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Molding apparatus of semiconductor package

Abstract

A molding apparatus for a semiconductor package includes a chamber including a lower mold configured to hold a substrate including a plurality of molding targets, an upper mold configured to move up and down with respect to the lower mold and define a cavity between the upper mold and the lower mold, and a port configured to provide a passage communicating with the cavity, a molding material supplier configured to supply a molding material to the port, a plunger configured to pressurize the molding material inside the port, a plunger actuator configured to apply a first pressure to the plunger such that the molding material provided in the port is supplied to the cavity, and a mold actuator configured to control actuation of the upper mold. The plunger actuator is configured to supply the molding material to the cavity by applying the first pressure to the plunger, and the mold actuator is configured to pressurize the molding material in the cavity by applying a second pressure to the upper mold. The mold apparatus further includes a controller configured to control the plunger actuator to reduce the first pressure applied to the plunger after the mold actuator begins applying the second pressure to the upper mold.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application is based on and claims priority under 35 U.S.C. § 119 to Korean Patent Application Nos. 10-2022-0067701 filed on Jun. 2, 2022 and 10-2022-0100158 filed on Aug. 10, 2022, in the Korean Intellectual Property Office, the disclosures of which are incorporated by reference herein in their entireties.

BACKGROUND

(2) Aspects of the inventive concept relate to a molding apparatus for a semiconductor package.

(3) In order to prevent damage to a semiconductor chip due to external impact or light, a molding process of molding the semiconductor chip with a sealing resin, such as an epoxy molding compound (EMC), is performed. The recent trend of a semiconductor industry is to continuously achieve small, thin, lightweight, highly integrated and highly dense semiconductor products. Accordingly, the thickness of a semiconductor package is decreasing, and the thickness of the molding resin is also decreasing. As a result, using conventional molding techniques, undesired voids may be present in a completed product such as a semiconductor package. Example embodiments discussed herein address this issue and may help remove or decrease voids formed in a mold layer of a product.

SUMMARY

(4) Aspects of the inventive concept provide a molding apparatus for a semiconductor package with a small thickness, reducing voids in a molding resin, and improving an unfilled molding resin, in relation to the apparatus for molding the semiconductor package.

(5) According to an aspect of the inventive concept, a molding apparatus for a semiconductor package includes a chamber including a lower mold configured to hold a substrate including a plurality of molding targets, an upper mold configured to move up and down with respect to the lower mold and define a cavity between the upper mold and the lower mold, and a port configured to provide a passage communicating with the cavity, a molding material supplier configured to supply a molding material to the port, a plunger configured to pressurize the molding material inside the port, a plunger actuator configured to apply a first pressure to the plunger such that the molding material provided in the port is supplied to the cavity, and a mold actuator configured to control actuation of the upper mold. The plunger actuator is configured to supply the molding material to the cavity by applying the first pressure to the plunger, and the mold actuator is configured to pressurize the molding material in the cavity by applying a second pressure to the upper mold. The mold apparatus further includes a controller configured to control the plunger actuator to reduce the first pressure applied to the plunger after the mold actuator begins applying the second pressure to the upper mold.

(6) According to another aspect of the inventive concept, a molding apparatus for a semiconductor package includes a cylindrical chamber including a lower mold configured to hold a substrate including a plurality of molding targets, and an upper mold configured to move up and down with respect to the lower mold and define a cavity between the upper mold and the lower mold, a first port formed on an inner sidewall of the chamber and configured to provide a passage communicating with the cavity, a second port formed in a top portion of the chamber and configured to provide a passage communicating with the cavity, a molding material supplier configured to supply a molding material to the second port, a plunger configured to pressurize the molding material inside the second port, a plunger actuator configured to apply a first pressure to the plunger such that the molding material provided in the second port is supplied to the cavity, and a mold actuator configured to control actuation of the upper mold. The plunger actuator is configured to supply the molding material to the cavity by applying the first pressure to the

plunger, and the mold actuator is configured to pressurize the molding material in the cavity by applying a second pressure to the upper mold.

(7) According to another aspect of the inventive concept, a molding apparatus for a semiconductor package includes a chamber including a lower mold configured to hold a substrate including a plurality of molding targets, and an upper mold configured to move and down with respect to the lower mold and define a cavity between the upper mold and the lower mold, a port formed on a sidewall of the chamber in a first direction, configured to provide a passage communicating with the cavity, and discharge a molding material to the cavity in a second direction perpendicular to the first direction, a molding material supplier configured to supply a molding material to the port, a plunger configured to pressurize the molding material inside the port, a plunger actuator configured to apply a first pressure to the plunger such that the molding material provided in the port is supplied to the cavity, and a mold actuator configured to control actuation of the upper mold. The plunger actuator is configured to supply the molding material to the cavity by applying a first pressure equal to or less than 5 MPa to the plunger, the mold actuator is configured to pressurize the molding material in the cavity by applying a second pressure higher than the first pressure to the upper mold. The molding apparatus further includes a controller configured to control the mold actuator to apply the first pressure to the plunger and apply the second pressure to the upper mold after the molding material molds the plurality of molding targets arranged at a farthest distance from the port, and to control the plunger actuator to reduce the first pressure applied to the plunger after the mold actuator begins applying the second pressure to the upper mold.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

- (1) Embodiments of the inventive concept will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings in which:
- (2) FIG. 1 is a perspective view schematically illustrating a molding apparatus for a semiconductor package according to an embodiment;
- (3) FIG. 2 is a perspective view schematically illustrating a molding apparatus for a semiconductor package according to another embodiment;
- (4) FIG. 3 is a cross-sectional view illustrating the molding apparatus for the semiconductor package shown in FIG. 1;
- (5) FIG. 4 is a cross-sectional view illustrating the molding apparatus for the semiconductor package shown in FIG. 2;
- (6) FIG. 5 is a cross-sectional view illustrating a molding apparatus for a semiconductor package according to another embodiment;
- (7) FIGS. 6A to 6D are cross-sectional views illustrating an operation process of the molding apparatus of the semiconductor package shown in FIG. 1;
- (8) FIGS. 7A to 7D are cross-sectional views illustrating an operation process of the molding apparatus of the semiconductor package shown in FIG. 2; and
- (9) FIG. 8 is a flow chart diagram showing an example method of manufacturing a semiconductor device using an example molding apparatus, according to an embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

(10) FIG. 1 is a perspective view schematically illustrating a molding apparatus **10** for a semiconductor package according to an embodiment.

(11) Referring to FIG. 1, a first direction (x direction) and a second direction (y direction) may cross each other among horizontal directions. For example, the first direction (x direction) and the second direction (y direction) may perpendicularly cross each other. A third direction (z direction) may cross both the first direction (x direction) and the second direction (y direction). For example,

the third direction (z direction) may be perpendicularly orthogonal to the first direction (x direction) and the second direction (y direction). The third direction (z direction) may be a vertical direction. Accordingly, the first direction (x direction), the second direction (y direction), and the third direction (z direction) may be orthogonal to each other.

(12) A quadrangular substrate **230** may include a plurality of molding targets **250**. Specifically, the plurality of molding targets **250** may be arranged on one surface of the substrate **230** at regular intervals. One surface of the substrate **230** may be a plane parallel to both the first direction (x direction) and the second direction (y direction). Terms such as “same,” “equal,” “planar,” “coplanar,” “parallel,” and “perpendicular,” as used herein encompass identity or near identity including variations that may occur, for example, due to manufacturing processes. The term “substantially” may be used herein to emphasize this meaning, unless the context or other statements indicate otherwise.

(13) The substrate **230** may be a printed circuit board (PCB). For example, the substrate **230** may be a substrate in which an electronic circuit is configured by fixing electronic components, such as resistors, capacitors, and integrated circuits, to the surface of a printed wiring substrate, and connecting the electronic components to each other by a copper wiring.

(14) According to an embodiment, although not shown, a wiring structure electrically connecting an upper surface of the substrate **230** to a lower surface of the substrate **230** may be inside the substrate **230**.

(15) The molding target **250** may include electronic components, such as a semiconductor chip and a semiconductor package. For example, the molding targets **250** may be various semiconductor packages requiring molding, such as a Package On Package (POP) structure and an interposer-inserted POP (i-POP) structure.

(16) A plurality of ports **310** may be arranged in the second direction (y direction) along the sidewall of a chamber (see **100** of FIG. 3). The ports **310** may be configured to discharge or supply a molding material in the first direction (x direction) perpendicular to the second direction through the sidewall of the chamber. For example, a hole in the sidewall of the chamber may be formed so that part of the sidewall is above the hole and part of the sidewall is below the hole. A detailed description of a process in which the port **310** discharges the molding material is given below. When the port supplying the molding material is disposed in the floor of the chamber **100**, the molding material is not smoothly supplied due to resistance of gravity, or greater energy is required for supplying the molding material. However, when the port for supplying the molding material is disposed on a part of the sidewall of the chamber **100**, the molding material can be uniformly and smoothly supplied toward the molding target due to the help of gravity. Ordinal numbers such as “first,” “second,” “third,” etc. may be used simply as labels of certain elements, steps, directions, etc., to distinguish such elements, steps, directions, etc. from one another. Terms that are not described using “first,” “second,” etc., in the specification, may still be referred to as “first” or “second” in a claim. In addition, a term that is referenced with a particular ordinal number (e.g., “first” in a particular claim) may be described elsewhere with a different ordinal number (e.g., “second” in the specification or another claim).

(17) FIG. 2 is a perspective view schematically illustrating a molding apparatus **20** for a semiconductor package according to another embodiment.

(18) Referring to FIG. 2, a circular substrate **240** may include the plurality of molding targets **250**. Specifically, the plurality of molding targets **250** may be arranged on one surface of the substrate **240** at regular intervals. One surface of the substrate **240** may be a plane parallel to both the first direction (x direction) and the second direction (y direction).

(19) The substrate **240** may be a disk, or wafer, formed by a single crystal pillar made by growing silicon (Si), gallium arsenide (GaAs), etc. being thinly sliced to a constant thickness.

(20) The plurality of ports **310** may be disposed to be spaced apart from each other along the circumference of the circular substrate **240**. The ports **310** may be configured to discharge or

supply molding materials toward the molding targets **250** arranged on one surface of the substrate **240** at regular intervals. The ports **310** may be configured to discharge or supply a molding material in a horizontal direction through the sidewall of the chamber. A detailed description of a process in which the ports **310** discharge molding materials is given below. An additional port **320** may also be formed at a center of the disk. A detailed description of this port **320** is given below.

(21) A gas adjustor **340** may be disposed to face the port **310** (e.g., to be opposite the port **310**). The gas adjustor **340** may be configured to supply or discharge gas onto or away from the substrate **240**. A detailed description of a process in which the gas adjustor **340** supplies or discharges gas thereto is given below.

(22) In FIG. **2**, the port **310** and the gas adjustor **340** are illustrated as being disposed two each, but the inventive concept is not limited thereto.

(23) FIG. **3** is a cross-sectional view illustrating the molding apparatus **10** for a semiconductor package shown in FIG. **1**.

(24) The molding apparatus **10** of the semiconductor package according to an embodiment includes a chamber **100**, an upper mold **210**, a lower mold **220**, the port **310**, a plunger **312**, a plunger actuator **360**, a molding material supplier **410**, a mold actuator **630**, and the gas adjustor **340**.

(25) The chamber **100** may be a housing forming the exterior of the molding apparatus **10** for a semiconductor package of the inventive concept. The chamber **100** may include other components, such as the upper mold **210** or the lower mold **220** therein. The chamber **100** may be configured to isolate the inside and the outside, and when a molding process is performed inside the chamber **100**, the inside of the chamber **100** may be maintained in a vacuum unlike the outside. The chamber **100** may be a rectangular chamber in one embodiment, that matches the shape of the substrate **230**.

(26) The chamber **100** may include an upper chamber **110** and a lower chamber **120**, also described as an upper housing and a lower housing. An upper mold **210** may be disposed in the upper chamber **110**, and a lower mold **220** may be disposed in the lower chamber **120**. The upper mold **210** may also be described as an upper mold plate, and the lower mold **220** may also be described as a lower mold plate. In a molding apparatus for a semiconductor package according to some embodiments, lower mold **220** may be fixed and the upper mold **210** may move up and down, or the upper mold **210** may be fixed and the lower mold **220** may move up and down, or both the upper mold **210** and the lower mold **220** may move up and down.

(27) The lower mold **220** may be configured to fix and hold the substrate **230** including the plurality of molding targets **250**. For example, the lower mold **220** may include sidewalls, notches, or other devices to hold the substrate **230** in place. The lower mold **220** may define a cavity **260** between the lower mold **220** and the upper mold **210** with the molding targets **250** seated on the substrate **230**. The substrate may be fixed to the top surface of the lower mold **220**. This is described in more detail below.

(28) The cavity **260** may be a space defined between the upper mold **210** and the lower mold **220**. The cavity **260** may be a space in which a molding material moves and is disposed on the plurality of molding targets **250**. According to some embodiments, the molding material is fluid when the temperature of the molding material increases, and thus, the molding material may be a mold film that fully fills the cavity **260** formed by the upper mold **210** and the lower mold **220** and is cured to cover the plurality of molding targets **250**.

(29) The port **310** may provide a passage communicating with the cavity **260** formed between the upper chamber **110** and the lower chamber **120**. The port **310** may provide a flow path extending in the first direction (x direction) and the third direction (z direction). The plunger **312** may be located inside the port **310**, and may move up and down inside the port **310**. For example, the plunger **312** may elevate in the third direction (z direction) inside the port **310**. The plunger **312** may move up and down so that the molding material provided in the port **310** may flow. The plunger **312** may pressurize the molding material so that the molding material inside the port **310** is supplied to the

cavity **260** through movement in the third direction (z direction) and first direction (x direction), and may perform molding on the plurality of molding targets **250** by using the molding material filled in the cavity **260**.

(30) Referring to FIG. **1** together, the molding material supplier **410** may be configured to supply a molding material **262** to the port **310**. The molding material **262** may include epoxy mold compound (EMC), for example. However, the embodiments are not limited thereto. The molding material **262** may be, for example, a thermoplastic resin or a thermosetting resin. The resin, for example, may be made of any one of a granular resin, a powdery resin, a liquid resin, a plate-shaped resin, a sheet-shaped resin, a film-shaped resin, and a paste-shaped resin, or a combination thereof. In addition, the resin, for example, may be made of any one of a transparent resin, a translucent resin, and an opaque resin, or a combination thereof. The molding material **262** may be disposed in the port **310** in a solid state and may be liquefied when the temperature of the molding material **262** increases to be fluid. When the molding material **262** is fluid, the molding material **262** may be provided on the plurality of molding targets **250** by the plunger **312**, and then cured so that the plurality of molding targets **250** may be molded.

(31) The plunger **312** may be configured to pressurize the molding material **262** inside the port **310**. Specifically, the plunger **312** may move up and down within the port **310**. The plunger **312** may move upward to push the molding material **262** into the cavity **260**. The plunger **312** may have almost the same size as that of the inner wall of the port **310**, but a gap may be between the outer surface of the plunger **312** and the inner wall of the port **310**.

(32) Because air in the cavity **260** may leak through the gap, the plunger **312** may include a first ring **314**. The first ring **314** may be a ring made of a Teflon material, for example. The first ring **314** may completely block a space between the outer surface of the plunger **312** and the inner wall of the port **310** to prevent the air inside the cavity **260** from leaking.

(33) Similar to the first ring **314**, a second ring **316** may also completely block the space between the outer surface of the plunger **312** and the inner wall of the port **310** to prevent the air inside the cavity **260** from leaking. The first ring **314** and the second ring **316** may maintain the vacuum of the cavity **260** by sealing between the port **310** and the plunger **312**. However, when the plunger **312** repeatedly moves up and down, a phenomenon may occur where the first ring **314** or the second ring **316** is worn, and undesired air flows into the cavity **260** through the gap between the plunger **312** and the port **310**.

(34) The controller **700** may control the plunger actuator **360** and the mold actuator **630**. The controller **700** may be implemented in hardware, firmware, software, or any combination thereof. For example, the controller **700** may be a computer device, such as a workstation computer, a desktop computer, a laptop computer, or a tablet computer. For example, the controller **700** may include a memory device, such as read only memory (ROM) and random access memory (RAM), and a processor configured to perform certain operations and algorithms, for example, a microprocessor, a central processing unit (CPU), a graphics processing unit (GPU), etc. The controller **700** may control the actions of the various devices described herein, such as the timing for exerting pressure, an amount of pressure, etc.

(35) The plunger actuator **360** may be configured to apply a first pressure to the plunger **312** such that the molding material **262** provided in the port **310** is supplied to the cavity **260**. For example, the plunger actuator **360** may include a motor, a hydraulic cylinder, a pneumatic cylinder, etc. For example, the plunger actuator **360** may include a motor, and may control a pressure condition applied to the plunger **312** by adjusting a torque value of the motor. Alternatively, the plunger actuator **360** may control the pressure condition applied to the plunger **312** by inputting air into the port **310**. However, the embodiments are not necessarily limited to the above. A detailed description of a process in which the plunger actuator **360** applies the first pressure to the plunger **312** so that the molding material **262** is supplied to the cavity **260** is given below.

(36) In addition, the controller **700** may adjust the rising speed of the plunger **312** in the port **310**.

For example, the controller **700** may instantaneously cause high pressure to be applied to the plunger **312** in order to increase the flow rate of the molding material **262** in a specific part of the cavity **260**. To the contrary, in order to reduce the flow rate of the molding material **262** in a specific part of the cavity **260**, the controller **700** may instantaneously cause low pressure to be applied to the plunger **312**. It should be noted that one plunger and plunger actuator is described above, but the controller **700** may control the plurality of ports **310**, each including a plunger and plunger actuator as described above.

(37) The mold actuator **630** may be configured to apply a second pressure to the upper mold **210** to pressurize the molding material **262** in the cavity **260**. For example, the mold actuator **630** may be connected to a driving motor **620** connected to a shaft **610** to control a pressure condition applied to the upper mold **210** by adjusting a torque value of the driving motor **620**, which thereby controls a movement pressure applied by the shaft **610** to the upper mold **210**. However, the embodiments are not necessarily limited to the above. A detailed description of a process in which the mold actuator **630** applies the second pressure to the upper mold **210** to mold the molding target **250** is given below.

(38) The molding material supplier **410** may be connected to the port **310**. The molding material supplier **410** may supply the molding material **262** to the port **310** having a pipe shape. The molding material supplier **410** may include a molding material supply line **412**, a nozzle **414**, and a fluid supply pump **416**. The fluid supply pump **416** may supply the molding material **262** in a fluid state to the molding material supply line **412**. The nozzle **414** may be configured to adjust the flow rate of the molding material **262** in the fluid state supplied by the fluid supply pump **416**.

(39) The gas adjustor **340** may be disposed on the sidewall of the chamber **100** to face the port **310**. The gas adjustor **340** may include a vent hole **341**, a sealing member **342**, a gas pipe **343**, a sensor **344**, a gas nozzle **345**, and a gas pump **346**. The sealing member **342** may be between the upper chamber **110** and the lower chamber **120**. The sealing member **342** may be disposed where the upper chamber **110** and the lower chamber **120** are engaged with each other. The sealing member **342** may perform sealing on a part where the lower chamber **120** and the upper chamber **110** are engaged with each other, except for the vent hole **341**. The volume of the sealing member **342** may increase or decrease according to a force applied thereto. The sealing member **342** may be configured to expand or contract according to the force applied thereto. Accordingly, the sealing member **342** may efficiently perform sealing and venting. The sealing member **342** may be, for example, a flexible rubber or plastic material that can expand and contract while maintaining a seal. For example the sealing member **342** may have an accordion-shaped configuration. Also, though only one vent hole **341** is shown, a plurality of vent holes **341** may be formed, and may be connected to a plurality of respective gas pipes **343**. In this case, a plurality of sensors **344**, gas nozzles **345**, and/or gas pumps **346** may also be used.

(40) The vent hole **341** may be formed adjacent to the sealing member **342** (e.g., it may be a hole in the sealing member **342**). The vent hole **341** may be disposed between the upper chamber **110** and the lower chamber **120**, where the upper chamber **110** and the lower chamber **120** are engaged with each other. The vent hole **341** may be opposite the port **310** within the chamber **100**. The air in the cavity **260** may be removed through the vent hole **341**. For example, the vent hole **341** may be connected to the gas pump **346** to discharge the air inside the cavity **260** to the outside. The gas pipe **343** may serve as a connection passage between the vent hole **341** and the gas pump **346**. The gas nozzle **345** may be configured to adjust the flow rate of introduced or discharged gas through the gas pump **346**.

(41) The sensor **344** may be connected to the vent hole **341**. The sensor **344** may detect whether the air in the cavity **260** leaks by sensing the pressure of the vent hole **341**. Accordingly, the sensor **344** may maintain the vacuum of the cavity **260**.

(42) FIG. 4 is a cross-sectional view illustrating the molding apparatus **20** for a semiconductor package shown in FIG. 2.

(43) Specifically, the molding apparatus **20** for a semiconductor package may be substantially the same as the molding apparatus **10** for a semiconductor package of FIGS. **1** and **3** except that the molding apparatus **20** for the semiconductor package includes the substrate **240** instead of the substrate **230** and further includes different arrangements of first ports **310** and includes a second port **320** and a second molding material supplier **420**. The same reference numerals as in FIGS. **1** and **3** denote the same members. In FIG. **4**, the same descriptions as those of FIGS. **1** to **3** are briefly given or omitted.

(44) The molding apparatus **20** of a semiconductor package according to an embodiment includes the chamber **100**, the upper mold **210**, the lower mold **220**, the first port **310**, the first plunger **312**, the second port **320**, a second plunger **322**, the plunger actuator **360**, the molding material supplier **410**, the mold actuator **630**, and the gas adjustor **340**. The chamber **100** may be a cylindrical chamber, for example, that matches the shape of the substrate **240**.

(45) The lower mold **220** may be configured to fix and hold the substrate **240** including the plurality of molding targets **250**. Unlike the substrate **230** of FIG. **3**, the substrate **240** may be in the form of a disk having a circular cross-section. The lower mold **220** may have sidewalls, notches, or other devices to hold the substrate **240** in place. The substrate **240** may be a semiconductor wafer, for example. The cavity **260** may be formed between the lower mold **220** and the upper mold **210** with the molding target **250** seated on the substrate **240** when the upper chamber **110** is coupled to the lower chamber **120**. This is described in more detail below.

(46) The second port **320** may be formed on the upper portion of the chamber **100** (e.g., on a ceiling, or top surface, of the chamber) to provide a passage communicating with the cavity **260**. The second port **320** may be aligned in the third direction (z direction) at the center of the circular cross-section of the substrate **240**. The second port **320** may discharge the molding material **262** toward the substrate **240**. The second port **320** may provide the passage extending in the third direction (z direction). The second plunger **322** may be positioned inside the second port **320**, and the second plunger **322** may move up and down inside the second port **320**. As the second plunger **322** moves up and down, a molding material previously disposed on the second plunger **322** inside the second port **320** may be filled into the cavity **260** so that molding may be performed on the plurality of molding targets **250**.

(47) The first port **310** may be formed between the upper chamber **110** and the lower chamber **120**, and thus may be formed in a sidewall of the chamber **100**, to provide a passage communicating with the cavity **260**. The first port **310** may provide the passage extending in the first direction (x direction) and the third direction (z direction). The first plunger **312** may be positioned inside the first port **310**, and the first plunger **312** may move up and down inside the first port **310**. The first plunger **312** may supply the molding material inside the first port **310** to the cavity **260** by moving up and down, and may perform molding on the plurality of molding targets **250** by using the molding material filled in the cavity **260**.

(48) The controller **700** may control the plunger actuator **360** and the mold actuator **630**. The plunger actuator **360** may be configured to cause a first pressure to be applied to the first plunger **312** and the second plunger **322** so that the molding material **262** provided in the first port **310** and the second port **320** is supplied to the cavity **260**. For example, the plunger actuator **360** may be connected to a motor to control a pressure condition applied to the first plunger **312** and the second plunger **322** by adjusting a torque value of the motor. Alternatively, the plunger actuator **360** may control the pressure condition applied to the first plunger **312** and the second plunger **322** by inputting air into the first port **310** and the second port **320**. Accordingly, the plunger actuator **360** may be connected to both the first port **310** and the second port **320**. However, the embodiments are not necessarily limited to the above. A detailed description of a process in which the plunger actuator **360** applies the first pressure to the first plunger **312** and the second plunger **322** so that the molding material **262** is supplied to the cavity **260** is given below.

(49) The plunger **322** may be configured to pressurize the molding material inside the second port

320. Specifically, the plunger **322** may move up and down within the second port **320**. The plunger **322** may move downward to push the molding material into the cavity **260**. The plunger **322** may have almost the same size as that of the inner wall of the second port **320**, but a gap may be between the outer surface of the plunger **322** and the inner wall of the second port **320**.

(50) The plunger actuator **360** may perform the steps described above in connection with the first plunger **312**, and may also control the second plunger **322** in a similar manner. Because air in the cavity **260** may leak through the gap between the second plunger **322** and the inner wall of the second port **320**, the second plunger **322** may include a first ring **324**. The first ring **324** may be a ring made of a Teflon material, for example. The first ring **324** may completely block a space between the outer surface of the second plunger **322** and the inner wall of the second port **320** to prevent the air inside the cavity **260** from leaking.

(51) Similar to the first ring **324**, a second ring **326** may also completely block the space between the outer surface of the second plunger **322** and the inner wall of the second port **320** to prevent the air inside the cavity **260** from leaking. The first ring **324** and the second ring **326** may maintain the vacuum of the cavity **260** by sealing between the second port **320** and the second plunger **322**. However, when the second plunger **322** repeatedly moves up and down, a phenomenon may occur where the first ring **324** or the second ring **326** is worn, and undesired air flows into the cavity **260** through the gap between the second plunger **322** and the second port **320**.

(52) FIG. 5 is a cross-sectional view illustrating a molding apparatus **30** for a semiconductor package according to another embodiment.

(53) Specifically, the molding apparatus **30** for a semiconductor package may be substantially the same as the molding apparatus **10** of FIGS. 2 and 4 except that the molding apparatus **30** of FIG. 5 includes a second gas adjustor **350** (and may include a plurality of gas adjustors **350** arranged around the circumference of the chamber **100**), and does not include the ports **310** along the sidewalls of the chamber **100**. The same reference numerals as in FIGS. 2 and 4 denote the same members. In FIG. 5, the same descriptions as those of FIGS. 2 to 4 are briefly given or omitted.

(54) The first gas adjustor **340** and the second gas adjustor **350** may be disposed on the sidewalls of the chamber **100**. The first gas adjustor **340** may include a first vent hole **341**, a first sealing member **342**, a first gas pipe **343**, a first sensor **344**, a first gas nozzle **345**, and a first gas pump **346**. The second gas adjustor **350** may include a second vent hole **351**, a second sealing member **352**, a second gas pipe **343**, a second sensor **354**, a second gas nozzle **355**, and a second gas pump **356**. The second gas adjustor **350** may be configured to perform the same function as the first gas adjustor **340**.

(55) According to an embodiment, the molding apparatus **30** for a semiconductor package may include only the second port **320** vertically spaced apart from the center of the circular cross-section of a substrate, differently from the molding apparatus **20** of the semiconductor package shown in FIG. 4. That is, the molding apparatus **30** of a semiconductor package may not include the first ports **310** (see FIG. 4) formed on the inner sidewall of a chamber.

(56) FIGS. 6A to 6D are cross-sectional views illustrating an operation process of the molding apparatus **10** of the semiconductor package shown in FIG. 1.

(57) Referring to FIGS. 6A and 6B, the molding material **262** may be supplied from the molding material supplier **410** and accumulated in the port **310**. After the molding material **262** is supplied to the port **310**, the plunger actuator **360** may apply a first pressure to the plunger **312**. The first pressure may be a pressure applied to the plunger **312** to allow the plunger **312** to move along the inner sidewall of the port **310**. When the first pressure increases, the plunger **312** may more quickly move along the inner sidewall of the port **310**, and the molding material **262** may be supplied to the cavity **260** more quickly.

(58) Although not shown in the drawings, an empty space may be between the molding target **250** and the substrate **230**. The molding material **262** may be supplied through the empty space. The empty space may be formed, for example, between solder balls or bumps connecting the molding

target **250** to the substrate **230**. When the molding material **262** is supplied to the cavity **260**, the flow of a fluid in a direction without an obstacle (e.g., above the molding targets **250**) may be relatively fast, and the flow of the fluid in a direction with the obstacle (e.g., below the molding targets **250**) may be relatively slow. Therefore, there is a possibility that a void may be generated in the space between the molding target **250** and the substrate **230** due to a difference in the speed of the molding material **262** for each region. In some embodiments, the molding material **262** may be supplied to the cavity **260** without generating a void by maintaining the first pressure applied to the plunger **312** to move the plunger **312** along the inner sidewall of the port **310** to be equal to or less than 5 MPa.

(59) The vent hole **341** may be connected to the gas pump **346** to discharge air inside the cavity **260** to the outside. When the molding material **262** is supplied to the cavity **260**, the vent hole **341** may discharge the air inside the cavity **260** to the outside to make the cavity **260** be in a vacuum state. The cavity **260** in the vacuum state may prevent generation of a void. To this end, the gas pump **346** may suck air through the vent hole **341**. Specifically, the gas pump **346** may suck air through the vent hole **341** before the mold actuator **630** applies the first pressure to the upper mold **210**. The gas pump **346** may also suck air through the vent hole **341** before the plunger actuator **360** applies the first pressure to the plunger **312**. As the gas pump **346** sucks air through the vent hole **341**, the cavity **260** may be in the vacuum state. The vacuum state referred to herein refers to a state where the pressure of the cavity **260** is equal to or less than 1 Torr. The gas pump **346** may suck air until the pressure of the cavity **260** is equal to or less than 1 Torr.

(60) Referring to FIGS. **6C** and **6D**, the mold actuator **630** may operate after the molding material **262** is sufficiently supplied to the cavity **260** to cover the plurality of molding targets **250**. The mold actuator **630** may be configured to apply a second pressure to the upper mold **210** to pressurize the molding material **262** in the cavity **260**. Specifically, the mold actuator **630** may apply the second pressure to the upper mold **210** after the molding material **262** molds (e.g., covers) the molding target **250** arranged at the farthest distance from the port **310**. In one embodiment, this may be before the molding material **262** completely covers an entire top surface of the substrate or completely fills the cavity **260**. For example, a sensor may detect when this occurs. In this regard, the second pressure may be higher than the first pressure in order for the molding material **262** to sufficiently cover and mold the molding targets **250**.

(61) The plunger actuator **360** may reduce the first pressure applied to the plunger **312** after the mold actuator **630** applies the second pressure to the upper mold **210** and pressurizes the molding material **262** in the cavity **260**. For example, in some embodiments, the first pressure applied to the plunger **312** may be applied at the same time as the second pressure applied to the upper mold **210**, after which the first pressure applied to the plunger **312** is reduced while the second pressure is continued to be applied to the upper mold **210**. Therefore, while molding material **262** is still being supplied to the cavity **260**, the second pressure may be initially applied by the mold actuator **630**, and thereafter, while the second pressure continues to be applied by the mold actuator **630**, the first pressure applied by the plunger actuator **360** may be decreased.

(62) The vent hole **341** may be connected to the gas pump **346** to have external air introduced into the cavity **270**. To this end, the gas pump **346** may supply air to the cavity **270** through the vent hole **341**. The gas pump **346** may make the pressure of the cavity **270** be equal to atmospheric pressure by supplying air to the cavity **270**. Atmospheric pressure here refers to a state where pressure is equal to or greater than 760 torr. Accordingly, the gas pump **346** may supply air until the pressure of the cavity **270** is equal to or greater than 760 torr. According to an embodiment, the gas pump **346** may supply air through the vent hole **341** after the mold actuator **630** applies the second pressure to the upper mold **210**.

(63) According to an embodiment, the molding apparatus **10** of the semiconductor package may perform a molding process primarily by supplying the molding material **262** to the cavity **260** through the port **310**, and then may perform a molding process secondarily by driving the upper

mold **210** and pressurizing the molding material **262**. The molding apparatus **10** of a semiconductor package may continuously perform a primary molding process and a secondary molding process, thereby preventing the generation of a void. Specifically, the first pressure applied to the plunger **312** to move the plunger **312** along the inner sidewall of the port **310** may remain to be equal to or less than 5 MPa, and thus, the generation of a void in the molding material **262** may be prevented. Subsequently, at first while the first pressure is still applied to the plunger **312**, and then after the first pressure applied to the plunger **312** is reduced and released, the mold actuator **630** may minimize the generation of a void by applying the second pressure to the upper mold **210** and pressurizing the molding material **262** in the cavity **260**.

(64) FIGS. 7A to 7D are cross-sectional views illustrating an operation process of the molding apparatus of the semiconductor package shown in FIG. 2.

(65) Specifically, the molding apparatus **20** of a semiconductor package may be substantially the same as the molding apparatus **10** of a semiconductor package shown in FIGS. 6A to 6D except that the molding apparatus **20** of FIGS. 7A-7D includes the substrate **240** instead of the substrate **230**, and further includes the second port **320** and the second molding material supplier **420**. The same reference numerals as in FIGS. 6A to 6D denote the same members. In FIGS. 7A to 7D, the same descriptions as in FIGS. 6A to 6D are briefly given or omitted.

(66) Referring to FIGS. 7A and 7B, the molding material **262** may be supplied from the first molding material supplier **410** and the second molding material supplier **420** and respectively accumulated in the second port **320** formed in the upper portion of a chamber and the first port **310** formed in the side portion of the chamber. After the molding material **262** is supplied to the second port **320** and the first port **310**, the plunger actuator **360** may apply a first pressure to the first plunger **312** and the second plunger **322**. The first pressure may be a pressure applied to respectively move the first plunger **312** and the second plunger **322** along the inner sidewalls of the second port **320** and the first port **310**. When the first pressure increases, the first plunger **312** and the second plunger **322** may more quickly move along the inner sidewalls of the second port **320** and the first port **310**, respectively, and the molding material **262** may also be supplied to the cavity **260** more quickly.

(67) Referring to FIGS. 7C and 7D, after the molding material **262** is sufficiently supplied to the cavity **260**, and in some embodiments, while the molding material **262** is still being supplied to the cavity **260**, the mold actuator **630** may operate. The mold actuator **630** may be configured to apply a second pressure to the upper mold **210** and pressurize the molding material **262** in the cavity **260**. Specifically, the mold actuator **630** may mold the molding target **250** after the molding material **262** is arranged at the farthest distance from the center of the substrate **240**, and then apply the second pressure to the upper mold **210**. In this regard, the second pressure may be higher than the first pressure in order for the molding material **262** to sufficiently mold the molding target **250**.

(68) The plunger actuator **360** may reduce the first pressure applied to the first plunger **312** and/or the second plunger **322** after the mold actuator **630** has already begun to apply the second pressure to the upper mold **210** to pressurize the molding material **262** in the cavity **260**.

(69) The vent hole **341** formed in the sidewall of the chamber may be connected to the gas pump **346** and have external air introduced into the cavity **270**, now formed above the upper mold **210**. To this end, the gas pump **346** may supply air to the cavity **260** through the vent hole **341**. According to an embodiment, the gas pump **346** may supply air into the cavity **260** through the vent hole **341** after the mold actuator **630** applies the second pressure to the upper mold **210**.

(70) According to an embodiment, the molding apparatus **20** of the semiconductor package may perform a molding process primarily by supplying the molding material **262** to the cavity **260** through the second port **320** and the first port **310** and then may perform a molding process secondarily by driving the upper mold **210** and pressurizing the molding material **262**. In this regard, the second port **320** is vertically spaced apart from the center of a circular cross-section of a substrate, thereby uniformly supplying the molding material **262** onto the substrate. According to

an embodiment, the molding apparatus **20** of a semiconductor package may continuously, and for a particular time period simultaneously, perform a primary molding process and a secondary molding process, thereby preventing the generation of a void. Specifically, the first pressure applied to move the plunger **312** along the inner sidewall of the port **310** may remain to be equal to or less than 5 MPa, and thus, the generation of a void may be prevented, and the molding material **262** may be supplied. Subsequently, and with some overlap with the first pressure, the mold actuator **630** may minimize the generation of a void by applying the second pressure to the upper mold **210** and pressurizing the molding material **262** in the cavity **260**.

(71) FIG. **8** is a flow chart diagram showing an example method **800** of manufacturing a semiconductor device using an example molding apparatus, according to an embodiment. As can be seen in FIG. **8**, in step **801**, a substrate including a plurality of molding targets arranged in an array pattern is provided. The substrate may be, for example, a package substrate for a semiconductor package, which may be a package-on-package device. The molding targets may be, for example semiconductor chips, or semiconductor packages, including conductive bumps or balls formed on a bottom surface and connected to the substrate. The substrate may be formed of an insulating material, or a semiconductor material.

(72) In step **802**, the substrate including the molding targets is disposed on a lower mold of a chamber, such as lower mold **220** depicted in the previous figures. In step **803**, molding material may be introduced to a cavity in the chamber, for example, as depicted and described in FIGS. **6A** and **6B**, or **7A** and **7B**, by applying pressure to a plunger **312** and/or **322**. In step **804**, a pressure may be applied to the molding material using pressure applied between the lower mold **220** and the upper mold **210** to compact and fill the mold to cover the plurality of molding targets, including spaces between each of the plurality of molding targets and the substrate. The pressure applied in step **804** may be applied at the same time as introducing molding material to the cavity, e.g., at the end portion of step **803**. Then, in step **805**, the molding material may be hardened. For example, in some embodiments, a temperature of the molding material may be adjusted to cure the molding material.

(73) Next, after the molding material is completely hardened, in step **806**, the substrate may be removed from the chamber, and may be placed in a chamber that performs further processing. For example, the substrate may be moved to a chamber where dicing of the substrate is performed, to singulate semiconductor devices (e.g., packages) from each other, resulting in a plurality of separated, completed semiconductor devices.

(74) While aspects of the inventive concept has been particularly shown and described with reference to embodiments thereof, it will be understood that various changes in form and details may be made therein without departing from the spirit and scope of the following claims.

Claims

1. A molding apparatus for a semiconductor package, the molding apparatus comprising: a chamber comprising a lower mold configured to hold a substrate comprising a plurality of molding targets, an upper mold configured to move up and down with respect to the lower mold and define a cavity between the upper mold and the lower mold; and a port configured to provide a passage communicating with the cavity; a molding material supplier configured to supply a molding material to the port; a plunger configured to pressurize the molding material inside the port; a plunger actuator configured to apply a first pressure to the plunger such that the molding material provided in the port is supplied to the cavity; a mold actuator configured to control actuation of the upper mold; wherein the plunger actuator is configured to supply the molding material to the cavity by applying the first pressure to the plunger, wherein the mold actuator is configured to pressurize the molding material in the cavity by applying a second pressure to the upper mold; and a controller configured to control the plunger actuator to reduce the first pressure applied to the

- plunger after the mold actuator begins applying the second pressure to the upper mold.
2. The molding apparatus of claim 1, wherein: the port is disposed on a sidewall of the chamber in a first direction, and the port is configured to discharge the molding material in a second direction perpendicular to the first direction.
 3. The molding apparatus of claim 1, wherein: the controller is configured to control the mold actuator to apply the second pressure to the upper mold after the molding material covers the plurality of molding targets arranged at a farthest distance from the port.
 4. The molding apparatus of claim 3, wherein: the controller is configured to control the mold actuator to apply the second pressure to the upper mold before the entire top surface of the substrate is covered with the molding material.
 5. The molding apparatus of claim 1, wherein the first pressure is equal to or less than 5 MPa.
 6. The molding apparatus of claim 1, wherein the second pressure is higher than the first pressure.
 7. The molding apparatus of claim 1, further comprising: a vent hole formed in a sidewall of the chamber, so that the vent hole is opposite the port; and a gas pump configured to suck or discharge air through the vent hole.
 8. The molding apparatus of claim 7, wherein: the controller is configured to control the gas pump to suck the air through the vent hole before the plunger actuator applies the first pressure to the plunger.
 9. The molding apparatus of claim 7, wherein: the controller is configured to control the gas pump to supply the air through the vent hole after the mold actuator applies the second pressure to the upper mold.
 10. A molding apparatus of a semiconductor package, the molding apparatus comprising: a cylindrical chamber comprising a lower mold configured to hold a substrate comprising a plurality of molding targets, and an upper mold configured to move up and down with respect to the lower mold and define a cavity between the upper mold and the lower mold; a first port formed on an inner sidewall of the chamber and configured to provide a passage communicating with the cavity; a second port formed in a top portion of the chamber and configured to provide a passage communicating with the cavity; a molding material supplier configured to supply a molding material to the second port; a plunger configured to pressurize the molding material inside the second port; a plunger actuator configured to apply a first pressure to the plunger such that the molding material provided in the second port is supplied to the cavity; and a mold actuator configured to control actuation of the upper mold, wherein the mold actuator is configured to pressurize the molding material in the cavity by applying a second pressure to the upper mold.
 11. The molding apparatus of claim 10, wherein: the second port is aligned at a center of the substrate in a vertical direction, and the second port is configured to discharge the molding material toward the substrate.
 12. The molding apparatus of claim 10, further comprising: a controller configured to control the mold actuator to apply the second pressure to the upper mold after the molding material covers the plurality of molding targets arranged at a farthest distance from a center of the substrate.
 13. The molding apparatus of claim 10, wherein: the upper mold includes a hole to which the second port is coupled in a center of a circular cross-section.
 14. The molding apparatus of claim 13, wherein: the second port extends in a vertical direction through the hole inside the upper mold.
 15. The molding apparatus of claim 10, wherein: the first pressure is equal to or less than 5 MPa, and the second pressure is higher than the first pressure.
 16. The molding apparatus of claim 10, wherein: the second port is configured to discharge the molding material toward a center of the substrate.
 17. The molding apparatus of claim 10, further comprising: a vent hole formed in a sidewall of the chamber to face the first port; and a gas pump configured to suck or discharge air through the vent hole.

18. The molding apparatus of claim 17, further comprising: a controller configured to control the gas pump to suck the air through the vent hole before the plunger actuator applies the first pressure to the plunger, and to supply the air through the vent hole after the mold actuator applies the second pressure to the upper mold.

19. A molding apparatus of a semiconductor package, the molding apparatus comprising: a chamber comprising a lower mold configured to hold a substrate comprising a plurality of molding targets, and an upper mold configured to raise and lower with respect to the lower mold and define a cavity between the upper mold and the lower mold; a port formed on a sidewall of the chamber in a first direction, configured to provide a passage communicating with the cavity, and discharge a molding material to the cavity in a second direction perpendicular to the first direction; a molding material supplier configured to supply a molding material to the port; a plunger configured to pressurize the molding material inside the port; a plunger actuator configured to apply a first pressure to the plunger such that the molding material provided in the port is supplied to the cavity; and a mold actuator configured to control actuation of the upper mold; wherein: the plunger actuator is configured to supply the molding material to the cavity by applying a first pressure equal to or less than 5 MPa to the plunger, the mold actuator is configured to pressurize the molding material in the cavity by applying a second pressure higher than the first pressure to the upper mold, and further comprising: a controller configured to: control the mold actuator to apply the first pressure to the plunger and apply the second pressure to the upper mold after the molding material molds the plurality of molding targets arranged at a farthest distance from the port, and control the plunger actuator to reduce the first pressure applied to the plunger after the mold actuator begins applying the second pressure to the upper mold.

20. The molding apparatus of claim 19, further comprising: a vent hole formed in a sidewall of the chamber to face the port; and a gas pump configured to suck or discharge air through the vent hole wherein the controller is further configured to control the gas pump to suck the air through the vent hole before the plunger actuator applies the first pressure to the plunger, and to supply the air through the vent hole after the mold actuator applies the second pressure to the upper mold.
