

RESIN MOLDING DIE SET AND RESIN MOLDING APPARATUS

FIELD OF TECHNOLOGY

The present invention relates to a resin molding apparatus capable of clamping and resin-molding a workpiece.

BACKGROUND TECHNOLOGY

The inventors of the present invention have already invented a transfer molding apparatus capable of mass-producing thin packages, in which thin semiconductor devices are resin-molded, having desired thicknesses without forming resin non-filling regions.

Concretely, a workpiece conveyed into a molding die set is clamped, by a clamper, such that a cavity piece is kept at a retreating position which is a position backwardly shifted a prescribed thickness from a thickness of a molded product, and a plunger is actuated to fill a cavity recess with a melted resin and maintains a first dwelling pressure with the clamper clamping the workpiece. After filling the resin, the cavity piece is further pushed toward the inside of the cavity recess until reaching a molding position, which corresponds to the desired thickness of the molded product, and a surplus resin is pushed and returned from the cavity recess to a pot via a gate, so that an amount of the resin can be adjusted to that corresponding to the desired thickness of the molded product. Further, the plunger is actuated again so as to thermally cure the resin at a second dwelling pressure which is higher than the first dwelling pressure (see Patent Document 1).

PRIOR ART DOCUMENT

PATENT DOCUMENT

Patent Document 1: Japanese Laid-open Patent Publication No.

2009-190400

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

In the molding die set disclosed in Patent Document 1, the workpiece is clamped between an upper die, in which an upper insert is movable, and a lower die having a rigid structure, on which the workpiece (e.g., substrate) is mounted; for example, in case of single layer substrates whose thickness variation is small, no problems occur, but, in case of multilayer substrates whose thickness variation is large, a clamping force between the clammer and the substrate is varied, so resin flashes will be formed and quality of the molded product will be lowered.

For example, in case of a product a part of which is exposed from a molding resin, e.g., a product having a heat sink, quality of the product will be lowered by resin flashes.

If the clamping force of the die set is made larger so as to prevent forming resin flashes, excessive clamping stress will be exerted on the workpiece, so the workpiece will be broken or damaged. In case of thin products, e.g., memory, a thickness of the molded part is badly influenced by a thickness of the workpiece, so it is difficult to equalize thicknesses of the molded parts.

The present invention solves the problems of the conventional technology and provides a resin molding die set which is capable of clamping the workpiece without exerting excessive stress thereon, regardless of existence and magnitude of variations in a thickness of the workpiece and a resin molding apparatus, which employs said resin molding die set so as to stabilize clamping balance and produce high quality products without forming resin flashes.

MEANS FOR SOLVING THE PROBLEMS

To achieve the above described objects, the present invention has following structures.

Namely, a resin molding die set for resin-molding a workpiece in which a second member is mounted on a first member, comprising: one molding die having a cavity recess, which constitutes a cavity for accommodating the second member and which is constituted by a cavity piece forming a bottom part of the cavity and a first insert enclosing the cavity piece; the other molding die having a workpiece support for supporting the workpiece and a second insert being located adjacent to the workpiece support; a pot and a plunger, which supply a molding resin, being provided to the one molding die or the other molding die; a cavity-height-varying mechanism for varying a height of the cavity recess, by moving the cavity piece in an opening/closing direction of the dies, so as to match a height of the second member; and a thickness-varying mechanism for varying a height of the workpiece support, by moving the workpiece support with respect to the second insert in the opening/closing direction of the dies, so as to match a thickness of the first member, and the height of the workpiece support is adjusted by the thickness-varying mechanism to match the thickness of the first member, and the height of the cavity recess is adjusted by the cavity-height-varying mechanism to match the height of the second member before the molding resin is supplied into the cavity.

By employing the above described resin molding die set, the heights of the workpiece support and the cavity recess, with respect to all workpieces (i.e., the first member and the second member), are adjusted, regardless of the existence and magnitude of variations in a thickness in the opening/closing direction of the dies, so that no

excessive stress is exerted on the workpiece, clamping balance can be stabilized and forming resin flashes can be prevented.

In the resin molding die set, the cavity-height-varying mechanism may include a wedge mechanism, which adjusts a position of the cavity piece in the opening/closing direction of the dies by moving a movable taper block by a driving source.

In this case, the position of the cavity piece in the opening/closing direction of the dies can be highly precisely controlled, so that stress exerted on the workpiece (i.e., the second member) can be reduced as much as possible when clamping the die set, and high quality products can be produced.

In the resin molding die set, one or both of the cavity piece and the first insert may be floating-supported by one of mold chases.

In this case, a depth of the cavity (i.e., a height from a substrate to the cavity piece) can be quickly changed by adjusting a floating amount of the cavity piece and/or the first insert when the die set is opened and closed. Especially, even if the height of the second member from the first member is varied, a difference of resin volume can be absorbed by the floating structure of the cavity piece and/or the first insert when the resin molding is performed.

In the resin molding die set, the thickness-varying mechanism may include a wedge mechanism, which adjusts a position of the workpiece support in the opening/closing direction of the dies by moving a movable taper block by a driving source.

In this case, the position of the workpiece support in the opening/closing direction of the dies can be highly precisely controlled, so that stress exerted on the workpiece (i.e., the first member) can be reduced as much as possible when clamping the die set, and high quality products can be produced.

Preferably, a dummy cavity is formed in a clamping face of the first insert, and the surplus resin is introduced from the cavity recess to the dummy cavity.

With this structure, voids formed in the molding resin for filling the cavity recess are washed away to the dummy cavity, so that quality of the product can be improved. Especially, a filling property of the resin for underfill molding can be improved.

The resin molding die set may further comprise closing means for pressing a part of the clamping face of the first insert, which is located on the outer side of the dummy cavity, so as to stop air purge.

In this case, by stopping the air purge from the decompression space at a desired timing by the closing means, leaking the resin from the dummy cavity and forming resin non-filling regions can be prevented.

Preferably, a closed space, which is shut off from outside, is formed before the one molding die and the other molding die are closed, and a decompression space including the cavity is formed by decompressing the closed space by a decompressing mechanism.

With this structure, forming voids in the molding resin can be suppressed by purging the remaining air from the cavity.

The resin molding die set may further comprise an intermediate plate, in which a through-hole for accommodating the second member and a resin path communicated to the through-hole are formed and which is provided to bridge a gap between an outer edge of the first member supported by the workpiece support and the second insert and piled on a clamping face of the other molding die.

In this case, gold plating for a runner is not required in the first member (e.g., substrate), and there is no possibility that the molding resin invades into a gap between the first member and the die and causes

a slide malfunction even if the molding resin includes fine fillers and has low viscosity and high fluidity.

In the resin molding die set, a dummy cavity may be formed in the intermediate plate and located on an outer side of the first member, and the surplus resin may be introduced from the through-hole to the dummy cavity. In this case, the dummy cavity is located on an outer side of the first member, so that number of products can be increased and capacity factor of the substrate can be improved.

Further, if the dummy cavity is a thorough-hole formed in the intermediate plate, the unused resin can be easily peeled from the die.

The resin molding die set may further comprise a swivel mechanism having a guide piece, and a guide face of the guide piece may face one face of the cavity piece, which is opposite to the other face contacting the second member, and the cavity piece is capable of being tilted along the guide face.

With this structure, even if the second member (e.g., semiconductor chip) on the first member (e.g., substrate) is inclined, the cavity piece inclines with following the inclination of the second member without biased contact with the cavity piece through the release film, so that no excessive stress is exerted on the second member and damaging and breaking the second member can be prevented.

In the resin molding die set, a pressing face of the cavity piece of the second member may be formed into a convex shape, and a recessed groove may be formed around the pressing face.

In this case, for example, a light emitting face of a semiconductor chip is pressed and exposed by the convex pressing face of the cavity piece, and a reflector enclosing the light emitting face can be efficiently formed by filling the recessed groove formed around the convex pressing face with a silicone resin (white resin) by transfer molding.

In case that a release film is sucked and held on a clamping face of the one molding die which includes the cavity recess, no molding resin directly contacts the cavity recess, so that maintenance of the die set can be easily performed and resin leakage can be prevented. Further, the cavity piece forming the bottom part the cavity contacts the workpiece through the release film, so that damaging the surface of the workpiece can be prevented.

A resin molding apparatus comprises: a workpiece supplying section; a pressing section in which a workpiece is clamped and resin-molded by the molding die set according to any one of claims 1-12; and an accommodating section for accommodating molded products, and an operation amount of the cavity-height-varying mechanism is set, according to the thickness of the first member and the height of the second member, to locate the cavity piece at a prescribed position in the opening/closing direction of the dies before the molding resin is supplied into the cavity, and then the first member is clamped and resin-molded.

By employing the above described resin molding apparatus, stress exerted on the workpieces, i.e., the first member and the second member, can be reduced, as much as possible, when clamping the workpieces by the molding die set.

In the resin molding apparatus, a liquid resin supplying section may be provided adjacent to the pressing section, and a liquid resin may be supplied by moving a resin supply nozzle into and away from a pot of the opened molding die set. In this case, underfill-molding a semiconductor chip, which is flip-chip-mounted, with an epoxy liquid resin having low viscosity can be realized, or qualities of LEDs and reflectors can be improved and life spans thereof can be extended by using a silicone resin having low viscosity

Note that, the resin is not limited to the liquid resin, so tablet resin,

for example, may be used.

EFFECT OF THE INVENTION

By the present invention, the resin molding die set, which is capable of clamping the workpiece without exerting excessive stress thereon, regardless of existence and magnitude of variations in the thickness of the workpiece, can be provided, and the resin molding apparatus, which employs said resin molding die set and which can stabilize clamping balance and produce high quality products with no resin flashes, can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[Fig. 1] It is a layout diagram of a resin molding apparatus relating to a first embodiment.

[Fig. 2] Figs. 2A and 2B are sectional views of the molding die set relating to the first embodiment, which explain molding actions.

[Fig. 3] Figs. 3C and 3D are sectional views of the molding die set, which explain molding actions following the actions shown in Figs. 2A and 2B.

[Fig. 4] Fig. 4E is a sectional view of the molding die set, which explains a molding action following the actions shown in Figs. 3C and 3D.

[Fig. 5] Figs. 5A and 5B are sectional views of the molding die set relating to a second embodiment, which explain molding actions.

[Fig. 6] Figs. 6A and 6B are sectional views of the molding die set relating to a third embodiment, which explain molding actions.

[Fig. 7] Figs. 7A and 7B are sectional views of the molding die set relating to a fourth embodiment, which explain molding actions.

[Fig. 8] Figs. 8A-8C are sectional views of the molding die set

relating to a fifth embodiment, which explain molding actions.

[Fig. 9] Figs. 9A-9C are sectional views of the molding die set relating to a sixth embodiment, which explain molding actions.

[Fig. 10] It is a layout diagram of a resin molding apparatus relating to a seventh embodiment.

[Fig. 11] Figs. 11A-11C are sectional views of the molding die set relating to the seventh embodiment, which explain actions for supplying a liquid resin.

EMBODIMENTS OF THE INVENTION

Preferred embodiments of the present invention will now be explained in detail with reference to the accompanying drawings. In the following embodiments, a transfer molding apparatus, in which cavity recesses are formed in an upper die of a die set and pots formed in a lower die thereof, will be explained. Further, in the transfer molding apparatus, the lower die is a movable die and the upper die is a fixed die.

[First Embodiment]

As shown in Fig. 1, a resin molding apparatus of the present embodiment comprises: a workpiece supplying section A; a preheating section B for preheating workpieces; pressing sections C for resin-molding the workpieces; an accommodating section D for accommodating molded products; and a conveying mechanism E. Each of the pressing sections C has a press unit, which includes a molding die set for clamping and resin-molding the workpieces. The conveying mechanism E conveys the workpieces to the pressing sections D and takes out the molded products from the pressing sections C.

(Workpiece Supplying section A)

In Fig. 1, the workpiece supplying section A has a stocker, and magazines, in each of which, strip-shaped substrates 1 (e.g., lead frames,

plastic boards), for example, are accommodated, are accommodated in the stocker. For example, a pair of the cut substrates 1, which have been pushed out from the magazine by a pusher, are set, in parallel, on a setting table 2. Note that, the substrates 1, which are accommodated in the magazine and directed in one direction, may be taken out and set, in parallel, on a turn table by the pusher, and then the substrates 1 may be transferred from the turn table to the setting table 2.

A tablet supplying unit 4 for supplying resin tablets 3 to positions corresponding to the pots of the molding die set, is provided to a side of the setting table 2. The substrates 1 on the setting table 2 are held and conveyed to the preheating section B by the conveying mechanism E (e.g., a loader 16) described later. The resin tablets 3 stored in the tablet supplying unit 4 are held and conveyed to the pressing sections C by the loader 16.

In each of the workpieces to be resin-molded, semiconductor chips 5, which correspond to “second members” of the present invention, are mounted (e.g., flip-chip-bonded, wire-bonded) on, for example, the strip-shaped substrate 1, which corresponds to a “first member” of the present invention (see Fig. 2B). Note that, a workpiece in which one or a plurality of the semiconductor chips 5 are layered on the substrate 1, a workpiece in which a semiconductor device is mounted on the substrate 1, a workpiece in which an imaging element is mounted on the substrate and a transparent glass is attached on a light receiving face of the imaging element, etc. may be resin-molded as the workpieces. Further, various types of plate shaped members, e.g., plastic board, ceramic board, metallic substrate, lead frame, carrier, wafer, may be employed as the “first member” of the present invention. Besides the semiconductor chip, various types of members, e.g., heat sink, lead frame for heat radiation and interconnection, electronic parts such as bumps for electric

connection, may be employed as the “second member” of the present invention. Therefore, in the “workpiece” of the present invention, the “second member” is mounted on the “first member”. Mounted parts may be respectively accommodated in cavities and resin-molded therein, and the mounted parts may be accommodated in one cavity and resin-molded collectively. With the above described structure, the workpiece can be resin-molded with exposing end faces of the first member and the second member by a resin molding manner described later.

(Preheating Section B)

The substrates 1 supplied from the workpiece supplying section A are transferred from a measuring table to a heater block, not shown, of the preheating section B by the loader 16 of the conveying mechanism E described later. The heater block preheats the substrates 1, which have been mounted on the heater block, until reaching a prescribed temperature. Preferably, the heater block is enclosed by an open/close cover so as to suppress thermal effects on other units. The substrates 1 which have been preheated are held and conveyed to the pressing sections C by the loader 16.

(Pressing Section C)

Each of the pressing sections C has a pressing unit 6, which opens and closes a molding die set 19 (see Fig. 2A) to clamp and resin-mold the workpieces. The pressing unit 6 comprises: a pressing mechanism for pressing and moving the molding die set 19, which will be described later, in an opening/closing direction of the dies; and a transfer mechanism for pressure-feeding the resin melted in the pots 35 of the molding die set 19 from the pots 35 to cavity recesses 32 (see Fig. 2A) so as to fill the cavity recesses.

The pressing unit 6 has a cavity-height-varying mechanism for pushing and moving cavity pieces 23 (see Fig. 2A) in the

opening/closing direction of the dies and a thickness-varying mechanism for pushing and moving workpiece supports 37 (see Fig. 2A) in the opening/closing direction of the dies. The cavity-height-varying mechanism has an upper die driving unit 7 for pushing and moving insert members (e.g., the cavity pieces 23) of the upper die in the opening/closing direction of the dies so as to relatively vary heights of the cavity recesses. In the upper die driving unit 7, number of servo motors 31 described later is equal to that of cavities (i.e., number of the cavity pieces 23), each of which is formed for each of the substrates 1, and the heights of the cavities can be respectively adjusted. Therefore, in case that a plurality of resin molding regions (e.g., three regions) are formed in each of the rectangular substrates 1, the same number of the servo motors 31 (i.e., three servo motors) may be provided.

The thickness-varying mechanism has a lower die driving unit 8 for pushing and moving insert members (e.g., the workpiece supports 37) of the lower die in the opening/closing direction of the dies (see Fig. 2A). In case of resin-molding some workpieces 1, relative height positions of the cavity recesses 32 in the opening/closing direction of the dies are adjusted to predetermined positions by adjusting operation amounts of the cavity-height-varying mechanism and the thickness-varying mechanism before supplying the molding resin into the cavities. Namely, the cavity-height-varying mechanism is set according to a height of the semiconductor chips 5 before supplying the molding resin into the cavities, and the thickness-varying mechanism is set according to a thickness of the substrates 1.

Note that, in the present embodiment, a molding face (a resin molding face) of the molding die set is covered with a release film 10. Therefore, the pressing unit 6 has a film supplying mechanism 9 for supplying the release film 10 to the molding face of the molding die set.

The film supplying mechanism 9 has a feeding roll 9a for feeding the release film 10 onto a surface of the die (e.g., the upper die) and a collecting roll 9b for winding the used release film 10. Note that, the surface of the molding die set need not be covered with the release film 10. The structure using no release film 10 may be employed. For example, ring-shaped seal members, which are composed of resin or metal, may be provided on outer peripheries of the cavity pieces 23 so as to eliminate gaps between the cavity pieces and an upper mold insert block 26 described later by thermal expansion of the seal members, so that resin leakage from the gaps can be prevented.

(Accommodating Section D)

The accommodating section D comprises: a setting part 12 in which resin-molded products 11 are set; a gate breaking part 13 for removing unused resins, e.g., gates, from the products 11; and an accommodating part 14 for accommodating the products 11 from which the unused resins have been removed. The products 11 are accommodated in magazines 15, and the magazines 15, in which the products have been accommodated, are sequentially accommodated in a stocker.

(Conveying Mechanism E)

The conveying mechanism E has the loader 16 for conveying the workpieces to the pressing sections C and an unloader 17 for taking out the molded products 11 from the pressing sections. In the resin molding apparatus, the workpiece supplying section A, the preheating section B, the pressing sections C and the accommodating section D are connected. Guide sections 18 are respectively provided on rear sides of said sections the guide sections 18 are linearly connected to form guide rails. The loader 16 and the unloader 17 are capable of reciprocally moving along the guide rails. The loader 16 and the unloader 17 are capable of linearly

moving toward the workpiece supplying section A, the preheating section B, the pressing sections C and the accommodating section D.

Therefore, the structure of the resin molding apparatus can be changed by changing combination of said sections with keeping the connection state. For example, in the example shown in Fig. 1, the two pressing units 6 are provided, but one pressing unit or three or more pressing units may be employed in the resin molding apparatus. Similarly, a plurality of liquid resin supplying sections F described later may be provided.

Resin molding action will be explained. In the workpiece supplying section A, the workpieces (i.e., the substrates 1), which have been set on the setting table 2, are held and conveyed to the preheating section B along the guide sections 18, and then preheated before being resin-molded.

While the unloader 17 takes out the molded products 11 from the pressing unit 6, the loader 16 is moved along the guide rails, takes out the resin tablets 3 from the tablet supplying unit 4 and takes out the substrates 1 from the preheating section B. Next, the loader 16 is moved to a side of the pressing unit 6, and then enters the pressing unit 6 and supplies the substrates 1 and the resin tablets 3 to the opened molding die set. The substrates 1 and the resin tablets 3 are heated by a heater (not shown) of the molding die set. After the loader 16 is moved away from the pressing unit 6, the workpieces are clamped by the molding die set 19 (see Fig. 3C), and the cavity recesses 32 (see Fig. 3D), which accommodate the semiconductor chips 5 and constitute the cavities, are filled with the melted molding resin, so that the semiconductor chips 5 are resin-molded.

After completing the resin molding, the unloader 16 enters the molding die set from the side of the pressing unit 6, takes out the molded

products and conveys out the same from the pressing unit 6. The molded products 11 conveyed out are transferred to a setting part 12 of the accommodating section D by moving the unloader 17 along the guide rails and conveyed to the gate breaking part 13 to remove unused resins, e.g., gates, then the molded products 11 are accommodated in the accommodating part 14. Note that, in case of using liquid resin, a thickness measuring unit for measuring a thickness of the parts to be resin-molded of the products 11 may be provided, and an amount of the resin to be supplied may be adjusted on the basis of the results of the measurements.

As described above, the substrates 1 are sequentially supplied from the workpiece supplying section A, the substrates 1 are resin-molded in the pressing sections C, and the molded products 11 are accommodated in the accommodating section D.

In the resin molding apparatus of the present embodiment, when resin-molding the workpieces (i.e., the substrates 1 and the semiconductor chips 5), the molding die set is driven to clamp the workpieces according to a thickness of the workpieces, so that stress exerted on the workpieces, which is generated by clamping the workpieces with the molding die set, can be reduced as much as possible, the workpieces can be highly precisely resin-molded without forming resin flashes.

Next, the resin molding die set used in the resin molding apparatus will be explained with reference to Fig. 2. The molding die set 19 includes the upper die 20 (i.e., one molding die) and the lower die 21 (i.e., the other molding die).

The upper die 20 will be explained with reference to Fig. 2A. In the upper die 20, the cavity pieces 23, which constitute bottom parts of the cavities, are suspended from an upper chase block 22 by springs 24.

In each of the cavity pieces 23, one face 23a, which is opposite to the other face contacting the workpiece, is formed into a wedged face. Each of the cavity pieces 23 is supported in a state where the wedged face 23a is stacked on a wedged face 25a of each of first movable wedged blocks 25 (a wedge mechanism).

In the upper chase block 22, an upper insert block 26 (a first insert) is supported in a rigid state. The cavity pieces 23 are inserted in and suspended in through-holes of the upper insert block 26 so as to form the bottom parts of the cavity recesses. The cavity pieces 23 may be supported by the first movable wedged blocks 25 in a state where the springs 24 are extended from their original length (i.e., in a state where restoring force is applied). In this case, the cavity pieces 23 are rigidly supported by the contact between their wedged faces and the wedged faces of the first movable wedged blocks 25. Recesses 26b constituting the cavity recesses 32 and resin paths, e.g., upper culls 26c, upper runners 26d, are formed in the upper insert block 26, and dummy cavities 26e are formed in a clamping face of the upper die. Note that, a depth of grooves (through gates), which makes the dummy cavities 26e communicate to the cavity recesses 32, may be smaller than a width of gaps (i.e., parts to be underfilled) between the flip-chip-bonded semiconductor chips 5 and the substrate 1. This manner is preferable because priority can be given to underfilling lower sides of the semiconductor chips 5 over filling the dummy cavities 26e with resin. An upper seal ring 27 seals a gap between an outer face of the upper insert block 26 and an inner face of the upper chase block 22, which are faced each other. The upper seal ring 27 is provided to realize independent functions which are given by two system lines respectively connected to decompression units 29 and 58 described later. Namely, a space for sucking the release film 10 and a space for decompressing the

cavities by the decompression unit 58 are divided by the upper seal ring 27.

An upper sucking path 28 is formed in the upper chase block 22. The upper sucking path 28 is connected to the decompression unit 29. The gap between the upper chase block 22 and the upper insert block 26, gaps between the upper insert block 26 and the cavity pieces 23 and sucking holes (not shown) formed in a clamping face of the upper insert block 26 are connected to the decompression unit 29 via the upper sucking path 28. The release film 10 is sucked and held on the clamping face of the upper die including the cavity pieces 23 by a sucking mechanism, which is constituted by the sucking holes (not shown) formed in the clamping face of the upper die and the gaps between the upper insert block 26 and the cavity pieces 23. The release film 10 has enough heat resistance to a heating temperature of the molding die set 19, softness and extensibility, and can be easily peelable from the surface of the die, so the preferable release film is, for example, PTFE film or ETEF film, PET film, FEP film, fluorine-impregnated glass cloth, polypropylene film, or a film composed of polychlorinated vinylidene.

Each of the first movable blocks 25 has the wedged face 25a, whose thickness is gradually reduced (or increased) toward the cavity piece 23. The first movable wedged blocks 25 are connected to the servo motors 31 by screw shafts 30 (an upper driving unit 7). By rotating the servo motors 31 in a prescribed direction, the first movable wedged blocks 25, which are screwed with the screw shafts 30, are moved along a bottom part of the upper chase block 22. With this structure, the cavity pieces 23 are capable of adjusting heights of the cavity recesses 32 (heights of upper faces thereof) on which the release film 10 is sucked, in the opening/closing direction of the dies, through the release film 10. Note that, the servo motors 31 may be separated from a wall face of the

upper die 20 which is heated. The screw shaft 30 may be optionally detached from the servo motors 31 so as to prevent the servo motors from being overheated by the dies and improve a maintenance property.

Next, the lower die 21 will be explained with reference to Fig. 2A. The lower die 21 is moved, by a known clamping mechanism which moves a lower movable platen, on which a lower chase block 33 is provided, upward and downward by a transmitting mechanism (e.g., toggle link, screw shaft) driven by a driving source (e.g., electric motor), so as to open and close the molding die set. Further, inclination of the lower movable platen, with respect to a fixed platen for supporting the upper die, may be corrected by supporting corners of the lower movable platen by at least three ball screw mechanisms and precisely adjusting an operation amount of the ball screws. In this case, a moving speed and a pressurizing force, etc. for moving the lower die 21 upward and downward can be optionally set, and a flow speed and a pressure of the molding resin can be optionally set when the action of filling the cavity recesses 32 with the molding resin and an action of returning a surplus resin from the cavity recesses 32, described later, are performed. These controls can be performed by the clamping mechanism, so the structure of the resin molding apparatus can be simplified.

A lower insert block 34 (a second insert) is attached to the lower chase block 33. The cylindrical pots 35, into which the molding resin (the resin tablets 3) will be supplied, are formed in a center part of the lower insert block 34. An upper end face of the lower insert block 34 is made level with upper end faces of the pots 35. Plunger 36, which can be moved upward and downward by a known transfer driving mechanism, is provided in the pots 35. A plurality of the plungers 36, which respectively correspond to the pots 35, are supported by a supporting block (not shown) as a multi plunger unit. Elastic members, not shown,

are respectively provided to supporting parts of the plungers 36, so that excessive pressing forces applied to the plungers 36 can be released by elasticity of the elastic members and the plungers can respond to variation of amount of the molding resin while dwelling.

The workpiece supports 37, onto which the workpieces will be mounted, are provided on an upper face of the lower chase block 33 and located adjacent to both sides of the lower insert block 34. Each of the workpieces is a device in which the semiconductor chips 5 are mounted on one of surfaces of the substrate 1. The workpiece supports 37 are floating-supported by springs 38, which are provided between the upper face of the lower chase block 33 and the workpiece supports.

Fixed wedged blocks 37 and second movable wedged blocks 39, which are stacked on each other, are provided between the workpiece supports 37 and the lower chase block 33. The fixed wedged blocks and the second movable wedged blocks are supported on the lower chase block in a state where wedged faces 57a, which are lower faces of the fixed wedged block 57 and wedged faces 39a of the second movable wedged blocks 39 are stacked on each other (a wedge mechanism). The workpiece supports 37 may be supported in a state where the springs 38 are contracted from their original length (i.e., in a state where elastic force is applied). The second movable wedged blocks 39 are connected to servo motors 41 by screw shafts 40 (a lower driving unit 8). By rotating the servo motors 41 in a prescribed direction, the second movable wedged blocks 39, which are screwed with the screw shafts 40, are moved along a bottom part of the lower chase block 33. With this structure, positions of the workpiece supports 37 in the opening/closing direction of the dies can be adjusted according to the thickness of the workpieces (the substrates 1), so that, for example, the upper faces of the substrates can be made almost level with a clamping face of the lower

die. Namely, by making the height of the upper faces of the substrates 1 a prescribed height higher than that of the clamping face of the lower die regardless of the thickness of the substrates 1, the substrates 1 can be suitably clamped, so that resin leakage can be prevented without breaking the substrates. The workpiece supports 37 are rigidly supported by the fixed wedged blocks 57, but gaps may be formed between the workpiece supports and the fixed wedged blocks 57. In this case, the substrates 1 can be clamped, by elasticity of the springs 38, without applying excessive clamping force. Note that, the workpiece supports 37 may be exchanged to other workpiece supports having a different thicknesses, according to the thicknesses of the workpieces (the substrates 1), so as to adjust the thicknesses of the substrates 1. In this case, if the substrates 1 are easily bent by preheating, the substrates may be sucked to the workpiece supports 37 and clamped in a state of being held flatly. By this manner, even if the substrates 1 are thin and easily bent, the substrates can be securely clamped without causing any positional deviation.

A lower seal ring 42 is provided on an outer face of the lower chase block 33 (the lower die 21). A lower sucking path 43 is formed in the lower chase block 33. The lower sucking path 43 is connected to the decompression unit 58. The lower sucking path 43 is opened on an inner side of the lower seal ring 42. When closing the molding die set 19, the upper chase block 22 and the lower chase block 33 clamp the lower seal ring 43, so that a closed space, whose outer side is closed, can be formed between the upper die 20 and the lower die 21. By actuating the decompression unit 58, a decompression space is formed through the lower sucking path 43.

Next, the opening and closing actions of the molding die set 19 will be explained with reference to Figs. 2A, 2B, 3C, 3D and 4E. Fig. 2A

shows the opened molding die set 19. The release film 10 is sucked and held, on the clamping face of the upper die, by actuating the decompression unit 29. In the present embodiment, operation amounts of the cavity-height-varying mechanism and the thickness-varying mechanism are precisely adjusted, according to, for example, the thickness of the workpiece (i.e., the substrate 1 and the semiconductor chips 5), before closing the molding die set 19.

Namely, the servo motors 31 are driven to slide the first movable wedged blocks 25 in one direction (i.e., to move forward or backward) by the screw shaft 30, according to the height of the semiconductor chips 5, so as to adjust the height positions of the cavity pieces 23 to the positions where the cavity pieces can press the semiconductor chips 5 without applying excessive stresses.

The servo motors 41 are driven to slide the second movable wedged blocks 39 in one direction (i.e., to move forward or backward) by the screw shaft 40, according to the height of the semiconductor chips 5, so as to adjust the height positions of the workpiece supports 37 to the positions where the workpiece supports can clamp the substrates 1 without applying excessive stresses.

Next, in Fig. 2B, the workpieces are supplied to the lower die 21 of the opened molding die set 19 by the loader 16 (see Fig. 1). Namely, the substrates 1, on which the semiconductor chips 5 are mounted, are conveyed to the workpiece supports 37, and the resin tablets 3 are supplied to the pots 35. In this process, the position of the workpiece supports 37 has been previously adjusted by the lower die driving unit 8, so that the substrates 1 are supported in a state where the substrates are almost level with the clamping face of the lower die. Note that, the semiconductor chips 5 may be wire-bonded. In this case, projections capable of clamping flat parts of the semiconductor chips 5, which are

located on inner sides of wire-bonding regions, may be formed in the cavity pieces 23, so that the workpieces in which semiconductor chips are wire-bonded can be clamped and resin-molded.

Next, in Fig. 3C, the lower die 21 is moved upward to close the resin molding die set 19. In this process, the decompression unit 58 may be actuated before or when beginning the clamping action so as to begin the sucking action through the lower sucking path 43. When the upper chase block 22 contacts the lower seal ring 42, the closed space is formed between the upper die 20 and the lower die 21, and the decompression space is formed therein by performing the sucking action through the lower sucking path 43.

By further progressing the clamping action, the upper insert block 26 contacts the lower insert block 34 and the substrates 1 through the release film 10 and the cavity pieces 23 contact the semiconductor chips 5 through the release film 10, then the clamping action is completed. Note that, the operation amounts of the cavity-height-varying mechanism and the thickness-varying mechanism may be precisely adjusted after closing the molding die set 19.

Next, in Fig. 3D, the transfer mechanism is actuated to move the plungers 36 upward and pressure-feed the melted resin to the cavity recesses 32 via the upper culls 26c and the upper runners 26d. In this process, upper faces of the semiconductor chips 5 are pressed by the cavity pieces 23, so if the semiconductor chips 5 flip-chip-bonded, spaces between the semiconductor chips and the substrates 1 can be underfilled by the melted resin. Namely, a manner of mold underfill (MUF) for underfilling the workpieces can be performed in the molding die set 19. Even if voids are included in the melted resin for underfilling the spaces immediately under the semiconductor chips 5, the voids can be flowed away by overflowing the melted resin from the cavity recesses

32 to the dummy cavities 26e, so that the filling property of resin to the cavities can be improved. The voids included in the molding resin are flowed prior to the resin, so the voids may be discharged into the decompression space, via air vents, after being overflowed, and then sucked and discharged through the lower sucking path 43. Further, by actuating the thickness-varying mechanism, the molding resin can be pressure-fed to the dummy cavities 26e, via grooves having a constant depth, regardless of the thickness of the substrates 1. According to materials of the substrates 1, reducing flow passage areas of the grooves will be caused by deforming and bending the substrates in the grooves, but this problem can be solved in the present embodiment. Therefore, even if the thicknesses of the substrates 1 are different, resin leakage can be prevented by securely overflowing the molding resin toward the dummy cavities 26e, so that the voids can be securely discharged regardless of the thicknesses of the workpieces and quality of the molded products can be stabilized.

Fig. 4E shows a step of not only underfilling the semiconductor chips 5 mounted on the substrates 1 but also overmolding the semiconductor chips 5 without being exposed. This step can be optionally performed on the basis of product-requirements of the workpieces. In Fig. 3D, if the semiconductor chips 5 are flip-chip-bonded, capacities of the cavity recesses 32 are increased by actuating the upper die driving unit 7 and moving the cavity pieces 23 upward after performing the underfill molding, i.e., after overflowing the molding resin toward the dummy cavities 26e. Concretely, the first movable wedged blocks 25 are slid, in a direction of moving away from plane positions of the cavity pieces 23, by actuating the servo motors 31 and rotating the screw shafts 30. With this action, the cavity pieces 23 are moved upward along the inclined wedged faces 25a and spaces

(cavity capacities) are formed between the cavity pieces and the semiconductor chips 5, and then the spaces are filled with the molding resin. In comparison with a case where the overfilling step and the underfilling step are simultaneously performed, occurring insufficient resin-filling can be securely prevented by performing the overfilling step after the underfilling step.

Note that, to further improve the filling property of the resin in the underfilling step, the up/down movement of the cavity pieces 23 may be repeated. In this case, the states shown in Figs. 3D and 4E are repeated by alternately rotating the servo motors 31 in a normal direction and a reverse direction to reciprocally move the first movable wedged blocks 25 by the screw shafts 30. Simultaneously, the resin may be pushed back from the cavity recesses 32 toward the pots 35 by repeating the up/down movement of the plungers 26. With this action, the spaces can be easily filled with the resin by increasing a flow amount of the resin. Note that, in case that the heights of the cavity pieces 23 are varied by the closing action of the dies as described in the following embodiments, the repeating action can be quickly performed, so that the resin molding with high filling property can be performed within a short time.

In the above described molding die set 19, even if the thicknesses of the substrates 1 are varied, the upper faces of the substrates 1 can be made level with the clamping face of the die by adjusting the heights of the workpiece supports 37 by the thickness-varying mechanism; and even if heights of the semiconductor chips 5 (including heights of the stacked semiconductor chips) from the substrates 1 are different in each workpiece, molding thicknesses can be constant by varying the heights of the cavity pieces 23 by a cavity piece adjusting mechanism.

Therefore, the clamping action can be performed, with stabilizing clamping balance and exerting no excessive stress on the workpieces,

regardless of the existence and magnitude of variations in the thickness of the workpieces (i.e., the substrates 1 and the semiconductor chips) in the thickness direction. Position control of the cavity pieces 23 and the workpiece supports 37 in the opening/closing direction of the dies can be precisely performed by providing wedge mechanisms to both of the cavity pieces 23 and the workpiece supports 37, so that stress exerted on the workpieces can be reduced, as much as possible, in the clamping step, and high quality of the products can be maintained.

Further, the voids formed in the molding resin for filling the cavity recesses 32 can be washed away, so that quality of the products can be improved. Especially, in case of performing the underfill molding, the filling property of the resin can be improved.

Therefore, the resin molding apparatus, in which molding thickness can be constant and which is capable of improving quality of the products, can be provided.

[Second Embodiment]

Successively, the resin molding apparatus of another embodiment will be explained. Structural elements are almost the same as the former embodiment, so characteristics of the molding die set will be mainly explained. The structural elements explained in the first embodiment are assigned the same symbols and the explanation of the first embodiment will be applied.

In Figs. 5A and 5B, the characteristic point is an intermediate plate 44, which is disposed between the upper die 20 and the lower die 21 to perform the resin molding. The intermediate plate 44 includes: first through-holes 44a being communicated to the pots 35; gates 44b (resin paths) being communicated to the upper runners 26d; second through-holes 44c (corresponding to the cavities) for accommodating the semiconductor chips 5 and being communicated to the gates 44b; and

through gates 44d (resin paths) being communicated to the dummy cavities 26e. A thickness of the intermediate plate 44 is equal to, for example, the height of the semiconductor chips 5 of the workpieces, and resin molding regions thereof correspond to the second through-holes 44c.

In Fig. 5A, as a premise, the height of the cavity pieces 23 is previously set at the height where the cavity pieces can press the semiconductor chips without exerting excessive stress on the semiconductor chips 5 by actuating the servo motors 31 to match the height of the semiconductor chips 5 on the basis of results measured by a workpiece measuring section and sliding the first movable wedged blocks 25 in the one direction (i.e., to move forward or backward) by the screw shafts 30.

Further, the height of the workpiece supports 37 is previously set at a height where the workpiece supports can clamp the substrates 1 without exerting excessive stress, on the basis of the thickness of the substrates 1, by actuating the servo motors 41 and sliding the second movable wedged blocks 39 in the one direction (i.e., to move forward or backward) by the screw shafts 40.

Next, the substrates 1 are mounted onto the workpiece supports 37 and the resin tablets 3 are supplied into the pots 35 by the loader 16, and then the intermediate plate 44 is provided to bridge over gaps between outer edges of the substrates 1 and the lower insert block 34 and is piled on the clamping face of the lower die. In this process, the intermediate plate 44 is disposed on the clamping face of the lower die in a state where the first through-holes 44a are disposed to correspond to the pots 35 and the second through-holes 44c accommodate the semiconductor chips 5. The intermediate plate 44 may be supplied to the molding die set 19 by an independent conveying mechanism or by the loader 16 together

with the resin tablets 3.

Next, the lower die 21 is moved upward to close the molding die set 19. When the upper chase block 22 contacts the lower seal ring 42, the closed space is formed between the upper die 20 and the lower die 21, and the decompression space is formed by sucking air through the lower sucking path 43. By further progressing the clamping action, the upper insert block 26 contacts the intermediate plate 44 through the release film 10 and the cavity pieces 23 contact the semiconductor chips 5 through the release film 10, then the clamping action is completed.

Next, in Fig. 5B, the transfer mechanism is actuated to move the plungers 36 upward, so that the melted resin is pressure-fed to the second through-holes 44c via the first through-holes 44a, the upper culls 26c, the upper runners 26d and the gates 44b. In this process, the melted resin flows on the intermediate plate 44, which bridges over the gaps between the substrates 1 and the die, and is directly supplied into the second through-holes 44c constituting the cavities. In case of molding the flip-chi-bonded semiconductor chips 5, the upper faces of the semiconductor chips are pressed by the cavity pieces 23, so the underfill molding can be performed by introducing the melted resin to the spaces between the semiconductor chips 5 and the substrates 1. Further, the voids (bubbles) can be washed away by overflowing the molding resin from the second through-holes 44c to the dummy cavities 26e via the through gates 44d, so that the resin filling property in the cavities can be improved.

In this case, performing gold plating for easily releasing the runners, forming the dummy cavities, etc., are not required in the substrates 1, and there is no possibility that the molding resin invades into gaps between the substrates 1 and the lower insert block 34 and causes a slide malfunction.

[Third Embodiment]

Successively, another embodiment of the resin molding apparatus will be explained. Structural elements are almost the same as the first embodiment, so characteristics of the molding die set will be mainly explained. The structural elements explained in the first embodiment are assigned the same symbols and the explanation of the first embodiment will be applied.

In the present embodiment, the intermediate plate 44 is used as well as the second embodiment, but a characteristic point is a swivel mechanism included in the upper die 20. Concretely, guide pieces 46 are provided between the first movable wedged blocks 25 and the cavity pieces 23, which contact the semiconductor chips 5 through the release film 10. The guide pieces 46 are suspended, from the upper chase block 22, by the springs 24. Pressing springs 47, whose elastic force is smaller than that of the springs 24, are elastically provided between the cavity pieces 23 and the guide pieces 46, i.e., being provided on a surface of the cavity pieces 23 opposite to a workpiece-contacting face, and gaps are formed between the cavity pieces 23 and the guide pieces 46. Note that, the gaps need not be formed, but it is preferable to form small gaps so as to reduce sliding resistances between the cavity pieces 23 and the guide pieces 46 and so as to smoothly tilt the cavity pieces 23.

Convex parts 23d (guide faces) are formed at centers of facing surfaces of the cavity pieces 23, which face the guide pieces 46; and recessed parts (guide faces not shown), to which the convex parts 23d can be fitted, are formed in facing surfaces of the guide pieces 46, which face the cavity pieces 23. When the cavity pieces 23 contact the semiconductor chips (or chip) 5 through the release film 10, the cavity pieces suitably tilt to follow height variation (inclination) of the semiconductor chips 5 and press in a state of tilting on the convex parts

23d.

When the clamping action by the upper die 20 and the lower die 21 is completed, the pressing springs 47 between the cavity pieces 23 and the guide pieces 46 are contracted, and the convex parts 23d fit in the recessed parts (not shown), so that the workpieces can be clamped in a rigid state where the gaps are eliminated. In this case, the convex parts 23d may have spherical surfaces, and centers of the spherical surfaces may correspond to centers of the cavity pieces 23 directed toward the semiconductor chips 5. With this structure, even if the semiconductor chips 5 are clamped with tilting the cavity pieces 23, the semiconductor chips can be suitably clamped without generating stress in a shearing direction. Note that, the convex parts 23d may be provided to the guide pieces 46.

In Fig. 6A, as a premise, the height of the cavity pieces 23 is previously set at the height where the cavity pieces can press the semiconductor chips without exerting excessive stress on the semiconductor chips 5 by actuating the servo motors 31 to match the height of the semiconductor chips 5 on the basis of results measured by a workpiece measuring section. Similarly, the height of the workpiece supports 37 is previously set at a height where the workpiece supports can clamp the substrates 1 without exerting excessive stress.

Next, the substrates 1 are mounted onto the workpiece supports 37 and the resin tablets 3 are supplied into the pots 35 by the loader 16, and then the intermediate plate 44 is provided to bridge over the gaps between outer edges of the substrates 1 and the lower insert block 34 and piled on the clamping face of the lower die.

Next, the lower die 21 is moved upward to close the molding die set 19. When the upper chase block 22 contacts the lower seal ring 42, the closed space is formed between the upper die 20 and the lower die 21,

and the decompression space is formed by sucking air through the lower sucking path 43. By further progressing the clamping action, the upper insert block 26 contacts the intermediate plate 44 through the release film 10 and the cavity pieces 23 contact the semiconductor chips 5 through the release film 10, then the clamping action is completed in a state where the cavity pieces 23 are tilted on the convex parts 23d by the swivel mechanism 45.

Next, in Fig. 6B, the transfer mechanism is actuated to move the plungers 36 upward, so that the melted resin is pressure-fed to the second through-holes 44c via the first through-holes 44a, the upper culls 26c, the upper runners 26d and the gates 44b. In this process, the upper faces of the semiconductor chips are pressed by the cavity pieces 23, so the underfill molding can be performed by introducing the melted resin to the spaces between the flip-chip-bonded semiconductor chips 5 and the substrates 1.

Further, the voids (bubbles) can be washed away by overflowing the molding resin from the second through-holes 44c to the dummy cavities 26e via the through gates 44d, so that the resin filling property in the cavities can be improved.

With the above described structure, even if the semiconductor chips 5 on the substrates 1 are inclined, the cavity pieces 23 incline to follow the inclination of the semiconductor chips 5 without biased contact with the cavity pieces 23 through the release film 10, so that no excessive stress is exerted on the semiconductor chips 5 and damaging and breaking the same can be prevented. Therefore, quality of the molded products can be improved. Further, since the cavity pieces 23 is inclinable, even in case of resin-molding, for example, packages each of which constitutes an inverter by sandwiching an IGBT (Insulated Gate Bipolar Transistor) and an FWD (Free Wheeling Device) between a pair

of lead frames and the lead frames and in each of which the lead frames are easily inclined because they sandwich the different elements, forming resin flashes can be securely prevented. In this molding sample, the lead frame disposed on a lower side corresponds to the “first member” of the present invention, and the IGBT, the FED and the lead frame disposed on an upper side correspond to the “second member” thereof.

[Fourth Embodiment]

Successively, another embodiment of the resin molding apparatus will be explained. Structural elements are almost the same as the first embodiment, so characteristics of the molding die set will be mainly explained. The structural elements explained in the first embodiment are assigned the same symbols and the explanation of the first embodiment will be applied.

In Fig. 7A, the dummy cavities 26e are formed in the clamping face of the upper insert block 26 and located on outer sides of parts facing the substrates. Closing pins 48 (closing means), which are capable of reciprocally moving and pressing the clamping face of the lower insert block 34 through the release film 10 to stop the decompressing action, may be provided in the clamping face and located on outer sides of the dummy cavities 26e. The closing pins 48 may be reciprocally moved by a driving mechanism, e.g., solenoid, cylinder.

With the above described structure, the dummy cavities 26e need not be formed on the substrates 1, so that number of the products 11 on each of the substrates 1 can be increased and usage rate of each of the substrates 1 can be improved. Resin leakage can be prevented by prohibiting air from being discharged from the molding die set 19 at a desired timing when, for example, the dummy cavities 26e are fully filled with the overflowed resin. By forming deep air vents (not shown)

which discharge air from the cavities and which extend toward an outer periphery, air can be easily discharged, so that the decompressing action can be quickly and securely performed to prevent poor resin filling.

As shown in Fig. 7B, the intermediate plate 44 is used in the present embodiment, and dummy cavities 44e are located on outer sides of the parts facing the substrates. The dummy cavities 44e are through-holes capable of storing the surplus resin overflowed from the second through-holes 44c via the through gates 44d. The closing pins 48, which are capable of pressing the clamping face of the intermediate plate 44 through the release film 10, are provided in the clamping face of the upper insert block 26 and located on outer sides of the dummy cavities 44e. With this structure, since the dummy cavities 44e are formed outside of the substrates 1, grooves communicated to the dummy cavities 44e and the cavity recesses 32 need not be formed in the substrates 1, so that number of the products 11 on each of the substrates 1 can be increased and usage rate of each of the substrates 1 can be improved. Further, since the dummy cavities 44e are through-holes of the intermediate plate 44, the unused resin in the dummy cavities 44e can be released from the die by pushing with, for example, pins (not shown), so that the unused resin can be easily released from the die. Note that, both of the dummy cavities 26e and the dummy cavities 44e may be formed.

[Fifth Embodiment]

Successively, another embodiment of the resin molding apparatus will be explained. Characteristics of the molding die set will be mainly explained. The structural elements explained in the first embodiment are assigned the same symbols and the explanation of the first embodiment will be applied. In the first to fourth embodiments, the wedge mechanisms support the cavity pieces 23 as the cavity-height-varying mechanism, but the cavity pieces 23 are suspended from the upper chase

block 22 in a rigid state as shown in Fig. 8A. Note that, the upper insert block 26 may be suspended by springs 49. No wedge mechanisms are provided to the upper die 20, but the wedge mechanisms, each of which includes the workpiece support 37 and the second movable wedged block 39, are provided to the lower die 21 only.

The clamping action of the molding die set 19 will be explained. In Fig. 8A, the servo motors 41 are driven to slide the second movable wedged blocks 39 in one direction (i.e., to move forward or backward) by the screw shaft 40, according to the thickness of the substrates 1, so as to adjust the height positions of the workpiece supports 37 to the positions where the workpiece supports can clamp the substrates 1 without applying excessive stresses. In this state, the loader 16 (see Fig. 1) supplies the workpieces to the lower die 21 of the opened molding die set 19. In this process, the position of the workpiece supports 37 has been previously adjusted by the lower die driving unit 8, so that the substrates 1 are supported in a state where the substrates are level with or slightly higher than the clamping face of the lower die.

Next, in Fig. 8B, the lower die 21 is moved upward to close the molding die set 19. When or before beginning of the clamping action, the decompression unit 58 may be actuated to begin the sucking action through the lower sucking path 43. When the upper chase block 22 contacts the lower seal ring 42, the closed space is formed between the upper die 20 and the lower die 21, and the decompression space is formed therein by sucking air through the lower sucking path 43.

By progressing the clamping action, the upper insert block 26 contacts the lower insert block 34 and the substrates 1 through the release film 10.

By further progressing the clamping action, the springs 49 are contracted, in a state where the upper insert block 26 contacts the lower

insert block 34 and the substrates 1, and the cavity pieces 23 contact the semiconductor chips 5 through the release film 10 as shown in Fig. 8C. In this case, the clamping force, which is generated, by the contracted springs 49, as a counter force against the lower movable platen, is detected, and the clamping action will be completed when the detected clamping force reaches a predetermined force.

To relatively move the cavity pieces 23 upward and downward, with respect to the upper insert block 26, so as to move in the opening/closing direction of the dies, the clamping mechanism for moving the lower movable platen upward and downward acts as the cavity-height-varying mechanism. Successively, the transfer mechanism is actuated to move the plungers 36 upward to pressure-feed the melted resin to the cavity recesses 32. In this case, the cavity height can be set to match the height of the semiconductor chips by completing the die closing action before feeding the molding resin into the cavity recesses 32.

To eliminate gaps between the substrates 1 and the lower insert block 34, a pressing mechanism, which is capable of pressing the substrates 1 onto a wall face of the lower insert 34 on the pot 35 side from outside, or a deforming mechanism, which is capable of physically deforming the substrates 1 to eliminate the gaps, may be provided if required. With this structure, leakage of the resin having high fluidity can be prevented as much as possible.

The cavity pieces 23 are rigidly supported by the upper chase block 22, but they may be suspended by springs. In this case, the upper insert block 26 is supported by the upper chase block 22 in a rigid state, so, before completing the clamping action, the die closing action may be completed after clamping the semiconductor chips 5 by the cavity pieces 23.

With the above described structure, amounts of floating the cavity pieces 23 and/or the upper insert block 26 (clamper) can be adjusted by upwardly moving the lower die 21 a predetermined amount corresponding to the height of the semiconductor chips 5 while closing the molding die set 19. Therefore, the depth of the cavities (the height from the substrates 1 to the cavity pieces 23) can be performed without separately adjusting. Namely, the clamping action can be performed, without exerting excessive pressing force on the workpieces, by upwardly moving the lower die 21 to the position set on the basis of the height of the semiconductor chips 5, so that the effects of the foregoing embodiments can be obtained by the simple structure.

[Sixth Embodiment]

Successively, another embodiment of the resin molding apparatus will be explained. Characteristics of the molding die set will be mainly explained. The structural elements explained in the first embodiment are assigned the same symbols and the explanation of the first embodiment will be applied.

In Fig. 9A, the cavity pieces 23 and the upper insert block 26 are suspended, from the upper chase block 22, by the springs 24 and 49. Contact faces of the cavity pieces 23, which contact the semiconductor chips, are partially projected downward. Namely, convex parts 23b and recessed grooves 23c formed around the convex parts are formed. No wedge mechanisms are provided to the upper die 20, but the wedge mechanisms, each of which includes the workpiece support 37 and the second movable wedged block 39, are provided to the lower die 21 only, as well as the fifth embodiment.

The clamping action of the molding die set 19 will be explained. In Fig. 9A, the servo motors 41 are driven to slide the second movable wedged blocks 39 in one direction (i.e., to move forward or backward)

by the screw shaft 40, according to the thickness of the substrates 1, so as to adjust the height positions of the workpiece supports 37 to the positions where the workpiece supports can clamp the substrates 1 without applying excessive stresses. In this state, the loader 16 (see Fig. 1) supplies the workpieces to the lower die 21 of the opened molding die set 19. In this process, the position of the workpiece supports 37 has been previously adjusted by the lower die driving unit 8, so that the substrates 1 are supported in a state where the substrates are level with or slightly higher than the clamping face of the lower die.

Next, in Fig. 9B, the lower die 21 is moved upward to close the molding die set 19. When or before beginning of the clamping action, the decompression unit 58 may be actuated to begin the sucking action through the lower sucking path 43. When the upper chase block 22 contacts the lower seal ring 42, the closed space is formed between the upper die 20 and the lower die 21, and the decompression space is formed therein by sucking air through the lower sucking path 43.

By progressing the clamping action, the upper insert block 26 contacts the lower insert block 34 and the substrates 1 through the release film 10. When the convex parts 23b of the cavity pieces 23 respectively contact the semiconductor chips 5 through the release film 10, the clamping action is completed. In this process, excessive pressing forces of the cavity pieces 23, which press the semiconductor chips 5, and an excessive pressing force of the upper insert block 26, which presses the substrates 1, can be released by the elasticities of the springs 24 and 49. Therefore, in case of clamping the semiconductor chips 5, e.g., upper face light emission type LEDs, with securely protecting upper faces of the semiconductor chips 5 and preventing resin flashes from being formed on the upper faces thereof, quality of the products can be improved.

In Fig. 9C, the transfer mechanism is actuated to move the plungers 36 upward, so that the melted resin is pressure-fed to the cavity recesses 32 via the upper culls 26c and the upper runners 26d. In this process, the upper faces of the semiconductor chips 5 are pressed by the convex parts 32b of the cavity pieces 23, so the underfill molding can be performed by introducing the melted resin to the spaces between the flip-chip-bonded semiconductor chips 5 and the substrates 1, and the recessed grooves 23c are filled with the molding resin, so that the upper faces of the semiconductor chips 5 are enclosed by the resin. Further, the voids can be washed away by overflowing the molding resin from the cavity recesses 32 to the dummy cavities 26e via the through gates 26f, so that the resin filling property in the cavities can be improved.

With the above described structure, reflectors enclosing light emitting faces of LEDs, which are the semiconductor chips 5, can be efficiently resin-molded by pushing and exposing the light emitting faces by the convex parts 23b of the cavity pieces 23 and filling the recessed grooves 23c enclosing the convex parts with silicone resin (white resin) having low viscosity by the transfer molding manner. Note that, heights of the light emitting faces of the reflectors need not be high, and the reflectors may be level with the light emitting faces. In this case, chip-contact faces of the cavity pieces 23 are made flat.

[Seventh Embodiment]

Successively, another embodiment of the resin molding apparatus will be explained. Characteristics of the molding die set will be mainly explained. The structural elements explained in the first embodiment are assigned the same symbols and the explanation of the first embodiment will be applied.

As shown in Fig. 10, the resin molding apparatus has a liquid resin supplying section F, which is separated from a substrate supplying

section (the workpiece supplying section A) and located adjacent to the pressing sections C. Concretely, the liquid resin supplying section F is located between the pressing sections C. In the resin molding apparatus, the unitized sections are connected by the guide sections 18 as well as the example shown in Fig. 1.

The molding die set 19 is the same as that used in the first embodiment, but the molding die sets 19 used in other embodiments may be employed.

The liquid resin supplying section F will be explained with reference to Fig. 11A dispenser (a liquid resin supplying unit) 50 comprises: a base not shown; a moving mechanism (including a rail, etc.) being provided on the base; and a rotary mechanism being capable of rotating on a moving table of the moving mechanism. The dispenser 50 has a syringe 51, which is vertically held and capable of turning to correspond to the two pressing units 6 and which is moved into the molding die set 19 so as to supply the liquid resin.

The dispenser 50 includes: the syringe 51 in which the liquid resin is stored; a tube 52 through which the liquid resin pushed out from the syringe 51 flows; and a dropping mechanism 53 for dropping the liquid resin into the pots 35. The tube 52, which is connected to the syringe 51 vertically held by a main body part of the dispenser not shown, is bent about 90 degrees and extended in a horizontal direction.

The dropping mechanism 53 includes: a pinch valve 54 being provided to an end part (a supplying port) of the tube 52, which is vertically bent from the horizontal direction; a resin receiving part 55 being capable of moving to and away from a position immediately under the open end of the tube; and a cooling mechanism 56 for cooling a periphery of the tube 52. The pinch valve 54 tightly closes the tube 52 except when dropping the liquid resin so as to prevent the liquid resin

from being dropped, prevents the liquid resin from being exposed to air and being deteriorated, and prevents air from invading into the tube 52. The resin receiving part 55 is usually located under the open end of the tube 52 to receive the liquid resin, and the resin receiving part is moved away from the position immediately under the open end of the tube 52 when the liquid resin is dropped. The resin receiving part 55 prevents the liquid resin from being dropped and prevents the open end of the tube 52 from being overheated when the liquid resin is not dropped.

The cooling mechanism 56 cools the periphery of the tube 52 to suppress response of the liquid resin when the dropping mechanism 53 is located in the pressing unit 6 of high temperature so as to supply the liquid resin. The cooling mechanism 56 is, for example, a mechanism which cools a casing accommodating the tube 52 by cooling means, e.g., air, water, or a mechanism which directly cools the liquid resin by passing a cooling agent through a thick part of the tube 52, and the both mechanisms may be employed. Further, the tube 52 may be cooled by providing a cooling element (cooling means), e.g., Peltier element, in the casing.

Next, an example of the liquid resin supplying action of the dispenser 50 will be explained.

As a premise, the height of the cavity pieces 23 is previously set at the height where the cavity pieces can press the semiconductor chips without exerting excessive stress on the semiconductor chips 5 by actuating the servo motors 31 to match the height of the semiconductor chips 5. Similarly, the height of the workpiece supports 37 is previously set at the height where the workpiece supports can clamp the substrates 1 without exerting excessive stress by actuating the servo motors 41 to match the thickness of the substrates 1.

Next, the loader 16 supplies the substrates 1 to the workpiece

supports 37. Further, as shown in Fig. 11A, the dispenser 50 is turned, by a rotary mechanism not shown, toward the pressing unit 6 to which the liquid resin will be supplied, and a posture of the dispenser is changed such that the dropping mechanism 53 can enter the opened molding die set 19 with a pinch valve 54 side being at the head. In this process, the pinch valve 54 is closed, and the resin receiving part 55 prevents immediately under the open end of the tube 52. Further, the cooling mechanism 56 is actuated so as to suppress the response of the liquid resin in the tube 52.

Next, as shown in Fig. 11B, the dispenser 50 is moved, by the moving mechanism not shown, toward the pressing unit 6 to which the liquid resin will be supplied. In this process, the dropping mechanism 53 enters the opened molding die set 19 of the pressing unit 6 and locates the pinch valve 54, which is provided to the front end of the tube 52, immediately above the pot 35. The resin receiving part 55 is moved away from the position immediately under the open end of the tube 52, and then the pinch valve 54 is opened so as to drop the liquid resin of the amount for one resin molding action into the pot 35 from the syringe 51.

When dropping the liquid resin of the amount for one resin molding action is completed, the pinch valve 54 is closed, and the resin receiving part 55 is moved to the position immediately under the open end of the tube 52. Then, the moving mechanism not shown is actuated to move the dispenser 50 away from the pressing unit 6, to which the liquid resin has been supplied. By this action, the dropping mechanism 53 is moved away from the molding die set 19.

Next, as shown in Fig. 3C, the lower die 21 is moved upward to close the molding die set 19 as well as the first embodiment. By further progressing the clamping action, the upper insert block 26 contacts the lower insert block 24 and the substrates 1 through the release film 10 and

the cavity pieces 23 contact the semiconductor chips 5 through the release film 10, then the clamping action is completed.

Next, as shown in Fig. 3D, the transfer mechanism is actuated to move the plungers 36 upward and pressure-feed the melted resin to the cavity recesses 32 via the upper culls 26c and the upper runners 26d to perform the underfill molding. Voids can be washed away by overflowing the melted resin from the cavity recesses 32 to the dummy cavities 26e, so that the filling property of resin to the cavities can be improved.

With the above described structure, the underfill molding, in which a liquid epoxy resin having low viscosity and including fine fillers is used so as to fill fine gaps between bumps, can be realized by the transfer molding manner. Further, lenses and reflectors of LEDs can be formed of a silicone resin having a low filling ratio of fillers and low viscosity, so that quality of molded products can be improved and life span thereof can be extended.

In each of the above described resin molding apparatuses, the cavities are formed in the upper die and the pots are formed in the lower die, but the cavities may be formed in the lower die, the pots may be formed in the upper die.

The upper die 20 is a fixed die and the lower die 21 is a movable die, but the present invention is not limited to that structure, the lower die 21 may be a fixed die and the upper die 20 may be a movable die.

The workpiece is not limited to the semiconductor chips 5 which are flip-chip-bonded or wire-bonded to the substrates 1, and the present invention can be applied to other workpieces, e.g., light emitting element such as white LED. Further, the present invention can be applied to a substrate on which a switching element of an electric circuit (e.g., IGBT, MOS-FET), an element of high calorific value (e.g., CPU, MPU), a

semiconductor element having input/output sections (e.g., LED) or a sensor generating and receiving signals (e.g., CCD sensor, CMOS sensor, fingerprint sensor, MEMS) is mounted as a workpiece. Further, a wafer, which is the workpiece and on which electronic parts, e.g., bumps, solder balls, are mounted, can be resin-molded by a wafer-level-package-molding manner. In this case, the wafer-level-package-molding can be performed by suitably clamping the bumps or solder balls by the cavity pieces 23.

The above described molding resin is, for example, the resin tablet 3 or the liquid resin, but other types of resins, e.g., granular resin, powder resin, resin including a fluorescent material can be used. The molding die set 19 may resin-mold a plurality of the semiconductor elements respectively or collectively and may perform map-type resin molding or matrix-type resin molding.

The pots 35 are formed in the lower insert block 34, but they may be formed on the upper die 20 side. Further, an arrangement of structural elements of the molding die set may be inverted.

In the above described cavity-height-varying mechanism, the cavity pieces 23 are driven by the wedge mechanisms, but the cavity-height-varying mechanism of the present invention is not limited to the wedge mechanisms. For example, the upper insert block 26 may be driven by one wedge mechanism. In this case, the cavity pieces 23 are rigidly supported by the upper chase block 22, and the height of the cavity can be varied by moving the upper insert block 26 upward or downward. In the above described embodiments, the height of the cavities are varied by the wedge mechanisms or the clamping mechanism, but the cavity pieces 23 or the upper insert block 26 may be directly driven by a driving source, e.g., hydraulic unit, ball bearing screw.

In the above described thickness-varying mechanism, the

workpiece supports 37 respectively supports the two substrates 1, which are disposed on the both sides of the plungers 36, and respectively driven by the wedge mechanisms, but the present invention is not limited to this structure. For example, a plurality of the substrates 1 are disposed on the both sides of the plungers 36, and a plurality of the workpiece supports 37, whose number is equal to that of the substrates, are respectively driven by the wedge mechanisms. Concretely, the servo motors 41 and the wedge mechanisms of the lower die driving unit 8 are arranged as well as the upper die driving unit 7. Namely, the upper die driving unit 7 and the lower die driving unit 8 are inverted, so that the position of the workpiece supports 37 with respect to the thickness of the substrates 1 can be more precisely adjusted. For example, as shown in Fig. 1, the one substrate 1 is disposed on each side of each of the three plungers 36 linearly arranged, and the six substrates 1 may be collectively resin-molded by the molding die set 19 after the heights of the workpiece supports 37 are respectively adjusted to match the thicknesses of the substrates.

Claims

1. A resin molding die set for resin-molding a workpiece in which a second member is mounted on a first member, comprising:

one molding die having a cavity recess, which constitutes a cavity for accommodating the second member and which is constituted by a cavity piece forming a bottom part of the cavity and a first insert enclosing the cavity piece;

the other molding die having a workpiece support for supporting the workpiece and a second insert being located adjacent to the workpiece support;

a pot and a plunger, which supply a molding resin, being provided to the one molding die or the other molding die;

a cavity-height-varying mechanism for varying a height of the cavity recess, by moving the workpiece support, with respect to the second insert, in an opening/closing direction of the dies, so as to match a height of the second member;

a thickness-varying mechanism for varying a height of the workpiece support, by moving the workpiece support with respect to the second insert in the opening/closing direction of the dies, so as to match a thickness of the first member; and

a decompressing mechanism for decompressing a closed space, which is shut off from outside and which is formed before completing a die closing action in which the first insert contacts the first member and the second insert, so as to form a decompressed space including the cavity,

wherein a dummy cavity for storing a surplus resin is formed in a clamping face of the first insert and located on an outer side of a workpiece facing surface, and closing means for stopping the decompressing action of the decompressing mechanism is located on an

outer side of the dummy cavity, the closing means is capable of moving close to and away from a facing clamping surface of the second insert, and

wherein the height of the workpiece support is adjusted by the thickness-varying mechanism to match the thickness of the first member, and the height of the cavity recess is adjusted by the cavity-height-varying mechanism to match the height of the second member before the molding resin is supplied into the cavity.

2. The resin molding die set according to claim 1, wherein the cavity-height-varying mechanism includes a wedge mechanism, which adjusts a position of the cavity piece in the opening/closing direction of the dies by moving a movable taper block by a driving source.

3. The resin molding die set according to claim 1, wherein one or both of the cavity piece and the first insert are floating-supported by one of mold chases.

4. The resin molding die set according to any one of claims 1-3, wherein the thickness-varying mechanism includes a wedge mechanism, which adjusts a position of the workpiece support in the opening/closing direction of the dies by moving a movable taper block by a driving source.

5. The resin molding die set according to any one of claims 1-4, further comprising an intermediate plate, in which a through-hole for accommodating the second member and a resin path communicated to the through-hole are formed and which is provided to cover a gap between an outer edge of the first member supported by the workpiece support and the second insert and piled on a clamping face of the other molding die.

6. The resin molding die set according to claim 5, wherein a dummy cavity is formed in the intermediate plate and located on an outer side of the first member, and the surplus resin is introduced from the through-hole to the dummy cavity.

7. The resin molding die set according to any one of claims 1-6, further comprising a swivel mechanism having a guide piece, wherein a guide face of the guide piece faces one face of the cavity piece, which is opposite to the other face contacting the second member, and the cavity piece is capable of being tilted along the guide face.

8. The resin molding die set according to any one of claims 1-7, wherein a pressing face of the cavity piece of the second member is an uneven surface including a plurality of convex parts corresponding to a contact face of a semiconductor chip and a recessed groove formed around the convex parts.

9. The resin molding die set according to any one of claims 1-8, wherein a release film is sucked and held on a clamping face of the one molding die, which includes the cavity recess.

10. A resin molding apparatus comprising: a workpiece supplying section; a pressing section in which a workpiece is clamped and resin-molded by the molding die set according to any one of claims 1-9; and an accommodating section for accommodating molded products,

wherein an operation amount of the cavity-height-varying mechanism is set, according to the thickness of the first member and the height of the second member, to locate the cavity piece at a prescribed position in the opening/closing direction of the dies before the molding resin is supplied into the cavity, and then the first member is clamped and resin-molded.

11. The resin molding apparatus according to claim 10, wherein a liquid resin supplying section is provided adjacent to the pressing section, and a liquid resin is supplied by moving a resin supply nozzle into and away from a pot of the opened molding die set.