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(54) **SEMICONDUCTOR DEVICE MANUFACTURING METHOD AND MANUFACTURING APPARATUS**

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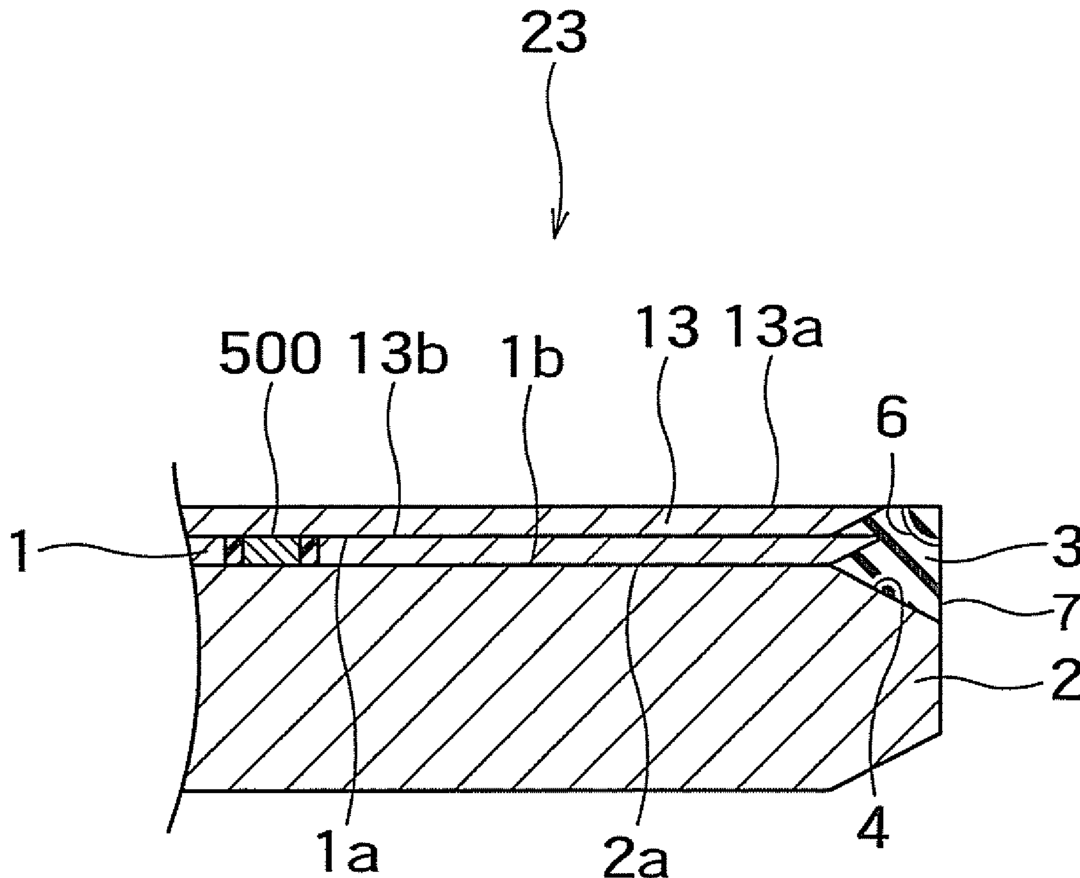
USPC **438/459**; 118/76; 118/75; 118/641

(57) **ABSTRACT**

According to one embodiment, a semiconductor device manufacturing method includes: bonding a first wafer and a second wafer to each other, to form a stack; rubbing a film attached with a fill material in a thin-film shape into a gap located between a bevel of the first wafer and a bevel of the second wafer, to fill the gap with the fill material; and thinning the first wafer.



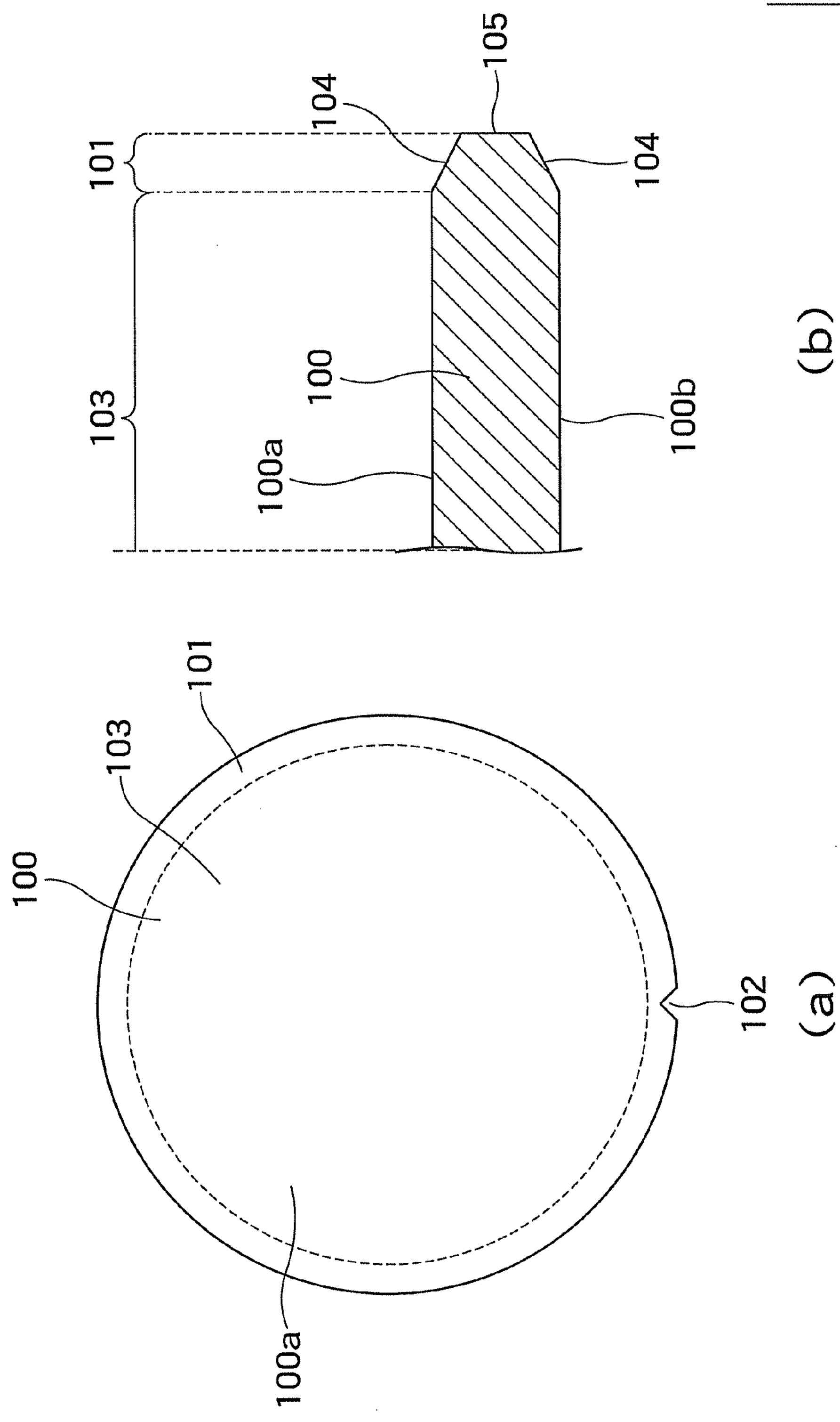


FIG. 1

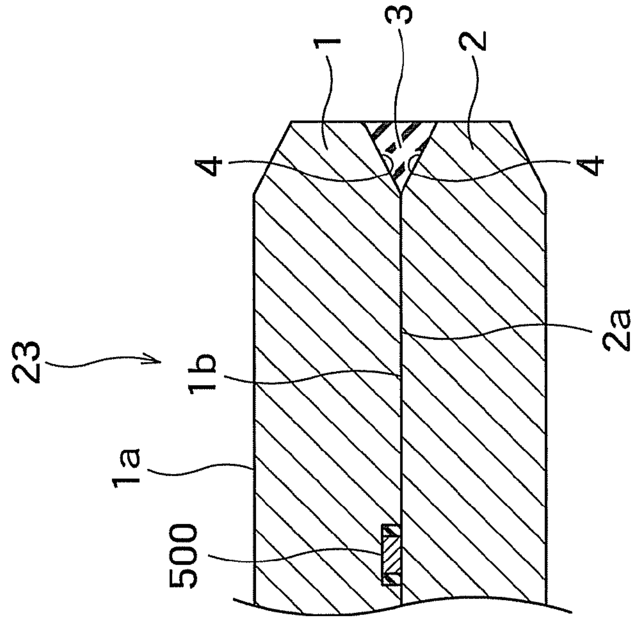


FIG. 2B

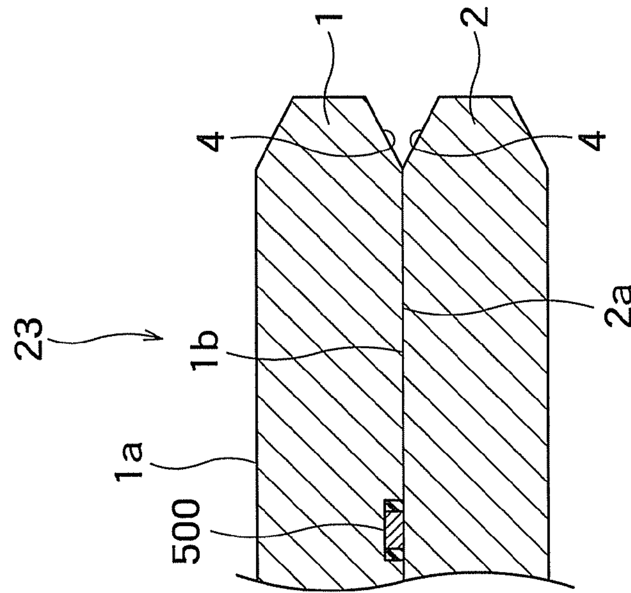


FIG. 2A

FIG. 2D

FIG. 2C

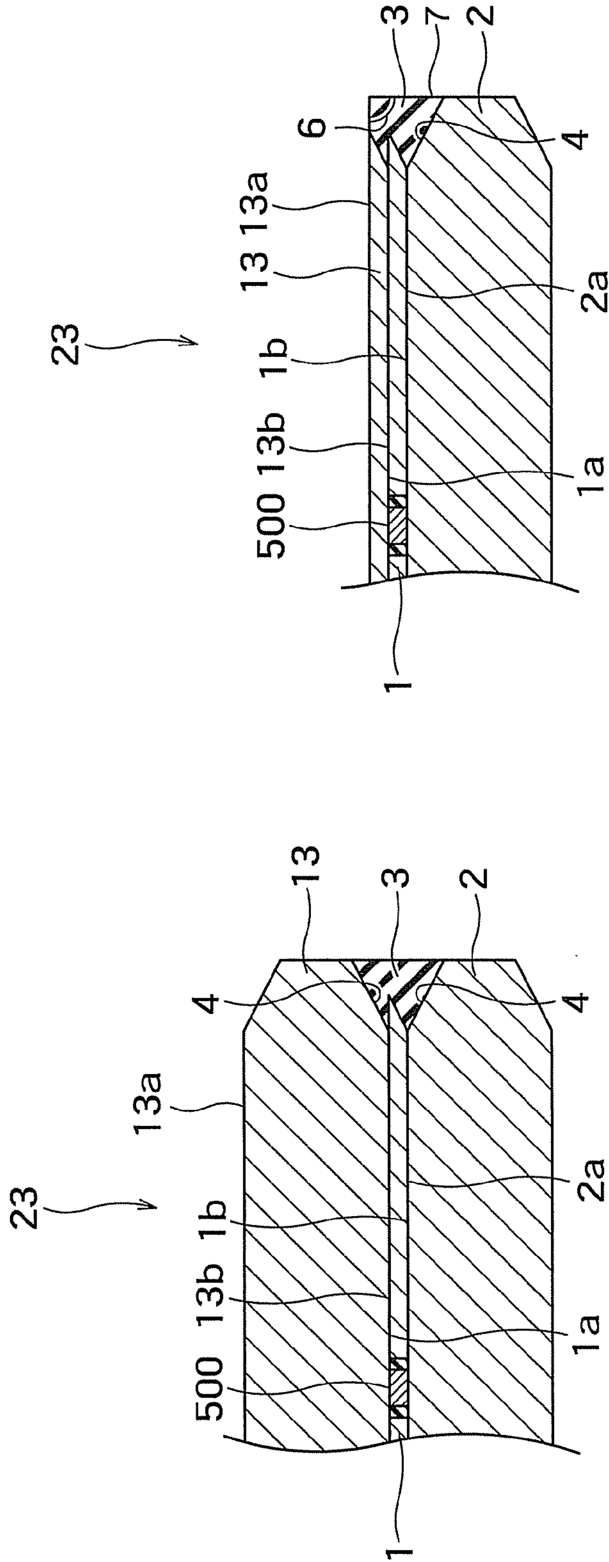


FIG. 2F

FIG. 2E

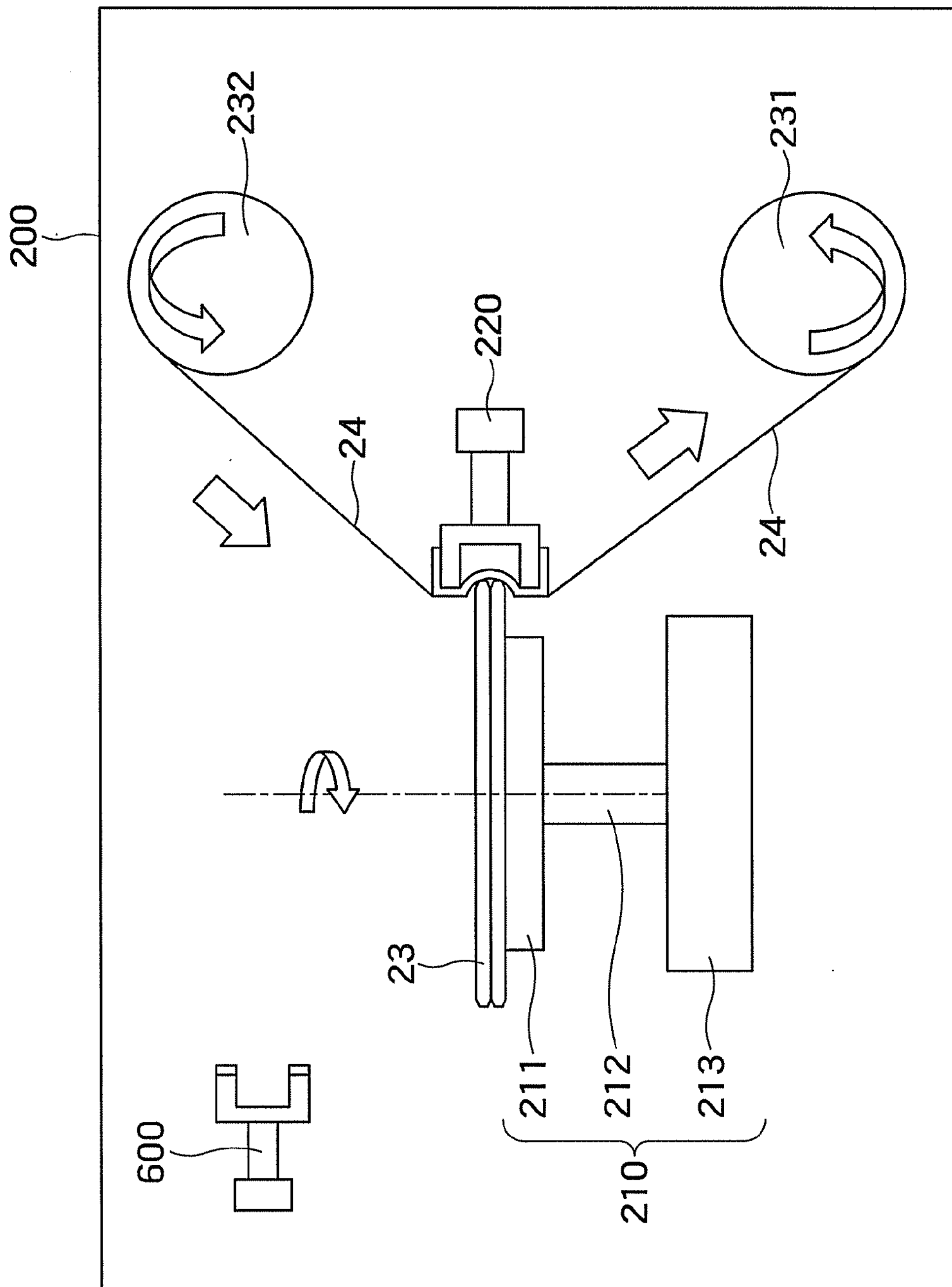


FIG. 3

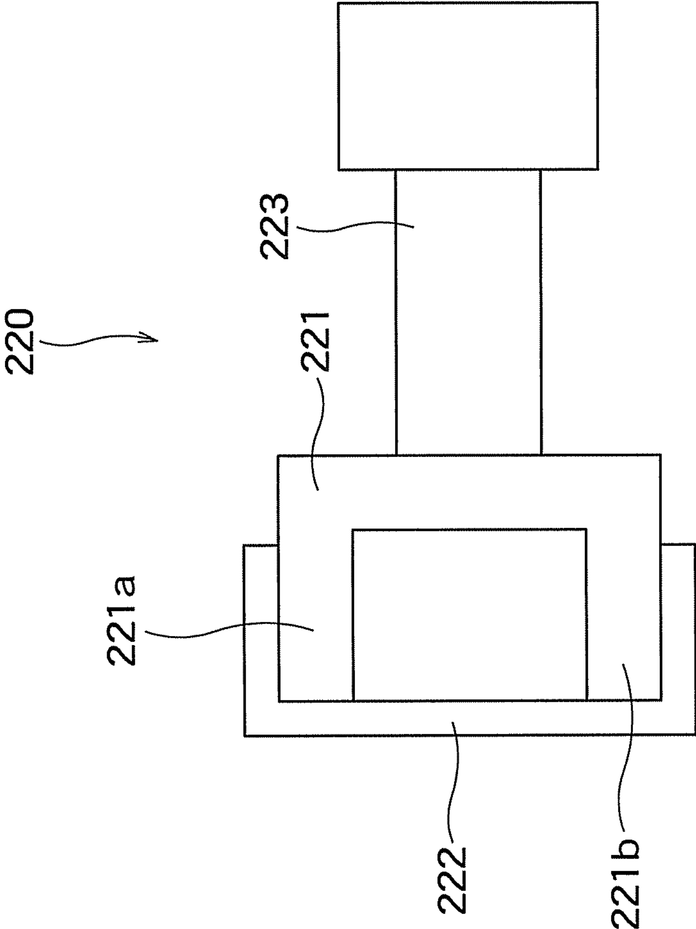


FIG. 4

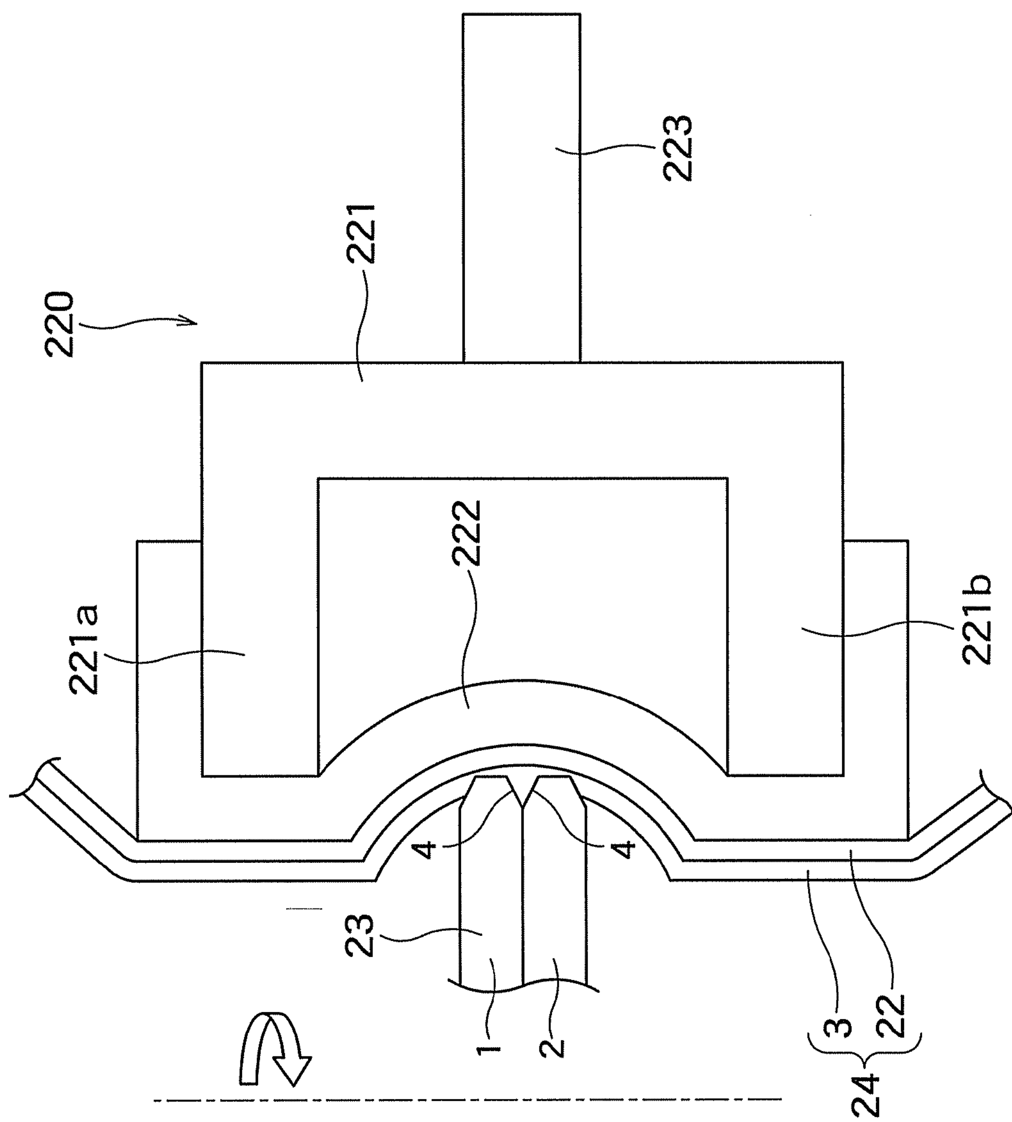


FIG. 5

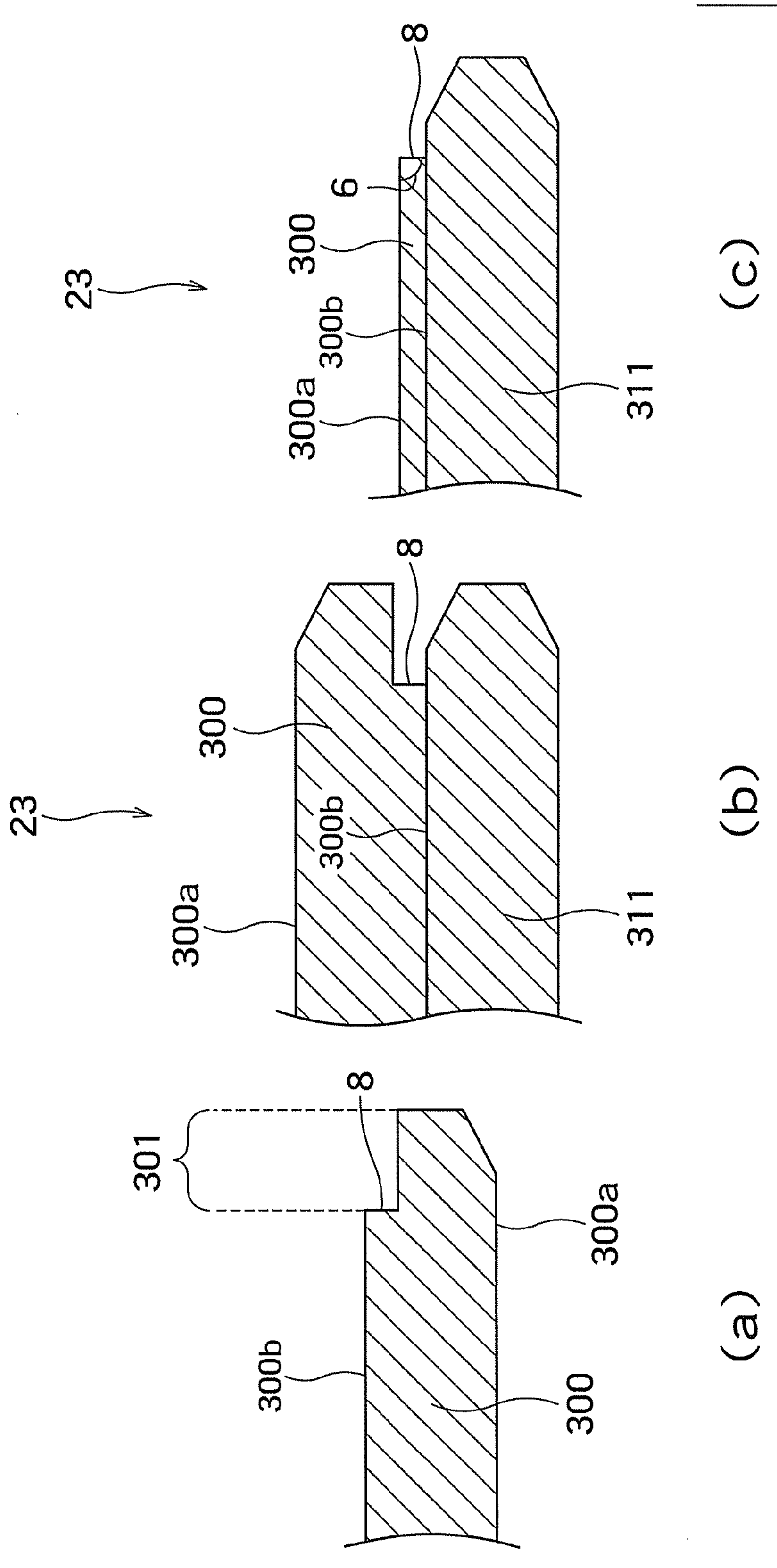


FIG. 6

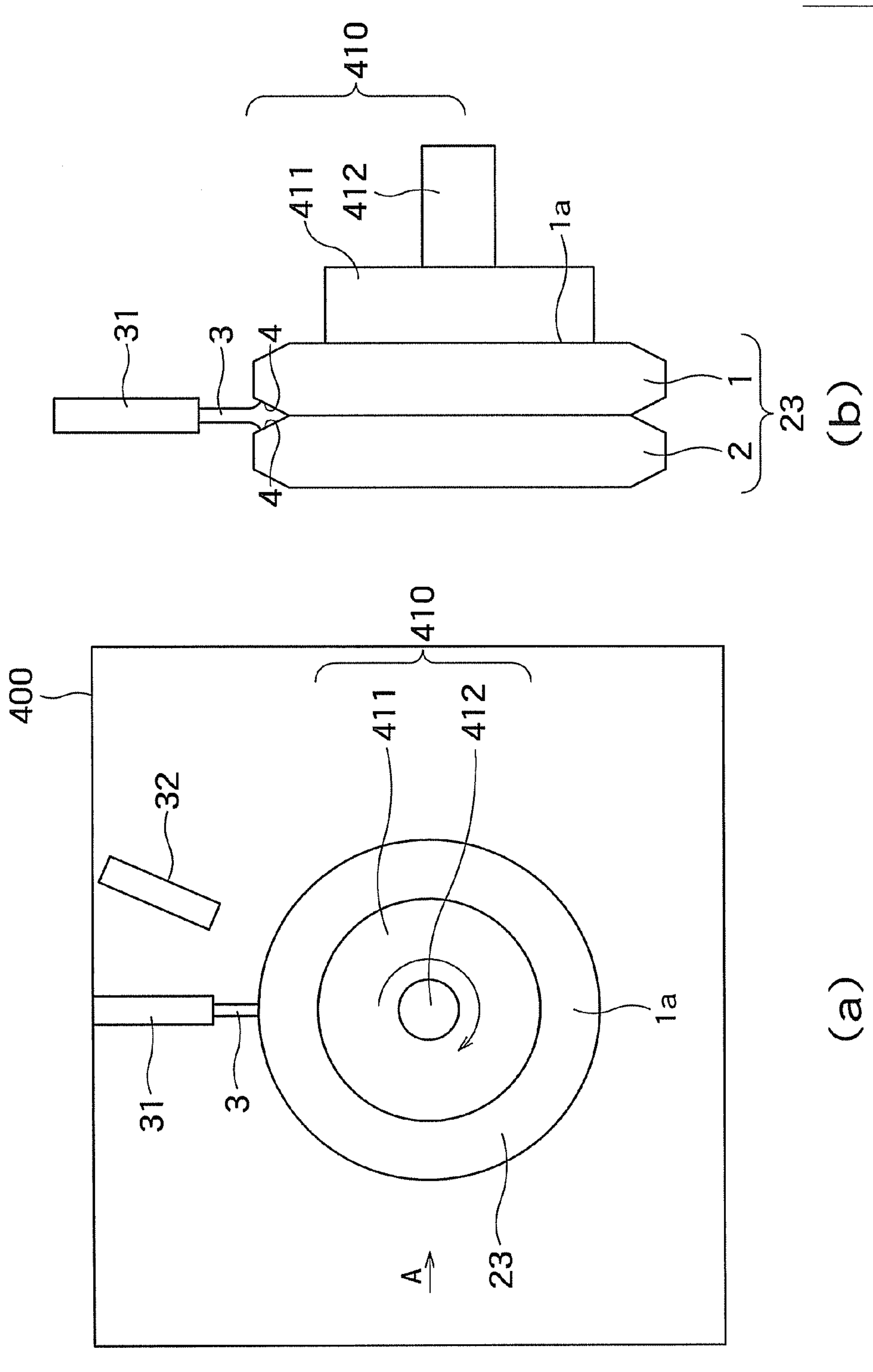


FIG. 7

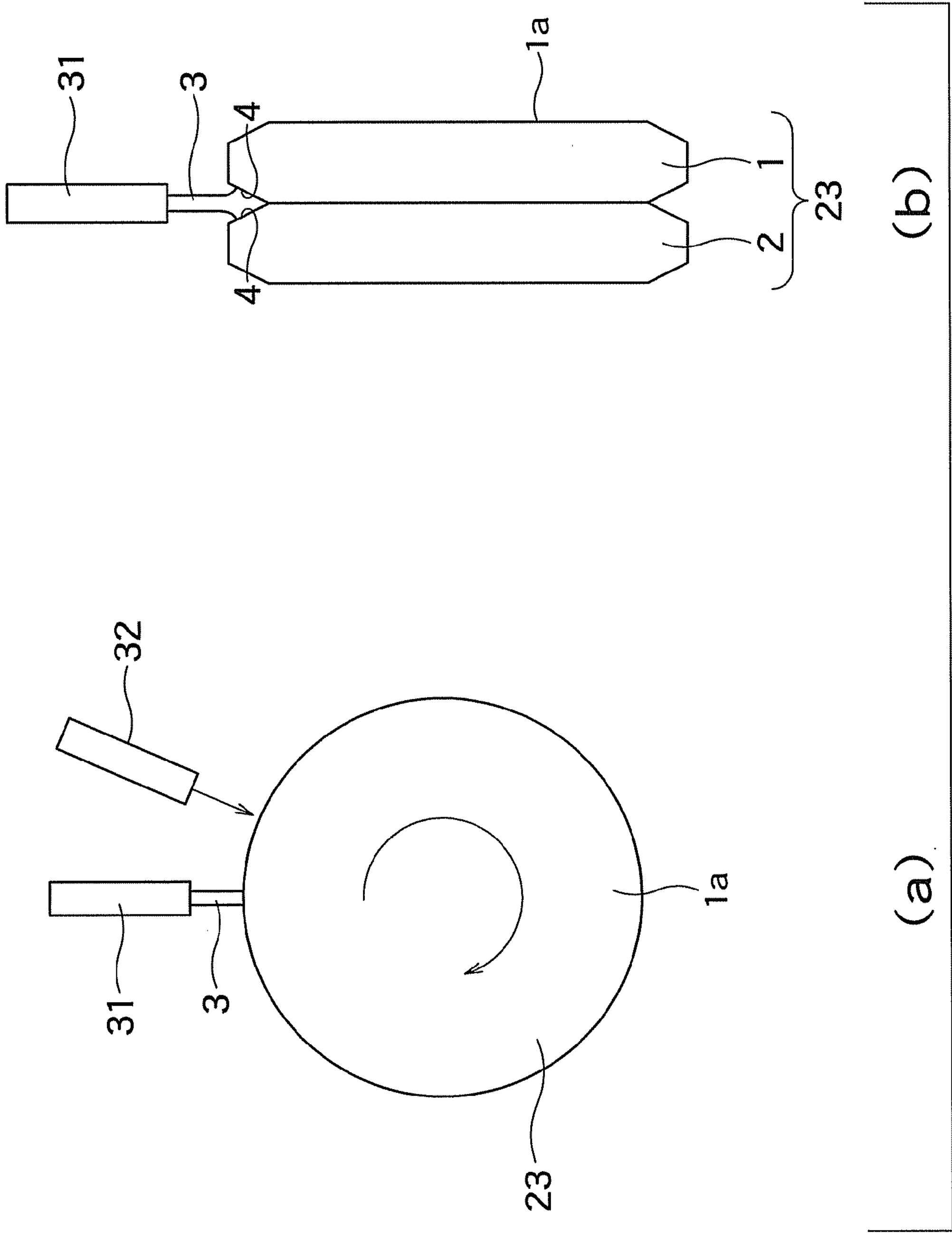


FIG. 8

SEMICONDUCTOR DEVICE MANUFACTURING METHOD AND MANUFACTURING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from prior Japanese Patent Application No. 2013-39025, filed on Feb. 28, 2013, the entire contents of which are incorporated herein by reference.

FIELD

[0002] Embodiments of the present invention relate to a semiconductor device manufacturing method and a manufacturing apparatus.

BACKGROUND

[0003] In recent years, it has come to be realized that there are limits on setting of finer semiconductor design rules, and it has thus been difficult to increase the number of devices in a semiconductor device to make it denser by means of the finer design rules. For this reason, as a new approach to a higher density other than the setting of finer design rules, a three-dimensional mounting technique for semiconductor chips has come under the spotlight. This three-dimensional mounting will be briefly described as follows. It corresponds to "separating two-dimensionally horizontally extended semiconductor devices into groups in accordance with respective functions, and vertically stacking those". That is, the idea is that the number of devices per unit area is increased by the three-dimensional mounting.

[0004] As the three-dimensional mounting, for example, a wire bonding system has come along in which semiconductor chips are stacked and connected to one another by wire bonding. This has brought about a higher density to a certain degree as compared with the conventional two-dimensional semiconductor devices. However, making a thickness of each semiconductor chip not larger than 50 μm is difficult, and further, a bonding mechanism layer (underfill layer) with a thickness of the order of 20 μm is interposed between the semiconductor chips. Hence, also from the viewpoint of a three-dimensional arrangement with respect to processes in the wire bonding, the number of stackable semiconductor chips is limited to the order of 16. Moreover, since the wire that connects the semiconductor chips has an extremely long wiring length, it is disadvantageous to speeding up of the semiconductor device.

[0005] Under such circumstances, three-dimensional mounting in a TSV system is recently drawing attention. A TSV is an abbreviation of a through-silicon via, and refers to a through-silicon electrode. In the TSV system, this TSV serves as a connection wire between semiconductor chips. Therefore, the wiring length for connection between the semiconductor chips is significantly small as compared with the wiring length of the wire in the wire bonding system described above. This can reduce a resistance component, a capacitance component and a reactance component of the wire that connects the semiconductor chips, and hence in the TSV system, a signal is resistant to attenuation even when being a high-frequency signal, and hence it is advantageous to speeding up of the semiconductor device.

[0006] In the TSV system, the stacked semiconductor chips are bonded to each other in the form of also being electrically connected to each other. Formation of a stacked module by means of the three-dimensional mounting in the TSV system is broadly divided as follows.

[0007] (1) A wafer (e.g., silicon wafer) is individually separated (divided) in advance to form a plurality of dice (semiconductor chips), and the dice are bonded to each other to be three-dimensionally mounted, to form stacked modules.

[0008] (2) A plurality of wafers are bonded to one another until the number of layers of the wafer stacked reaches an eventual number, to form a wafer stack, which is finally individually separated to form stacked modules.

[0009] Currently, (1) is generally performed, and costly advantageous (2) is said to be generally performed in the future. Performing (2) requires a stable, tough wafer stack, in the periphery of which a wafer is not peeled off.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a view for explaining each region of a wafer;

[0011] FIGS. **2**A to **2**F are views for explaining a semiconductor device manufacturing method according to the present embodiment;

[0012] FIG. **3** is a side view of a semiconductor manufacturing apparatus according to a first embodiment;

[0013] FIG. **4** is a side view of a rubbing head according to the first embodiment;

[0014] FIG. **5** is a view for explaining a manufacturing process using a semiconductor manufacturing apparatus of the first embodiment;

[0015] FIG. **6** is a view for explaining a semiconductor device manufacturing method of a comparative example;

[0016] FIG. **7** is a view of a semiconductor manufacturing apparatus according to, a second embodiment; and

[0017] FIG. **8** is a view for explaining a semiconductor device manufacturing method according to the second embodiment.

DETAILED DESCRIPTION

[0018] In one embodiment, a semiconductor device manufacturing method includes: bonding a first wafer and a second wafer to each other, to form a stack; rubbing a film attached with a fill material in a thin-film shape into a gap located between a bevel of the first wafer and a bevel of the second wafer, to fill the gap with the fill material; and thinning the first wafer.

[0019] Hereinafter, embodiments will be described with reference to the drawings. However, the present invention is not limited to these embodiments. It is to be noted that a portion in common throughout the drawings is provided with a common numeral, and a repeated description thereof will be omitted. Further, the drawings are schematic views for explaining the invention and promoting understanding thereof, and some places may have shapes, sizes, ratios or the like different from those in an actual device, but these can be appropriately subjected to design changes in light of the following descriptions and known techniques.

[0020] However, an expression such as "flat", "almost flat", "right-angled", "almost right-angled", "horizontal" or "almost horizontal" used for a shape and a position of a plane and an angle of an edge, or an expression of a shape in the following description does not only mean a case where it is mathematically (geometrically) flat, right-angled or horizontal or a case where it is mechanically defined, but also means

a case where it is different or rough to an industrially allowable degree in a manufacturing process of a semiconductor device or it has a shape belonging to the above shape.

[0021] A wafer such as a silicon wafer will be treated in the present embodiment, each region of a general wafer will be described using FIGS. **1** (*a*) and **1** (*b*) in advance of explanation of the present embodiment. FIG. **1** (*a*) is a plan view of a front surface **100***a* of a wafer **100**, seen from above. FIG. **1** (*b*) is a sectional view of the wafer **100** in a peripheral portion **101** of the wafer **100** and in its vicinity. As shown in FIG. **1** (*a*), the front surface **100***a* of the wafer **100** has a central portion **103** extending in the center of the wafer **100**, and the peripheral portion **101** located on the periphery of the central portion. Moreover, the wafer **100** is provided with a notch, referred to as a notch **102**, in part of the periphery of the wafer **100** for the purpose of facilitating discrimination of the wafers **100** in a crystal direction and alignment of the wafers **100**. Then, the front surface **100***a* of the wafer **100** is almost flat in the central portion **103**, as shown in FIG. **1** (*b*). In the peripheral portion **101**, the front surface **100***a* is continuing to an end surface **105** of the periphery of the wafer **100** while being inclined. By performing a beveling process to form the cross section of the peripheral portion **101** of the wafer **100** into such a shape, the strength of the peripheral portion **101** of the wafer **100** is ensured. The plane inclined in the peripheral portion **101** is referred to as a bevel **104**. It is to be noted that a rear surface **100***b* of the wafer **100** which is located on the opposite side to the front surface **100***a* has a similar configuration to that of the front surface **100***a*.

First Embodiment

[0022] A method for manufacturing a wafer stack **23** according to the present embodiment will be described using FIGS. **2**A to **2**F. FIGS. **2**A to **2**F are sectional views of the wafer stack **23** in a peripheral portion of the wafer stack **23** and in its vicinity in respective processes of the manufacturing method of the present embodiment.

[0023] First, a first wafer **1** formed with semiconductor devices and the like and a second wafer **2** for grinding support are prepared. It is to be noted that in the first wafer **1**, a through electrode **500** passing through the first wafer **1** may be formed in advance, or may be formed after grinding/polishing of the first wafer **1**. The second wafer **2** may also be formed in advance similarly to the above as necessary. As shown in FIG. **2**A, the first wafer **1** and the second wafer **2** are aligned such that the front surface **1***b* of the first wafer **1** as a device surface formed with an electrode and the like and a front surface **2***a* of the second wafer **2** are opposed to each other, and the centers and the notches of the first wafer **1** and the second wafer **2** are superimposed on each other. In order to keep the aligned state, the first wafer **1** and the second wafer **2** are bonded to each other by an adhesive method, a fusion bonding method or the like, to form the wafer stack **23**. It is to be noted that the second wafer **2** for grinding support can not only play a function to support the first wafer **1** at the time of grinding/polishing the first wafer **1**, but also play a device function in the wafer stack **23** by formation of an electrode and the like on the front surface **2***a* of the second wafer **2** before the bonding. In this case, the second wafer **2** is not peeled off the first wafer **1**, and left in the eventually formed wafer stack **23**. On the other hand, when the second wafer **2** is only to play the function of grinding support, the second wafer **2** may be eventually peeled off the first wafer **1**.

[0024] Subsequently, as shown in FIG. **2**B, a circuit of a gap located between a bevel **4** of the first wafer **1** and a bevel **4** of the second wafer **2** is filled with a fill material **3** along the periphery of the wafer stack **23**. Hereinafter, the filling with the fill material **3** will specifically be described.

[0025] First, the fill material **3** is formed into a thin-film shape with a thickness of the order of 300 μm, which is attached to a tape-shaped film **22**, to form a fill material-attached tape (film) **24**. The fill material **3** will specifically be described later.

[0026] Next, FIG. **3** shows a side view of a semiconductor manufacturing apparatus **200** which is used at the time of filling with the fill material **3**. This semiconductor manufacturing apparatus **200** has a holding portion (rotating unit) **210** that holds the wafer stack **23**, and a rubbing head **220** that rubs the fill material-attached tape **24** into the gap in the peripheral portion of the wafer stack **23**. Further, it has a take-up reel **231** and a supply reel **232** for supplying the fill material-attached tape **24** and taking it up while applying predetermined tensile force to the fill material-attached tape **24**.

[0027] The holding portion **210** has a holding table **211** that vacuum-adsorbs the wafer stack **23** to hold the wafer stack **23**, a support shaft **212** that supports the holding table **211**, and a motor **213** for rotating the support shaft **212**. A lower end of this support shaft **212** is connected to the motor **213**, and the support shaft **212** and the holding table **211** are rotated in an integrated manner by the motor **213**. For example, the holding table **211** rotates around the support shaft **212** as a rotating shaft, while the plane of the holding table **211** that holds the wafer stack **23** is kept in such a state as to be horizontal to the ground.

[0028] FIG. **4** is a side view of the rubbing head **220**. The rubbing head **220** has a support portion **221** having two protruding portions **221***a* and **221***b*, an elastic member **222** which is made of elastic rubber and the like, tightly stretched between the protruding portions **221***a* and **221***b*, and an air cylinder **223** connected to the support portion **221**. Using this air cylinder **223**, the rubbing head **220** is shifted to the optimal position.

[0029] It is to be noted that in a mechanism of a beveling polishing unit used at the time of polishing the end surface of a wafer in the conventional semiconductor device manufacturing process, a polishing tape can be replaced by the fill material-attached tape **24**, so as to use the beveling polishing unit as the semiconductor manufacturing apparatus **200** according to the present embodiment.

[0030] In the semiconductor manufacturing apparatus **200** as described above, the wafer stack **23** is held on the holding table **211**. At this time, the wafer stack **23** is arranged on the holding table **211** such that the centers of the first wafer **1** and the second wafer **2** in the wafer stack **23** are superimposed on the center of the support shaft **212**. The fill material-attached tape **24** is fixed such that its plane on the film **22** side comes into contact with the elastic member **222**. Then, the air cylinder **223** is driven to shift the rubbing head **220** such that the peripheral portion of the wafer stack **23** is placed between the two protruding portions **221***a* and **221***b*, and the periphery of the wafer stack **23** is connected to the elastic member **222** via the fill material-attached tape **24**. Subsequently, the wafer stack **23** is rotated at a constant speed by use of the holding portion **210**. Further, the take-up reel **231** and the supply reel **232** are rotated at a constant speed to supply and take up the fill material-attached tape **24**, while applying constant tensile force to the fill material-attached tape **24** (cf. FIG. **3**).

[0031] More specifically, as shown in FIG. **5** as an enlarged side view of the vicinity of the rubbing head **220** in FIG. **3**, the fill material-attached tape **24** is pressed against the periphery of the wafer stack **23** by the elastic member **222** tightly stretched between the protruding portions **221***a* and **221***b*. At this time, the elastic member **222** pressed against the periphery of the wafer stack **23** via the fill material-attached tape **24** is stretched, and the elastic member **222** thus generates tensile force. By the tensile force of the elastic member **222**, constant force is applied to the periphery of the wafer stack **23** via the fill material-attached tape **24**, and the fill material **3** of the fill material-attached tape **24** is rubbed into the gap located between the bevel **4** of the first wafer **1** and the bevel **4** of the second wafer **2**. Since the take-up reel **231** and the supply reel **232** are rotated at a constant speed, a new surface of the fill material-attached tape **24** is constantly pressed against the gap, and moreover, since the wafer stack **23** is rotated at a constant speed, the fill material **3** can be rubbed along the periphery of the wafer stack **23**.

[0032] After the gap has been filled with the fill material **3**, a drying treatment, a heating treatment or a light irradiation treatment is performed as necessary, to cure the fill material **3**. As the means for curing the fill material **3**, the optimal one is selected in accordance with a material for the fill material **3**.

[0033] Moreover, in order to form a shape of the fill material **3** and prevent the wafer stack **23** from being contaminated by the residual fill material **3**, it is preferable that, after curing of the fill material **3**, the residual fill material **3** that extends off the gap in the peripheral portion of the wafer stack **23** be polished and removed by a polishing film. In this case, the semiconductor manufacturing apparatus **200** may be provided with a polishing head **600** for pressing the polishing film, and the polishing-removal may be performed in the semiconductor manufacturing apparatus **200**. Alternatively, a commercially available bevel polishing unit (e.g., EAC200bi-T, EAC300bi-T by EBARA CORPORATION) using a polishing tape may be employed.

[0034] In such a manner, a structure shown in FIG. **2**B can be obtained. Moreover, the second wafer **2** is used as grinding support, and the rear surface **1***a* of the first wafer **1** not connected with the second wafer **2** is grounded/polished. As thus described, the first wafer **1** having had a thickness of several hundreds micrometer is thinned so as to have a film thickness of the order of 50 μm, for example. As seen from FIG. **2**C, with the gap being filled with the fill material **3**, an angle of an edge **6** formed by the rear surface **1***a* of the first wafer **1** and a periphery-side end surface **7** of the fill material **3** is close to a right angle, and is not a knife edge (acute angle).

[0035] Subsequently, as shown in FIG. **2**D, a third wafer **13** is stacked on the polished rear surface **1***a* of the first wafer **1**. It is to be noted that the third wafer **13** can also be formed with a through electrode (not shown) in advance in a similar manner to the first wafer **1**. Specifically, the first wafer **1** and the third wafer **13** are bonded to each other such that a front surface **13***b* of the third wafer **13** as a device surface formed with an electrode and the like and the rear surface **1***a* of the first wafer **1** are opposed to each other, and the centers and the notches of the third wafer **13** and the first wafer **1** are superimposed on each other.

[0036] Then, as shown in FIG. **2**E, a gap located between a bevel **4** of the third wafer **13** and the fill material **3** is further filled with the fill material **3** in a similar manner to what has been described above. Then as shown in FIG. **2**F, a rear surface **13***a* of the third wafer **13** is grounded/polished. Also in this case, since the gap located between the bevel **4** of the third wafer **13** and the fill material **3** has further been filled with the fill material **3**, an angle of an edge **6** formed by the rear surface **13***a* of the third wafer **13** and the end surface **7** of the fill material **3** is close to a right angle, and is not a knife edge.

[0037] Moreover, stacking of a wafer, further filling of a gap in the peripheral portion of the formed wafer stack **23** with the fill material **3** and grinding/polishing of the rear surface of the newly stacked wafer are repeated until the number of wafers becomes just a desired number. Hence it is possible to obtain the wafer stack **23** containing the desired number of wafers. Moreover, by individually separating this wafer stack **23**, stacked modules can be obtained.

[0038] Next, the material for the fill material **3** will be described. The fill material **3** is preferably provided with characteristics and the like as below:

(1) having high adhesion to a film (e.g. silicon oxide film) located on the uppermost surface of each wafer;

(2) having mechanical resistance to grinding/polishing;

(3) having chemical resistance to a polishing solution and a cleaning solution for wafers;

(4) having thermal resistance to a high-temperature heat that is applied in a thermal process performed after bonding of wafers (e.g., preferably having thermal resistance to a heat of the order of 200° C.);)

(5) being cured and shrunk in a small degree;

(6) having a record of being used inside a clean room which is used in semiconductor device manufacturing;

(7) having a thermal expansion coefficient closer to that of a material for a wafer (e.g. silicon); and

(8) being not brittle (being elastic, if possible, so as to be able to disperse or alleviate stress).

[0039] Therefore, examples of the fill material **3** provided with the characteristics as described above may include materials mainly composed of a glass material, an inorganic polymer or an organic polymer. Specifically, the glass material is excellent in being resistant to heat. Examples of the material mainly composed of the glass material may include liquid glass, spin-on-glass, silane and silazane. Further, examples of the material mainly composed of a polymer may include thermal resistant synthetic resins, namely a fluorine resin, a silicon resin (silicone), a polyimide resin, a melamine resin and a benzocyclobutene resin. Moreover, a plastic-made composite resin (mixture of a photo-curable resin and a spherical filler), used as a tooth filling, may be used.

[0040] Furthermore, as the viscosity of the fill material **3**, the optimal viscosity is selected so as to facilitate handling thereof. For example, an amount of the fill material **3** filling the gap located between the bevel **4** of the first wafer **1** and the bevel **4** of the second wafer **2** in the wafer stack **23** is approximately 0.024 cm^3 in the case of each wafer having a diameter of 300 mm. This filling amount is certainly a very small one. Under such circumstances, in order to facilitate rubbing of the fill material **3** into the gap without its flowing out of the gap, it is preferable that the viscosity of the fill material **3** be relatively high. Moreover, as described above, since the curing-shrinkage of the fill material **3** is relatively small, a proportion of a solvent component in the fill material **3** is preferably small.

[0041] According to the present embodiment, by filling the gap in the periphery of the wafer stack **23** with the fill material **3**, the angle of the edge **6** formed by the rear surface **1***a* of the first wafer **1** after polishing and the end surface **7** of the fill

material **3** becomes close to a right angle, and can thus avoid becoming a knife edge that causes chipping. Moreover, with the fill material **3** existing in the peripheral portion of the wafer stack **23**, it is possible to avoid peeling of wafers off each other, so as to obtain the stable, tough wafer stack **23**. Furthermore, with the chipping being preventable, it is possible to use semiconductor chips formed in the peripheral portion of each wafer or in the vicinity of the peripheral portion without wasting those chips, so as to increase the number of semiconductor chip usable from one wafer as compared with the manufacturing method having hitherto been considered by the present inventors. A specific description will be provided as follows.

[0042] As described above, the beveling process has been performed on the peripheral portion of the wafer. It has hitherto been known that, when such a wafer is not subjected to a further process and bonded to a support substrate to be grounded/polished, a pointy knife edge appears in the peripheral portion of the wafer. In this knife edge part, the wafer has a small thickness and is not in contact with the support substrate, thus having low strength. Hence chipping (cracking/cleavage) tends to occur in such a knife edge part.

[0043] Accordingly, the present inventors have considered an edge trimming method. The edge trimming method will be described using FIG. **6** as a comparative example of the present embodiment. FIGS. **6** (*a*) to **6** (*c*) are sectional views of a wafer **300**, a peripheral portion **301** of the wafer stack **23** and its vicinity in respective processes of the edge trimming method. As shown in FIG. **6** (*a*), the peripheral portion **301** with a width of several millimeters on the front surface **300***b* of the wafer **300** is, for example, vertically dug down approximately 50 μm. A wall surface **8** formed by the digging-down becomes not a truncated conic side surface, but a cylindrical side surface. Next, as shown in FIG. **6** (*b*), the wafer **300** and a support substrate **311** are bonded to each other such that the front surface **300***b* of the wafer **300** comes into contact with the support substrate **311**. Moreover, as shown in FIG. **6** (*c*), the wafer **300** is thinned by grinding/polishing its rear surface **300***a*. As also apparent from FIG. **6** (*c*), the edge **6** formed by the wall surface **8** and the rear surface **300***a* becomes almost a right angle after thinning of the wafer **300**, and hence appearance of the knife edge can be avoided. However, there has been a problem with this method in that digging down the peripheral portion **301** causes reduction in a diameter of the wafer **300** from its periphery side, and a semiconductor chip formed in the peripheral portion **301** and the like of the wafer **300** cannot be used as a product, thus decreasing the number of semiconductor chips that can be acquired from one wafer. Further, there has been a problem in that the bonded wafers are peeled off in the peripheral portion **301**.

[0044] However, according to the present embodiment, it is possible to avoid peeling of wafers off each other by filling the gap in the peripheral portion of the wafer stack **23** with the fill material **3**, so as to obtain the stable, tough wafer stack **23**. Moreover, with the peripheral portion **301** not being subjected to the digging-down process, it is possible to use semiconductor chips formed in the peripheral portion of each wafer or in the vicinity of the peripheral portion without wasting those chips.

[0045] Further, according to the present embodiment, the fill material **3** is used in the tape shape, and hence the fill material **3** can be handled in a fairly easy manner. Moreover, the viscosity and the like of the fill material **3** are set to the optimal values, whereby it is possible to make the curing time for the fill material **3** short, so as to suppress contamination of the wafer stack **23** by the fill material **3**. Furthermore, the fill material-attached tape **24** is rubbed to perform filling with the fill material **3**, whereby it is possible to make short the time taken for filling with the fill material **3**, so as to avoid deterioration in manufacturing efficiency. Then, the gap is filled after the wafers have been stacked in advance, whereby it is possible to make an amount of the fill material **3** used small.

Second Embodiment

[0046] The present embodiment is different from the first embodiment in that the gap is filled with the fill material **3** by transferring or dropping the fill material **3** thereinto. Herein, a portion having the same configuration and function as in the first embodiment is provided with the same numeral, and a description thereof will be omitted.

[0047] First, FIGS. **7** (*a*) and **7** (*b*) show a semiconductor manufacturing apparatus **400** used at the time of filling with the fill material **3**. FIG. **7** (*a*) is a side view of the semiconductor manufacturing apparatus **400** mounted with the wafer stack **23**, seen from the rear surface **1***a* side of the first wafer **1** in the wafer stack **23**. FIG. **7** (*b*) is a view of the periphery of a holding portion (rotating unit) **410** of the semiconductor manufacturing apparatus **400**, seen from an arrow A side shown in FIG. **7** (*a*). The semiconductor manufacturing apparatus **400** has the holding portion **410**, a dispense nozzle (fill material supply unit) **31**, and a light irradiation unit **32**. The holding portion **410** has a holding table **411** that vacuum-adsorbs the surface of a wafer in the wafer stack **23** to hold the wafer stack **23**, a support shaft **412** that supports the holding table **411**, and a motor (not shown) for rotating the support shaft **412**. For example, the holding table **411** rotates around the support shaft **412** as a rotating shaft, while the plane of the holding table **411** that holds the wafer stack **23** is kept in such a state as to be almost right-angled to the ground. The dispense nozzle **31** transfers or drops the fill material **3** into the gap located between the bevel **4** of the first wafer **1** and the bevel **4** of the second wafer **2** in the wafer stack **23**. Moreover, the light irradiation unit **32** irradiates the fill material **3**, transferred or dropped into the gap, with light and cure the fill material **3**.

[0048] Next, a manufacturing method of the present embodiment will be described using FIGS. **8** (*a*) and **8** (*b*). FIGS. **8** (*a*) and **8** (*b*) are views for explaining a process for filling with the fill material **3** in the manufacturing method of the present embodiment, and specifically, FIG. **8** (*a*) corresponds to FIG. **7** (*a*), and FIG. **8** (*b*) corresponds to FIG. **7** (*b*).

[0049] First, in a similar manner to the first embodiment, the first wafer **1** and the second wafer **2** are superimposed on each other, to form the wafer stack **23**. Further, as shown in FIGS. **8** (*a*) and **8** (*b*), using the semiconductor manufacturing apparatus **400** as thus described, the wafer stack **23** is held on the holding table **411**. At this time, the wafer stack **23** is arranged on the holding table **411** such that the center of each wafer is superimposed on the center of the support shaft **412** and that the surfaces (front surface and rear surface) of each wafer in the wafer stack **23** are almost right-angled to the ground. With this state being kept, the wafer stack **23** is rotated at the order of 1 rpm, for example. Then the fill material **3** is transferred or dropped into the gap in the peripheral portion of the wafer stack **23** by use of the dispense nozzle **31**. Moreover, the fill material **3** immediately after being transferred or dropped into the gap is irradiated with light from the light irradiation unit **32**, and the fill material **3** is

thereby cured. It is preferable to select infrared rays as the light when the fill material **3** is a thermosetting resin, and select ultraviolet rays as the light when the fill material **3** is an ultraviolet curable resin. As thus described, by the fill material **3** being cured immediately after transferred or dropped, the gap can be filled with the fill material **3** without the fill material **3** dripping therefrom. It is to be noted that, although the fill material **3** according to the present embodiment can be selected from the materials used in the first embodiment, one is preferably selected which has such viscosity that the fill material **3** does not run from the gap and fills the gap.

[0050] In a similar manner to the first embodiment, after curing of the fill material **3**, the residual fill material **3** that extends off the gap in the peripheral portion of the wafer stack **23** may be polished and removed. It should be noted that a description of a specific method for the polishing-removal will be omitted since it is similar to the first embodiment.

[0051] Then, the rear surface **1***a* of the first wafer **1** is grounded/polished in a similar manner to the first embodiment. Moreover, stacking of a wafer, filling with the fill material **3** and grinding/polishing of the wafer are repeated until the number of wafers becomes just a desired number, to eventually obtain the wafer stack **23** containing the desired number of wafers.

[0052] According to the present embodiment, it is possible to avoid the knife edge in a similar manner to the first embodiment by filling the gap, located between the bevels **4** of the stacked first wafer **1** and second wafer **2**, with the fill material **3**. Moreover, with the fill material **3** existing in the gap in the peripheral portion of the wafer stack **23**, it is possible to avoid peeling of wafers off each other, so as to obtain the stable, tough wafer stack **23**. Moreover, with the chipping being preventable, it is possible to use semiconductor chips formed in the peripheral portion of each wafer or in the vicinity of the peripheral portion without wasting those chips.

[0053] Furthermore, according to the present embodiment, the fill material **3** is cured immediately after being transferred or dropped into the gap, and hence the gap is filled with the fill material **3** without the fill material **3** dripped therefrom. Since the time taken for the filling with the fill material **3** is thus short, it is possible to prevent deterioration in manufacturing efficiency. Moreover, since the gap is filled after stacking of wafers in advance, the amount of the fill materials **3** can be made small.

[0054] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel methods and systems described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

1. A semiconductor device manufacturing method, comprising:

bonding a first wafer and a second wafer to each other, to form a stack;

rubbing a film attached with a fill material in a thin-film shape into a gap located between a bevel of the first wafer and a bevel of the second wafer, to fill the gap with the fill material; and

thinning the first wafer.

2. The semiconductor device manufacturing method according to claim **1**, further comprising

forming a through electrode in at least one wafer out of the first wafer and the second wafer before formation of the stack.

3. The semiconductor device manufacturing method according to claim **1**, further comprising

polishing and removing the residual fill material that extends off the gap by use of a polishing film after filling with the fill material.

4. The semiconductor device manufacturing method according to claim **1**, wherein a material containing a glass material, an inorganic polymer or an organic polymer is used as the fill material.

5. The semiconductor device manufacturing method according to claim **1**, further comprising

performing a treatment to cure the fill material after filling with the fill material.

6. The semiconductor device manufacturing method according to claim **5**, wherein the treatment to cure the fill material is a drying treatment, a heating treatment, or a light irradiation treatment.

7. A semiconductor device manufacturing method, comprising:

bonding a first wafer and a second wafer to each other, to form a stack;

transferring or dropping a fill material into a gap located between a bevel of the first wafer and a bevel of the second wafer, to fill the gap with the fill material;

irradiating the fill material for curing; and

thinning the first wafer.

8. The semiconductor device manufacturing method according to claim **7**, further comprising

forming a through electrode in at least one wafer out of the first wafer and the second wafer before formation of the stack.

9. The semiconductor device manufacturing method according to claim **7**, further comprising

polishing and removing the residual fill material that extends off the gap by use of a polishing film after filling with the fill material.

10. The semiconductor device manufacturing method according to claim **7**, wherein a material containing a glass material, an inorganic polymer or an organic polymer is used as the fill material.

11. A semiconductor manufacturing apparatus, comprising:

a rubbing head that includes a support portion having two protruding portions and an elastic member tightly stretched between the two protruding portions,

wherein the rubbing head is capable of rubbing a film attached with a filmy fill material into a gap located between bevels of a plurality of wafers in a state where the film is supported by the elastic member.

12. The semiconductor manufacturing apparatus according to claim **11**, wherein

the rubbing head has an air cylinder for shifting the rubbing head, and

in a state where the film is supported by the elastic member, the rubbing head is shifted by the air cylinder such that a periphery of a stack containing the plurality of wafers comes into contact with the elastic member via the film, thereby to extend the elastic member and make the elas-

tic member generates tensile force, followed by pressing of the film against the gap by the tensile force.

13. The semiconductor manufacturing apparatus according to claim **11**, further comprising

a rotating unit that rotates a stack containing the plurality of wafers.

14. The semiconductor manufacturing apparatus according to claim **13**, wherein

the rotating unit has a holding table that holds the stack, and

the rotating unit rotates in such a state where a plane of the holding table is horizontal to the ground.

15. The semiconductor manufacturing apparatus according to claim **11**, further comprising:

a supply reel that supplies the tape-shaped film; and

a take-up reel that takes up the film.

16. The semiconductor manufacturing apparatus according to claim **11**, further comprising

a polishing head that presses a polishing film against the gap filled with the fill material.

17. A semiconductor manufacturing apparatus, comprising:

a fill material supply unit that transfers or drops a fill material into a gap located between bevels of a plurality of wafers, and

a light irradiation unit that irradiates the fill material with light, to cure the fill material.

18. The semiconductor manufacturing apparatus according to claim **17**, further comprising

a rotating unit that rotates a stack containing the plurality of wafers.

19. The semiconductor manufacturing apparatus according to claim **18**, wherein

the rotating unit has a holding table that holds the stack, and

the rotating unit rotates in such a state where a plane of the holding table is right-angled to the ground.

20. The semiconductor manufacturing apparatus according to claim **17**, further comprising

a polishing head that presses a polishing film against the gap filled with the fill material.

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