, the punch and die assembly **1** in accordance with one embodiment of the present invention comprises a die block **20**, a stripper plate **40** and a top plate **60**. The die block **20** is fixedly mounted on a base (not shown), wherein the die block is configured to receive and support a molded integrated circuit (IC) **30**. The molded IC **30** can be fed into the punch and die assembly **1** by an indexing and alignment mechanism, wherein the molded IC **30** undergoes a punching process. The use of the indexing and alignment mechanism is well known in the art and will not be discussed in detail herein. The details of the punching process will be discussed hereinafter. Furthermore, the die block **20** comprises a plurality of channels **24** that allow waste materials from the punching of the molded IC **30** to fall through and be disposed of.

[0023] The top plate **60** is movable relative to the die block **20** in a direction parallel to the central axis **AA**. Typically, driving means such as servomotors are used to move the top plate **60** towards or away from the die block **20**. Guide rods (not shown) are usually coupled to the top plate **60** and die block **20** to guide the movement of the top plate relative to the die block. In particular, the die block **20** is configured with a plurality of apertures **26** for supporting the guide rods. Furthermore, the top plate **60** is configured with a plurality of apertures **66** for receiving the guide rods. The use of guide rods is well known and thus will not be discussed in detail herein. The top plate **60** may further comprises a cover plate **80** for sealing the top plate **60**.

[0024] The stripper plate **40** is disposed between the top plate **60** and the die block **20**, wherein the stripper plate **40** is movable with respect to the top plate **60** in a direction parallel to the central axis **AA**. The stripper plate **40** may comprise a plurality of apertures **46** for receiving the guide rods. Typically, a stud component (not shown) is securely attached to the stripper plate at portion **48**, and the stud component is slidable in the slot **68** of the top plate **60**. Furthermore, a spring component (not shown) is coupled between the stripper plate **40** and the top plate **60** to bias the stripper plate **40** from the top plate **60**. A punch holder block **50** is securely mounted on the top plate **60** and inserted into the opening **44** of the stripper plate **40**. The punch holder block **50** is configured to secure a plurality of cutting tools or punches **100**. The stripper plate **40** further comprises a stripper block **42**, wherein the stripper block is fixedly mounted in the opening **44** of the stripper

plate 40. Furthermore, the stripper block 42 aligns the plurality of punches 100 to the molded IC 30 that is supported on the die block 20. Specifically, the plurality of punches 100 are slidable along a plurality of orifices 43 on the stripper block 42.

[0025] FIG 2 and FIG 3 illustrates an enlarged view of the punch 100. The punch 100 is preferably made from ceramic materials. In a preferred embodiment, punch 100 has an elongate body with a cutting edge 102 at one end and a protruding edge 104 at the other end, wherein the cutting edge 102 is tapered at a predetermined angle. The protruding edge 104 is configured to mount the punch 100 securely onto the punch holder block 50. FIG 4 shows an enlarged view of the cutting edge 102 profile in FIG 2, where the angle of the cutting 102 has a preferred range of 5 to 10 degrees. The angle of the cutting edge 102 profile is predetermined to provide a lower percentage of material fracture in the end product during the punching process, thus resulting in higher yield.

[0026] FIG 5 and FIG 6 show an alternative embodiment of the punch 100, which is referred herein as the comb punch 110. Referring particularly to FIG 6, the comb punch 110 has a rectangular body with a series of cutting edges 112 disposed at one end. The arrangement and number of cutting edges 112 of the comb punch 110 can be predetermined to suit the punching process of different forms of molded IC 30. Furthermore, the comb punch 110 may comprise a plurality of recesses 113, wherein the recesses 113 are configured to allow the comb punch 110 to be securely mounted onto the punch holder block 50. The cutting edge 112 profile of the comb punch 110 may be the same as that illustrated in FIG 4.

[0027] The punching or “dedam/dejunk” process cycle of the molded IC 30 will now be described. The punch and die assembly 1 first assumes an open configuration to allow the molded IC 30 to be fed onto the die insert 29 in a direction perpendicular to the axis AA (see FIG 1). FIG 7 shows a top plan view of feeding the molded IC 30 into the punch and die assembly 1. Typically, the molded IC 30 comprises a plurality of packages 210 molded on a leadframe structure 230, which will be discussed in detail below. Indexing and alignment mechanisms (not shown) are used to align the molded IC 30 onto the die insert 29. In particular, the molded IC 30 is aligned to the plurality of punches 100. FIG 8 shows a partial top plan view of the punch 100 aligned to the molded IC 30. The molded IC 30 comprises a molded package 210 and leadframe 230. Further, the leadframe 230 comprises a plurality of dambars 233 that traps the epoxy spilled over from the molded

package 210 during the encapsulation process. The epoxy trapped by the plurality of dambars 233 is referred herein as the junk 211. The molded IC 30 is aligned in a way that the punch 100 is positioned over the dambar 233 and the junk 211.

[0028] After the alignment process is completed, the top plate 60 is moved relative to the die block 20, thereby causing the stripper plate 40 to move towards the die block 20. The stripper plate 40 is moved towards the die block 20 until the stripper block 42 rests on the molded IC 30. Thereafter, a further movement of the top plate 60 causes the punch holder block 50 to move towards the stripper block 42, causing the plurality of punches 100 to extend from the plurality of orifices 43 in the stripper block 42. As a result, the plurality of punches 100 punches the dambar 233 and the junk 211, thereby removing the dambar 233 and the junk 211 from the molded IC 30. The spring component coupled between the top plate 60 and the stripper plate 40 is now compressed.

[0029] After the molded IC 30 has been punched, the dambar 233 and the junk 211 from the molded IC 30 drop into the channels 24 of the die block 20 to be collected for disposal. The top plate 60 is then moved away from the die block 20, causing the spring component coupled between the top plate 60 and stripper plate 40 to uncompress. The uncompressing of the spring moves the stripper block 42 away from the punch holder block 50, causing the plurality of punches 100 to move away from the punched molded IC or end product and retract into the plurality orifice 43 of the stripper block 42. The “dedam/dejunk” process cycle is then repeated until all the dambars 233 and junks 211 on the molded IC 30 are removed. Alternatively, the comb punch 110 could be used to remove all the dambars 233 and junks 211 during one “dedam/dejunk” process cycle. FIG 9 illustrates the end product where all the dambars 233 and junks 211 have been removed, thereby defining the leads 235 on the molded package 210.

[0030] The die block 20 may comprise an ejecting means 22 to eject the molded package 210 after the “dedam/dejunk” process cycle. The ejecting means 22 are well known in the art and will not be discussed in detail herein. The end product is then removed from the punch and die assembly 1 and a new molded IC 30 is fed in. The same punching process is repeated for the newly inserted molded IC 30.

[0031] In a typical punch and die assemblies, the punches are made from tungsten carbide materials. Typically, these tungsten carbide punches have a threshold of 300’000 to 500’000 hits or punches. In comparison, the present invention utilizes ceramic punches

that demonstrate a higher threshold of 600'000 to 1'000'000 hits. Therefore, the use of these ceramic punches significantly reduces maintenance downtimes for the punch and die assembly, thereby increasing manufacturing productivity. Furthermore, the ceramic punch is able to produce a higher manufacture yield.

[0032] While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the spirit and scope of the present invention. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

CLAIMS

What is claimed is:

1. A punch and die assembly comprising:
 - a die block securely mounted on a base, wherein the die block supports a die;
 - a first plate coupled to the die block, wherein the first plate is movable relative to the die block;
 - a stripper plate disposed between the die block and the first plate, wherein the stripper plate is coupled to the first plate, wherein the stripper plate is movable relative to the first plate, the stripper plate comprising an opening, wherein a stripper component is aligned to the die and is slidable in the stripper plate opening;
 - a punch holder block securely mounted on the first plate and slidable along an opening in the stripper plate, wherein the punch holder block is configured with at least one ceramic punch, the ceramic punch being slidable along the apertures of the stripper component;
 - whereby the first plate moves towards the die block till the stripper component rest on the die, wherein further movement of the first plate towards the die block causes the at least one ceramic punch to protrude from the apertures of the stripper component and thereby punching the die.
2. The punch and die assembly of claim 1, wherein the first plate is coupled to the die block via guide rods, wherein the guide rods aligns the relative movement of the first plate to the die block.
3. The punch and die assembly of claim 1, wherein the stripper component is coupled to the die first plate via a stud component.
4. The punch and die assembly of claim 1 further comprising an uncompressed spring coupled between the first plate and stripper plate.

5. The punch and die assembly of claim 1, wherein the at least one ceramic punch has a punching edge tapered at an angle, the angle having a range of 5 to 10 degrees.
6. The punch and die assembly of claim 1, wherein the die block comprises openings to allow the waste materials from the punched die to fall through.
7. A punch and die machine comprising:
 - a die block securely mounted on a base, wherein the die block supports a die;
 - a feeding mechanism for inserting the die into the die block;
 - a first plate coupled to the die block, wherein the first plate is movable relative to the die block;
 - a stripper plate disposed between the die block and the first plate, wherein the stripper plate is coupled to the first plate, wherein the stripper plate is movable relative to the first plate, the stripper plate comprising an opening, wherein a stripper component is aligned to the die and is slidable in the stripper plate opening;
 - a punch holder block securely mounted on the first plate and slidable along an opening in the stripper plate, wherein the punch holder block is configured with at least one ceramic punch, the ceramic punch being slidable along the apertures of the stripper component;
 - a servo motor for moving the first plate relative to the die block, wherein the first plate moves towards the die block till the stripper component rest on the die, wherein further movement of the first plate towards the die block causes the at least one ceramic punch to protrude from the apertures of the stripper component and thereby punching the die.
8. The punch and die machine of claim 7, wherein the first plate is coupled to the die block via guide rods, wherein the guide rods aligns the relative movement of the first plate to the die block.
9. The punch and die machine of claim 7, wherein the stripper component is coupled to the die first plate via a stud component.

10. The punch and die machine of claim 7 further comprising an uncompressed spring coupled between the first plate and stripper plate.
11. The punch and die machine of claim 7, wherein the at least one ceramic punch has a punching edge tapered at an angle, the angle having a range of 5 to 10 degrees.
12. The punch and die machine of claim 7, wherein the die block comprises openings to allow the waste materials from the punched die to fall through.