Transfer Molding Apparatus With Cull Removal and Cull Reduction

Field of Invention

[001] The present invention relates to a transfer molding apparatus in the manufacture of semiconductor devices. In particular, the invention relates to a multi-gang pot transfer mold with cull removing and cull reducing features and its associated molding press.

Background

[002] In the conventional manufacture of semiconductor devices, transfer molding apparatuses are used to encapsulate semiconductor devices mounted on carriers, such as substrates or leadframes. In transfer molding, the encapsulant, typically thermoset resin, is first melted in a resin pot before it is injected into a mold cavity. The molten encapsulant, together with the design of the mold cavity, runners and gates, ensures that conductive wires in the semiconductor devices are not moved into contact with another – a condition known as wire sweep. In addition, molten encapsulant allows it to flow inside each mold cavity and to ensure void-free packaging. Encapsulation of a semiconductor device in a package of resin to protect it from dust, moisture, electrostatic discharge, shock, damage and so on, is thus an important manufacturing process.

[003] As can be seen in FIGs. 1A and 1B, products of conventional transfer molding have excess encapsulant that hardened in the runners and resin pots. The excess encapsulant portions, known as culls 16 and runner portions 18, are removed and discarded by further processing. In addition, with an ever increasing demand for high-density mounting of semiconductor devices and advances in functionality of integrated circuits in a price competitive environment, there is a need for innovations in high throughput production of reliable, high-quality semiconductor packages at the same or yet lower cost level. It can thus be seen that there exists a need for another transfer molding apparatus that helps remove the cull immediately after each encapsulation process and/or reduce volume of the cull to save costs.

Summary

[004] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[005] The present invention discloses 2-plate and 3-plate multi-gang port transfer molds, and associated molding presses. An advantage of the present invention is that volume of the culls is reduced and/or the culls are broken off after each transfer molding cycle. The present invention allows block encapsulation of relatively large sizes and this makes high throughput production of multi-chip packages possible.

[006] In one embodiment, the present invention provides a transfer molding assembly comprising: a top mold plate; a bottom mold plate having a mold cavity; and a pot sleeve and associated plunger disposed in said bottom mold plate, wherein said plunger has a groove formed on a top face of said plunger.

[007] In one embodiment of the transfer molding assembly, it comprises a centre cavity plate, which is disposable between said top and bottom mold plates.

[008] In another embodiment, the present invention provides a transfer molding press comprising: a top mold plate; a centre mold plate on which is mountable a centre cavity plate; a bottom mold plate; and a pot and associated plunger disposed in said bottom mold plate, wherein a top face of said plunger has a groove; wherein, before use, a substrate is disposed on said centre cavity plate and a resin pellet is disposed inside said pot and, during use, said top mold, centre cavity and bottom mold plates are clamped together and then resin molten in said pot is injected by said plunger into one or more mold cavities formed between said centre cavity plate and substrate, such that after molding and curing of said resin, opening of both said top and centre mold plates causes a cull formed on said top face of said plunger to break off at said mold cavities and said cull retained on said top face of said plunger is readily removeable from said groove.

[009] In one embodiment, said groove on said top face of said plunger has a dovetail or C-shape. In another embodiment, said groove is tapered along said top face of said plunger.

[0010] In yet another embodiment, the pot sleeve, surrounding a plunger, has a discharge end formed with gates to allow molten encapsulant to be injected directly from inside said pot sleeve through said gates into the associated mold cavities.

Brief Description of the Drawings

[0011] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0012] FIGs. 1A and 1B illustrate results of two known encapsulated semiconductor packages with attached culls and runner resins; FIG. 1C illustrates result of block resin molding according to the present invention;

[0013] FIG. 2A illustrates a 3-plate mold of a transfer molding apparatus according to an embodiment of the present invention; FIG. 2B illustrates a 3-plate mold of a transfer molding apparatus according to another embodiment of the present invention.

[0014] FIG. 3A illustrates a top, plan view of a cavity plate for use with a centre platen of the above transfer molding apparatus, whilst FIG. 3B illustrates an elevation along section XX; FIG. 3C illustrates position of the plunger during encapsulation whilst FIG. 3D illustrate position of the plunger after the centre cavity plate 45 has been lifted; and FIG. 3E illustrates a double cavity plate 3-plate mold according to another embodiment of the present invention;

[0015] FIG. 4A illustrates relative positions of mold plates of the 3-plate mold shown in FIG. 2A or 2B when a substrate is loaded onto a cavity plate;
FIG. 4B illustrates the relative positions of mold plates of the 3-plate mold when resin pellets are loaded into multi-gang resin pots;

FIG. 4C illustrates the clamped position of the 3-plate mold when molten resin is injected into mold cavities by the associated respective plungers; and

FIG. 4D illustrates opening of the top and centre mold plates from the bottom mold plate thereby causing the cull to break off at each of the respective mold cavities;

[0016] FIG. 5A is a sectional view showing arrangement of a plunger injecting encapsulant directly into the mold cavities so as to reduce material wastage; FIG. 5B shows a result of resin molding according to the present invention, whilst FIG. 5C shows the top of the pot sleeve formed with gates; and

[0017] FIG. 6 shows a 2-plate mold with a plunger injecting encapsulant directly into mold cavities according to yet another embodiment of the present invention.

Detailed Description

[0018] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details, such as mold heaters, plungers, process controller, etc. are not described so as not to obscure the present invention. For ease of reference, common reference numerals or series of numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0019] FIGs. 1A and 1B show two types of known encapsulated semiconductor packages 10 mounted on substrates or leadframes 12. The multi-chip packages 10 shown in FIG. 1B are then diced along cutting lines 14 to form individual semiconductor devices. As can be seen from FIGs. 1A and 1B, two separate strips of encapsulated semiconductor packages 10 are joined together by the culls 16 and runner portions 18, that have set in the gang pots and runners. The attached culls 16 and runner portions 18 will require additional processes for their removal, and this adds to the costs of manufacturing semiconductor packages. As seen in FIGs. 1A and 1B, these prior art encapsulations are formed in relatively small

packages 10 to reduce warpage. In contrast, FIG. 1C shows the encapsulations are formed on a relatively large substrate 12 with reduced cull and runner volume, which translates to less wastes. The present invention also discloses a 3-plate multi-gang pot mold 40 and associated transfer molding presses that facilitate removal of the culls 16 and runner portions 18 immediately after the semiconductor packages 10 are formed and cured.

[0020] FIG. 2A shows an arrangement of a 3-plate mold 40 and associated press 20 according to an embodiment of the present invention. The 3-plate mold 40 is made up of a bottom mold plate 42, a top mold plate 44 and a centre cavity plate 45 (seen more clearly in FIG. 3B). As shown in FIG. 2A, the press 20 is made up of a base structure 22, a top frame 24 and a plurality of guide posts 26 connecting the top frame 24 to the base structure 22. The base structure 22 has a base platen 30, on which the bottom mold plate 42 of the 3-plate mold 40 is mounted. A top platen 32 is slidable on the guide posts 26 by actuating a hydraulic clamp cylinder 35 mounted on top of the top frame 24. On the lower side of the top platen 32, is mounted the top mold plate 44. A centre or middle platen 34 forms a slidable frame 36 subassembly. As seen in FIG. 2A, the centre cavity plate 45 is mounted on an upper side of the middle platen 34. The slidable frame 36 subassembly is arranged to slide up and down with respect to the top platen 32. As shown in FIG. 2A, the slidable frame 36 subassembly is actuated by a lifter cylinder 39 mounted between the slidable frame 36 and the top platen 32. Stroke of the lifter cylinder 39 determines a substrate loading daylight between the centre cavity plate 45 and the top mold plate 44, whilst stroke of the clamp cylinder 35 determines a pellet loading daylight between the bottom mold plate 42 and the middle platen 34. The substrate and pellet loading daylights of between about 10 to about 30 cm are generally required; when a loading fixture is used to load a substrate 12 or pellets 70, the daylight can be as low as 10 cm.

[0021] Referring again to FIG. 2A, the bottom mold plate 42 has a plurality of resin pots 50, which correspond with the number of cull cavities 46 formed on a bottom side of the centre cavity plate 45 (as seen in FIG. 3A). Each resin pot 50 is shaped and dimensioned to receive a pellet 70 of encapsulant or mold compound. In each resin pot 50, there is a plunger 52. The plungers 52 are operated to reciprocate inside the respective resin pots 50, that is, either to inject molten encapsulant into the cavity plate 45 or to retract into the resin pot 50.

The plungers 52 are operated simultaneously in a gang corresponding to a group of cull cavities 46, for example, by a hydraulic ram (not shown in the figures).

[0022] Sizing of the clamp cylinder 35 depends on pressure of the molten encapsulant, the total area of the mold cavities and the clamping force to prevent molten encapsulant from bleeding through the interfaces between the top mold plate 44, substrate 12 and cavity plate 45. Generally, the pressure of the molten encapsulant is about 70 kgf/cm sq and the clamping pressure on the substrate or leadframe 12 is about 140 kgf/cm sq.

[0023] FIG. 2B shows an arrangement of a 3-plate mold 40 and associated press 20a according to another embodiment of the present invention. As shown in FIG. 2B, the press 20a is made up of a base structure 22a, a top frame 24a and a plurality of posts 26a connecting the top frame 24a to the base structure 22a. Arranged inside an upper part of the base structure 22a is a base platen 30a, on which a bottom mold plate 42 of the 3-plate mold 40 is mounted. Movement of the base platen 30a and plunger 52 is actuated by a clamping cylinder 35a disposed inside the base structure 22a.

[0024] As shown in FIG. 2B, a top platen 32a of the press 20a is mounted on a lower part of the top frame 24a. As in the above embodiment, a centre or middle platen 34 forms a slidable frame 36 subassembly, which is arranged to slide up and down with respect to the top platen 32a by a lifter cylinder 39a. Mounted on the lower side of the top platen 32a is a top mold plate 44 whilst mounted on an upper side of the centre platen 34 is a centre cavity plate 45. As in the above embodiment, the bottom mold plate 42 has a plurality of resin pots 50, in each is disposed a plunger 52. Operation of the press 20, 20a will be described with reference to FIGs. 4A-4D.

[0025] FIG. 3A shows a top, plan view of the centre cavity plate 45. FIG. 3B shows a sectional elevation of the centre cavity plate 45 along section line XX. Each centre cavity plate 45 has a plurality of mold cavities 49 but only one gang of four mold cavities 49 is shown in FIG. 3A. Each exemplary gang of mold cavities 49 is connected to a cull cavity 46 by four runners 47 radiating from the cull cavity 46. The cull cavity 46 and runners 47 are formed on a bottom side of the centre cavity plate 45 whilst the mold cavities 49 are formed on a top side of the centre cavity plate 45 such that a portion of each mold cavity 49

vertically overlaps part of the associated runner 47 so that a pin-hole gate 48 communicating each mold cavity 49 to its runner 47 allows molten encapsulant to flow from the cull cavity 46 and runner 47 into the associated mold cavity 49. As an example, the centre cavity plate 45 is made of mold steel. In one embodiment, the centre cavity plate 45 is about 8 mm in thickness. Generally, the cull cavity 46 and runners 47 are about 2 mm deep whilst the mold cavity 49 may vary from about about 1 mm to about 3 mm depending on the desired semiconductor package 10, and each pin-hole gate 48 is about 1 mm in diameter.

[0026] As seen in FIG. 3B, a top face of each plunger 52 has a tapered dovetail groove 54 according to another embodiment of the present invention. The taper of the dovetail groove 54 is along the face of each plunger 52. Preferably, the taper of the dovetail grooves 54 on all the plungers 52 are orientated to a predetermined direction, such as to a cull collection chute (not shown in the figures). The taper of the dovetail groove 54 allows an operator of the 3-plate mold 40 to easily and quickly remove the culls 16 after each encapsulation process. A reader will appreciate this cull removing feature after reading the following description:

[0027] FIG. 3C shows a position of one plunger 52 after the encapsulant in the mold cavities 49 is cured. As shown in FIG. 3C, a bottom of the dovetail groove 54 is a distance d above the bottom plate 42 of the 3-plate mold 40. At this position, the plunger ram (not shown in the figures) for actuating the plunger 52 has not reached its dead-end, ie. the plunger ram is not fully extended. In one embodiment, the distance d is about 1 mm. After the encapsulant has cured, the centre cavity plate 45 is moved up by retracting the lifter cylinder 39, 39a and the culls 16 becomes broken off at the mold cavities 49, in particular at the runner portions 18. With the force on the culls 16 being removed, the plunger 52 extends upward (as seen in FIG. 3D) until the plunger ram reaches its dead-end; at this position, the top of the plunger 52 is about 5 mm from the surface of the bottom mold plate 42 and the bottom of the cull 16 is about 3 mm (distance d1) from the bottom mold plate 42.

[0028] FIG. 3E shows a sectional elevation of a 3-plate double cavity mold 40a according to another embodiment of the present invention. In contrast with the above 3-plate mold 40, this 3-plate double-cavity mold 40a has a top mold plate 44a having mold cavities. By

providing flow holes 13 through a thickness of the substrate 12, the same transfer molding press shown in FIG. 2A, 2B is operable with the 3-plate double cavity mold 40a for double-side encapsulation of semiconductor packages 10.

[0029] FIGs. 4A-4F show a sequence of operations of the above 3-plate mold 40. Operation of the 3-plate double cavity mold 40a is similar and this is not further described. As shown in FIG. 4A, the middle platen 34, together with the centre cavity plate 45, is lowered with respect to the top mold plate 44. With a daylight between the centre cavity plate 45 and the top mold plate 44, it allows a substrate 12 to be loaded onto the centre cavity plate 45. In one embodiment, a loading frame or fixture 60 is employed for manual loading of the substrate 12 onto the centre cavity plate 45. In another embodiment, loading of the substrate 12 onto the centre cavity plate 45 is done automatically with a handler, with or without use of a loading frame 60. Locating pins (not shown in the figures) on the centre cavity plate 45 and holes 13a on the substrate 12 ensure accurate positioning of the substrate 12 on the centre cavity plate 45.

[0030] Once the substrate 12 is positioned on the centre cavity plate 45, the lifter cylinder 39,39a moves the middle platen 34 upwards so that the substrate 12 is in contact with the top mold plate 44 and this provides the pellet loading daylight between the middle platen 34 and the bottom mold plate 42, as shown in FIG. 4B. Resin pellets 70 are then put into the resin pots 50.

[0031] Whilst not shown, the bottom mold plate 42 is heated. After the resin pellets 70 are put into the resin pots 50, the 3-plate mold 40 is then closed with a clamp force. For example, the clamp cylinder 35 lowers the entire sliding frame 36 sub-assembly so that the centre cavity plate 45 comes into contact with the bottom mold plate 42, as shown in FIG. 4C and they are clamped close. In another example, the clamp cylinder 35a lifts the entire base platen 30a and plunger sub-assembly upwards and closes the 3-plate mold 40 with a clamp force. Once the 3-plate mold 40 and substrate 12 are heated to a predetermined temperature and the resin pellets 70 become molten, the plungers 52 are then actuated and the molten resin is transferred into the mold cavities 49 through the associated cull cavity 46, runners 47 and pin-hole gates 48. After a lapse of a predetermined time when the resin in the mold cavities is cured, the clamp cylinder 35, 35a separates the centre cavity plate 45

from the bottom mold plate 42, as seen in FIG. 4D. In this operation, the resin material at the pin-hole gates 48 become broken and the culls 16 remain attached to the top of the plungers 52, as seen in FIG. 3D. The culls 16 are then easily removed from the plunger 52 faces by sliding each cull 16 from the associated dovetail groove 54.

[0032] FIG. 5A shows a sectional view of a 3-plate mold 40b according to another embodiment of the present invention. As shown in FIG. 5A, the 3-plate mold 40b is different from the above 3-plate mold 40, 40a in that the centre cavity plate 45a has an through aperture to receive the plunger 52. In this embodiment, the molten encapsulant is injected by the plunger 52 directly into the mold cavities 49. FIG. 5B shows the result of the encapsulant molded on a substrate 12. FIG. 5C shows a pot sleeve 56 in which the plunger 52 is reciprocated. As shown in FIG. 5C, a top or discharge end of each pot sleeve 56 has four gates 58 that allow molten encapsulant to flow directly from inside the pot sleeve into the mold cavities 49.

[0033] FIG. 6 shows a sectional view of a 2-plate mold 80 according to yet another embodiment of the present invention. As shown in FIG. 6, the 2-plate mold is made up of a bottom mold plate 42 and a top mold plate 44. As in the above embodiment 40b, a plunger 52 is disposed inside a pot sleeve 56. A top face of the plunger 54 has a groove 54 while a discharge end of the pot sleeve 56 has gates 58, as shown in FIG. 5C.

[0034] An advantage of the present invention is that the culls 16 are broken off and separated immediately after the encapsulation process, in the case of the 3-plate mold 40, 40a, 40b. This reduces the number of post-encapsulation handling and processes, and this leads to reduction of manufacturing costs. In the case of a double cavity 2-plate mold 80 or 3-plate mold 40a, the groove 54 on the plunger 54 top face holds the cull 16 down as the mold is being opened after each encapsulation process; this helps to release the molded package 10 from the mold cavities 49 in the top mold plate. In addition, the pot sleeve 56 with integral gates 58 allows the volume of the culls to be reduced, thereby reducing material waste, leading to saving costs. The present invention is amenable for new packages 10 that are relatively thin but with relatively large surface areas. In addition, the present invention provides a solution to high throughput production of new multi-chip packages because larger block encapsulation is made possible.

[0035] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the present invention. For example, the above describes a cavity-up mold configuration; the principle of the present invention remains the same for a cavity-down mold configuration. In the above description, the groove on the plunger face is described as a dovetail; grooves of other sectional shapes, such as C-shaped, are also possible as long as the grooves are able to hold the culls 16, for example, as the centre cavity plate 45 is being moved away from the bottom mold plate 42.

CLAIMS:

1. A transfer mold assembly comprising:

a top mold plate;

a bottom mold plate having a mold cavity; and

a pot sleeve and an associated plunger disposed in said bottom mold plate, wherein said plunger has a groove formed on a top face of said plunger.

2. A transfer mold assembly according to claim 1, wherein said groove has a dovetail or C shape.

3. A transfer mold assembly according to claim 1, wherein said groove is tapered along said top face of said plunger.

4. A transfer mold assembly according to any one of claims 1-3, further comprising a centre cavity plate disposable between said top and bottom mold plates.

5. A transfer mold assembly according to any one of claims 1-4, wherein a discharge end of said pot sleeve has a plurality of gates to allow molten encapsulant to be injected directly from inside said pot sleeve, through said gates and into mold cavity.

6. A transfer mold assembly according to any one of claims 1-5, wherein said top mold plate further comprises a mold cavity.

7. A transfer molding press comprising:

a top mold plate;

a centre mold plate on which is mountable a centre cavity plate;

a bottom mold plate; and

a pot and an associated plunger disposed in said bottom mold plate, wherein a top face of said plunger has a groove;

wherein, before use, a substrate is disposed on said centre cavity plate and a resin pellet is disposed inside said pot and, during use, said top mold, centre cavity and bottom mold plates are clamped together and then resin molten in said pot is injected by said plunger into one or more mold cavities formed between said centre cavity plate and

substrate, such that after molding and curing of said resin, opening of both said top and centre mold plates causes a cull formed on said top face of said plunger to break off at said mold cavities and said cull retained on said top face of said plunger is readily removeable from said groove.

8. A transfer molding press according to claim 7, wherein said groove has a dovetail or C shape.

9. A transfer molding press according to claim 8, wherein said groove is tapered along said top face of said plunger.

10. A transfer molding press according to any one of claims 7-9, further comprising a pot sleeve, wherein a discharge end of said pot sleeve has a plurality of gates to allow said molten encapsulant to be injected directly from inside said pot sleeve through said plurality of gates into respective said mold cavities.

11. A transfer molding press according to any one of claims 7-10, wherein said top mold plate further comprises a mold cavity.

12. A method of transferring mold resin onto a substrate during a semiconductor encapsulation process with subsequent cull removal, said method comprising:

disposing a resin pellet into a pot and allowing said resin to melt, with said resin pot being disposed on a bottom mold plate;

lowering a centre mold plate, on which is mounted a centre cavity plate;

placing a substrate onto said centre cavity plate;

clamping a top mold, said centre cavity and said bottom mold plates together;

operating a plunger disposed inside said resin pot to inject said molten resin into one or more mold cavities formed between said centre cavity plate and said substrate; and

after allowing said molten resin to cure after a predetermined time interval, opening both said centre cavity and top mold plates together causes a cull formed on a top face of said plunger to break off at said mold cavities and said cull retained by a groove on said top face of said plunger is readily removed by sliding said cull from said groove.

13. A method according to claim 12, wherein said groove has a dovetail or C shape.

14. A method according to claim 13, wherein said groove is tapered along said top face of said plunger.

15. A method according to any one of claims 12-14, further comprises forming gates at a discharge end of a pot sleeve, in which said plunger is disposed, so that encapsulant is injected directly into said mold cavities so as to reduce volume of said cull, thereby reducing wastes.

16. A method according to any one of claims 12-15, wherein said top mold plate further comprises a mold cavity.