

is insufficient due to a configuration of the furnace port, and by-products by the precursor gas may adhere to the furnace port. In particular, when metal parts are used in the furnace port, by-products tend to adhere to the metal parts. For this reason, even as cleanings are performed more frequently, particles may be generated.

[0006] The present disclosure provides some embodiments of a protective plate, a substrate processing apparatus, and a method of manufacturing a semiconductor device, which are capable of suppressing adhesion of by-products by a precursor gas to a furnace port.

[0007] According to one or more embodiments of the present disclosure, there is provided a technique that includes a protective plate installed on a lid including: a disc portion having a disc shape, wherein at least a part of a lower surface of the disc portion is in contact with an upper surface of the lid, a side wall portion extending vertically from an outer peripheral end of the disc portion, a groove having a loop shape and formed in the lower surface of the disc portion, and a stepped portion formed to be closer to the outer peripheral end of the disc portion than the groove, a predetermined clearance being formed between the upper surface of the lid and the stepped portion, wherein the groove is configured to be able to form a flow of a gas that runs through a gap flows between the lid and the stepped portion, and is supplied to an entire outside of the side wall portion.

[0008] According to the present disclosure in some embodiments, it is possible to suppress adhesion of by-products and generation of particles and thus improve productivity.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. 1 is a vertical cross sectional view showing a substrate processing apparatus according to first embodiments of the present disclosure.

FIG. 2 is a vertical cross sectional view showing a furnace port of the substrate processing apparatus.

FIG. 3A is a plan perspective view showing a protective plate used in the substrate processing apparatus, and FIG. 3B is a bottom perspective view showing the protective plate.

FIG. 4A is a plan view showing the protective plate used in the substrate processing apparatus, and FIG. 4B is a view taken along line A-A in FIG. 4A.

FIG. 5 is an explanatory view showing a flow velocity distribution of a second purge gas in the furnace port.

FIG. 6A is a vertical cross sectional view showing a process gas concentration distribution in the furnace port having a reference structure, and FIG. 6B is a cross sectional view showing the process gas concentration distribution in the furnace port having the reference structure.

FIG. 7A is a vertical cross sectional view showing a process gas concentration distribution in the furnace port of the first embodiments, and FIG. 7B is a cross sectional view showing the process gas concentration distribution in the furnace port of the first embodiments.

FIG. 8 is a graph showing a comparison between the process gas concentration distribution in the furnace port of the first embodiments and the process gas concentration distribution in the furnace port having the reference structure.

FIG. 9A is a plan view showing a protective plate used in a substrate processing apparatus according to second embodiments of the present disclosure, FIG. 9B is a bottom view showing the protective plate, and FIG. 9C is a view taken along line B-B in FIG. 9A.

DETAILED DESCRIPTION

[0010] Embodiments of the present disclosure will now be described with reference to the drawings. Throughout the drawings, the same or corresponding components are denoted by the same or corresponding reference numerals, and explanation thereof may be omitted.

[0011] First embodiments may include a substrate processing apparatus which is a vertical substrate processing apparatus (hereinafter referred to as a "processing apparatus") 1 that performs a substrate processing process such as heat treatment or the like as a manufacturing process in a method of manufacturing a semiconductor device.

[0012] As shown in FIG. 1, the processing apparatus 1 includes a reaction tube 2 having a cylindrical shape and a heater 3 as a heating mechanism (heating means) installed on the outer periphery of the reaction tube 2. The reaction tube 2 is made of, for example, quartz (SiO₂),

200 degrees C or less, and a water jacket (not shown) can be attached to the flanges of the reaction tube 2 or the manifold 5.

[0016] The process chamber 8 stores therein a boat 14 as a substrate holder for supporting a plurality of wafers W, for example, 25 to 150 wafers W, vertically in a shelf shape. The boat 14 is made of, for example, quartz, SiC, or the like, and is supported above a heat-insulating structure 15.

[0017] The heat-insulating structure 15 has an outer shape of cylinder with a generally flat bottom and is supported by the rotary shaft 13 that penetrates the lid 9. The rotary shaft 13 is connected to a rotation mechanism 16 installed below the lid 9. For example, a magnetic fluid seal is installed at a portion of the rotary shaft 13 that penetrates the lid 9, and the rotary shaft 13 is configured to be rotatable in a state where the interior of the reaction tube 2 is hermetically sealed. When the rotary shaft 13 is rotated, the heat-insulating structure 15 and the boat 14 are rotated together. The lid 9 is driven in the vertical direction by a boat elevator 17 as an elevator. The substrate holder and the lid 9 are integrally moved up or down by the boat elevator 17, so that the boat 14 is loaded/unloaded into/from the reaction tube 2.

[0018] The processing apparatus 1 includes a gas supply mechanism 18 that supplies a precursor gas as a process gas to be used for substrate processing, a reaction gas, and an inert gas into the process chamber 8. The process gas supplied by the gas supply mechanism 18 is selected according to the type of a film to be formed. In the first embodiments, the gas supply mechanism 18 includes a precursor gas supplier, a reaction gas supplier, an inert gas supplier, a first purge gas supplier, and a second purge gas supplier.

[0019] The precursor gas supplier includes a gas supply pipe 19a. A mass flow controller (MFC) 21a, which is a flow rate controller (flow rate control part), and a valve 22a, which is an opening/closing valve, are installed in the gas supply pipe 19a in order from an upstream direction. A downstream end of the gas supply pipe 19a is connected to the nozzle 23a that penetrates the side wall of the manifold 5. The nozzle 23a is vertically installed in the reaction tube 2 along the inner wall of the reaction tube 2, and has a plurality of supply holes formed to open toward the wafers W held by the boat 14. A precursor gas is supplied to the wafers W

process chamber 8, and an APC (Auto Pressure Controller) valve 34 which is a pressure regulator (pressure regulation part). With this configuration, the internal pressure of the process chamber 8 can be set to a processing pressure corresponding to the processing. The exhaust pipe 32 is installed at a position facing the nozzles 23a, 23b, and 23c.

[0024] The rotation mechanism 16, the boat elevator 17, and the MFCs 21a to 21g, valves 22a to 22g and APC valve 34 of the gas supply mechanism 18 are connected to a controller 36 for controlling them. The controller 36 includes, for example, a microprocessor (computer) including a CPU, and is configured to control the operation of the processing apparatus 1. For example, an input/output device 37 configured as a touch panel or the like is connected to the controller 36.

[0025] A storage device 38, which is a storage medium, is connected to the controller 36. The storage device 38 stores, in a readable manner, a control program for controlling the operation of the processing apparatus 1, and a program (also referred to as a recipe) that causes each component of the processing apparatus 1 to execute a process in accordance with processing conditions.

[0026] The storage device 38 may be a memory device (hard disk or flash memory) built in the controller 36, or a portable external recording device (a magnetic tape, a magnetic disk such as a flexible disk or a hard disk, an optical disk such as a CD or DVD, a magneto-optical disk such as an MO, or a semiconductor memory such as a USB memory or a memory card). Further, the program may be provided to the computer using a communication means such as the Internet or a dedicated line. The program is read from the storage device 38 according to an instruction or the like from the input/output device 37 as necessary, and the controller 36 executes a process according to the read recipe to cause the processing apparatus 1 to execute a desired process under control of the controller 36.

[0027] The protective plate 12 installed on the upper surface of the lid 9 is made of a heat-resistant and corrosion-resistant material such as quartz or the like. When the protective plate 12 covers the metal lid 9, the contact of a process gas to the lid 9 is suppressed, and corrosion and deterioration of the lid 9 due to the process gas are accordingly suppressed.

[0028] FIG. 2 shows the internal structure of a furnace port and the heat-insulating structure 15. The heat-insulating structure 15 includes a cylindrical body 39 having a columnar shape and a bottom plate 40 made of metal and having a disc shape supported by the rotary shaft 13. The cylindrical body 39 is made of a heat-resistant material such as quartz or the like, has a hollow structure with its lower end opened, and is placed on the bottom plate 40. In addition, a heat-insulating plate support pillar 42 having a hollow cylindrical shape is installed on the bottom plate 40 in the cylindrical body 39.

[0029] The heat-insulating plate support pillar 42 holds disc-shaped heat-insulating plates 43 made of a heat-resistant material such as quartz or the like, which are stacked in multi-stage. A sub-heater 44 is inserted into the heat-insulating plate support pillar 42. The sub-heater 44 has a ring shape above the heat-insulating plate support pillar 42, and the upper surface of the cylindrical body 39 and the lower portion of the process chamber 8 are heated by the sub-heater 44. The rotary shaft 13 also has a hollow structure in order to insert the sub-heater 44, and a third purge gas branched from a first purge gas is introduced into the rotary shaft 13 through a through hole 13c installed in a side portion of the rotary shaft 13 near a magnetic seal.

[0030] After the first purge gas supplied from the first purge gas supplier ascends over the outer periphery of the rotary shaft 13, the first purge gas changes its course horizontally, and is supplied to the lower portion of the process vessel 7, which is the furnace port, while purging the gap 41, which is narrow, between the bottom plate 40 and the protective plate 12. That is, the first purge gas purges the periphery of the rotary shaft 13 in the upstream, then purges the exposed surface of the protective plate 12 and the bases of the nozzles 23a to 23c in the downstream, and finally is discharged through the exhaust port 26 formed at the lower end of the reaction tube 2. In some embodiments, a supply path of the first purge gas supplied from the first purge gas supply mechanism may exclude a side wall portion 29.

[0031] The protective plate 12 has a first thin portion 28 formed to extend to the vicinity of the manifold 5 except for the location where the nozzles 23a, 23b and 23c are disposed. In addition, the side wall portion 29 extending vertically along the inner wall of the manifold 5 is formed at the outer peripheral end of the first thin portion 28. A clearance having a predetermined interval is formed between the first thin portion 28 and the lid 9, and a clearance

the sectorial region S is, for example, 60° and is appropriately set within a range of $0^\circ < \alpha < 120^\circ$ according to the number of nozzles installed or the like. When the central angle α exceeds 120° , the process gas concentration may exceed the critical value, and there is a possibility that by-products may adhere to the process vessel 7, which is not preferable.

[0045] The thick portion 45 is formed with a protruding portion 49 that protrudes radially outward from the boundary with the third thin portion 48 (the inner peripheral end of the third thin portion 48) to the outer peripheral end of the third thin portion 48. The position where the protruding portion 49 is formed is, for example, a position facing the exhaust port 26 (the opposite side of the exhaust port 26). A height of the upper surface of the protruding portion 49 is the same as a height of the inside of the thin portion.

[0046] As shown in FIG. 3B, a groove 27 having a predetermined width and a predetermined depth (hereinafter referred to as a "second purge gas flow path") is engraved in the back surfaces of the thick portion 45 and the protruding portion 49 along the outer peripheral ends of the thick portion 45 and the protruding portion 49. The second purge gas flow path 27 includes a first flow path 27a extending from the distal end of the protruding portion 49 in the central direction, a second flow path 27b that branches from the proximal end of the protruding portion 49, is curved in the circumferential direction and extends along the inner peripheral end of the third thin portion 48, and a third flow path 27c having an annular shape that is curved outward in the side end of the third thin portion 48 in the radial direction, is further curved in the circumferential direction along the outer peripheral end of the thick portion 45, extends along the outer peripheral end of the thick portion 45 and is continuous with the second flow path 27b.

[0047] A stepped portion 52 having a decreasing thickness is formed on the back surface of the protective plate 12 on the outer peripheral side (the back surfaces of the first thin portion 28, the second thin portion 47 and the third thin portion 48) of the second purge gas flow path 27. Further, the stepped portion 52 is formed to be closer to the outer peripheral end of the disc portion than the groove 27. Accordingly, when the protective plate 12 is installed on the lid 9, a central portion 51 (the back surface of the thick portion 45) closer to the center side than the second purge gas flow path 27 and the upper surface of the lid 9 are in contact with each other, and a slight clearance is formed

flux of the second purge gas 54 in the vicinity of the exhaust port 26, a small amount of second purge gas 54 actually flows.

[0051] FIGS. 7A and 7B show the process gas concentration (gas partial pressure) distribution in the furnace port in the structure for intensively supplying the first purge gas 53 to the bases of the nozzles 23a to 23c and supplying the second purge gas 54 to the other portions, according to the first embodiments. As shown in FIGS. 7A and 7B, in the case of the configuration of the first embodiments, it can be seen that the process gas concentration in the furnace port is reduced over the entire region, and in particular, the process gas concentration is remarkably reduced in the bases and peripheral portions (the vicinity of a first measurement point and a second measurement point) of the nozzles 23a to 23c.

[0052] FIG. 8 is a graph showing a comparison between results of measurement on gas partial pressure at the first to seventh measurement points shown in FIGS. 6B and 7B. In FIG. 8, a solid line indicates the process gas concentration distribution of the reference structure, and a broken line indicates the process gas concentration distribution of the structure of the first embodiments.

[0053] As can be seen from FIG. 8, in the structure of the first embodiments, in the bases and peripheral portions (the vicinity of the first measurement point and the second measurement point) of the nozzles 23a to 23c to which the first purge gas 53 is intensively supplied, the process gas concentration is reduced to about 1/2 of that in the reference structure. As can be further seen, in the portions (the third to seventh measurement points) where the side wall portion 29 is formed and the second purge gas 54 is supplied between the side wall portion 29 and the manifold 5 through the second purge gas flow path 27, the process gas concentration is reduced to 1/4 or less of that in the reference structure.

[0054] Next, a process of forming a film on a substrate using the above-described processing apparatus 1 (film-forming process) will be described. Here, examples of forming a silicon oxide (SiO_2) film on wafers W by supplying a DCS (SiH_2Cl_2 : dichlorosilane) gas as a precursor gas and an O_2 (oxygen) gas as a reaction gas to the wafers W will be described. In the following description, the operation of each of the parts constituting the processing apparatus 1 is

controlled by the controller 36.

(Wafer Charging and Boat Loading)

[0055] When a plurality of wafers W are charged into the boat 14 (wafer charging), the boat 14 is loaded into the process chamber 8 by the boat elevator 17 (boat loading), and the lower portion of the reaction tube 2 is hermetically closed (sealed) by the lid 9. In this operation, a N₂ gas as the first purge gas 53 is supplied from the first purge gas supplier to the bases of the nozzles 23a to 23c through the gap 41. Further, a N₂ gas as the second purge gas 54 is supplied from the second purge gas supplier between the side wall portion 29 and the manifold 5 through the second purge gas flow path 27. The supply of the first purge gas 53 and the second purge gas 54 is continued at least until the film-forming process is completed.

(Pressure Adjusting and Temperature Adjusting)

[0056] The process chamber 8 is vacuum-exhausted (depressurization-exhausted) by the vacuum pump 35 so that the internal pressure of the process chamber 8 reaches a predetermined pressure (degree of vacuum). The internal pressure of the process chamber 8 is measured by the pressure sensor 33, and the APC valve 34 is feedback-controlled based on the measured pressure information. Further, the wafers W in the process chamber 8 are heated by the heater 3 so as to reach a predetermined temperature. In this operation, the supply of power to the heater 3 is feedback-controlled based on the temperature information detected by the temperature detector 4 so that the process chamber 8 has a predetermined temperature distribution. Further, the rotation of the boat 14 and the wafers W by the rotation mechanism 16 is started.

(Film-Forming Process)

[Precursor Gas Supplying]

[0057] When the internal temperature of the process chamber 8 is stabilized at a preset processing temperature, the DCS gas is supplied to the wafers W in the process chamber 8. A DCS gas is controlled so as to have a desired flow rate by the MFC 21a, and is supplied into the process chamber 8 through the gas supply pipe 19a and the nozzle 23a. In this operation, a N₂ gas is supplied from the first purge gas supplier and the second purge gas supplier to the furnace port. As a result, the bases and peripheral portions of the nozzles 23a to 23c can be intensively

purged with the first purge gas 53, and the other portions can be purged with the second purge gas 54, to dilute the precursor gas concentration in the furnace port. In this operation, the supply of N₂ gas by the first purge gas supplier and the second purge gas supplier may be temporarily increased.

[Precursor Gas Exhausting]

[0058] Next, the supply of DCS gas is stopped, and the interior of the process chamber 8 is vacuum-exhausted by the vacuum pump 35. In this operation, a N₂ gas as an inert gas may be supplied from the inert gas supplier into the process chamber 8 (inert gas purge).

[Reaction Gas Supplying]

[0059] Next, an O₂ gas is supplied to the wafers W in the process chamber 8. The O₂ gas is controlled to have a desired flow rate by the MFC 21b, and is supplied into the process chamber 8 through the gas supply pipe 19b and the nozzle 23b. In this operation, a N₂ gas is supplied from the first purge gas supplier and the second purge gas supplier to the furnace port. As a result, the bases and peripheral portions of the nozzles 23a to 23c can be purged intensively, and other portions can also be purged, to dilute the reaction gas concentration in the furnace port.

[Reaction Gas Exhausting]

[0060] Next, the supply of O₂ gas is stopped, and the interior of the process chamber 8 is vacuum-exhausted by the vacuum pump 35. In this operation, a N₂ gas may be supplied from the inert gas supplier into the process chamber 8 (inert gas purge).

[0061] By performing a cycle of performing the above-described four steps a predetermined number of times (once or more), a SiO₂ film having a predetermined composition and a predetermined film thickness can be formed on each of the wafers W.

(Boat Unloading and Wafer Discharging)

[0062] After the film having the predetermined film thickness is formed, a N₂ gas is supplied from the inert gas supplier to replace the interior of the process chamber 8 with the N₂ gas, and the internal pressure of the process chamber 8 is returned to the normal pressure. Thereafter, the lid 9 is lowered by the boat elevator 17 and the boat 14 is unloaded from the reaction tube 2 (boat unloading). Thereafter, the processed wafers W are taken out from the boat 14 (wafer

WHAT IS CLAIMED IS:

1. A protective plate installed on a lid comprising:
 - a disc portion having a disc shape, wherein at least a part of a lower surface of the disc portion is in contact with an upper surface of the lid;
 - a side wall portion extending vertically from an outer peripheral end of the disc portion;
 - a groove having a loop shape and formed in the lower surface of the disc portion; and
 - a stepped portion formed to be closer to the outer peripheral end of the disc portion than the groove, a predetermined clearance being formed between the upper surface of the lid and the stepped portion,wherein the groove is configured to be able to form a flow of a gas than runs through a gap between the lid and the stepped portion, and is supplied to an outside of the side wall portion.
2. The protective plate of Claim 1, further comprising a thin portion formed in a part of an outer peripheral end of an upper surface of the protective plate, a gap being wide and partially formed between the thin portion and a member installed close to an upper side of the protective plate,
 - wherein a gas supplied into the member intensively flows out from the gap.
3. A substrate processing apparatus comprising:
 - a process vessel, in which a substrate to be processed is accommodated, having an opening at a lower end of the process vessel;
 - a lid for hermetically closing the opening;
 - a substrate holder that holds the substrate in the process vessel;
 - a heat-insulating structure installed between the lid and the substrate holder;
 - a process gas supplier comprising a nozzle configured to supply a process gas into the process vessel;

a protective plate installed on an upper surface of the lid;

a first purge gas supplier configured to supply a first purge gas to a base of the nozzle and a peripheral portion of the base, through a first gap formed between the heat-insulating structure and the protective plate, the base being located at a lower portion of the process vessel; and

a second purge gas supplier configured to supply a second purge gas to at least a portion other than the base of the nozzle and the peripheral portion of the base through a second gap formed between the lid and the protective plate,

wherein the protective plate comprises:

a disc portion having a disc shape, wherein at least a part of a lower surface is in contact with the upper surface of the lid;

a side wall portion extending vertically from an outer peripheral end of the disc portion;

a groove having a loop shape and formed in the lower surface of the disc portion; and

a stepped portion formed to be closer to the outer peripheral end of the disc portion than at least the groove, a predetermined first clearance being formed between the upper surface of the lid and the stepped portion, and

wherein the second purge gas supplier is configured to supply the second purge gas to the groove through a gas supply port formed in the lid and to purge an outside of the side wall portion with a predetermined range of flow rate or flow velocity.

4. The substrate processing apparatus of Claim 3,

wherein the process vessel comprises:

a cylindrical reaction tube having a closed upper end; and

a cylindrical manifold connected to a lower end of the reaction tube, the manifold being shorter than the reaction tube,

wherein the nozzle is attached to the manifold and the reaction tube is closed by the lid with the manifold interposed between the reaction tube and the lid.

5. The substrate processing apparatus of Claim 3, wherein the first clearance between the lid and the stepped portion serves as a part of a flow path of the second purge gas,

the second purge gas supplied to the groove flows radially outward between the lid and the stepped portion,

a predetermined second clearance is formed between the side wall portion and a manifold, and

the second clearance between the side wall portion and the manifold serves as a part of the flow path of the second purge gas.

6. The substrate processing apparatus of Claim 3, wherein the process vessel comprises an exhaust port connected to a vacuum pump, and the exhaust port is installed on an opposite side of the nozzle.

7. The substrate processing apparatus of Claim 3, wherein the side wall portion does not serve as a part of a supply path of the first purge gas supplied from the first purge gas supplier.

8. The substrate processing apparatus of Claim 3, wherein the protective plate further comprises a thin portion that is formed in a part of an outer peripheral end of an upper surface of the protective plate, a third gap being wide and partially formed between the heat-insulating structure and the thin portion.

9. The substrate processing apparatus of Claim 8, wherein a protruding portion is formed in the upper surface of the protective plate so as to protrude from an inner peripheral end to an outer peripheral end of the thin portion, a height of the protruding portion is the same as a height

of an inside of the thin portion, and the gas supply port is installed on a back surface of the protruding portion.

10. A method of manufacturing a semiconductor device using a substrate processing apparatus, comprising:

closing hermetically an opening of a cylindrical reaction tube formed in a lower end of the reaction tube with a lid on which a protective plate is installed, the protective plate comprising:

a disc portion having a disc shape, wherein at least a part of a lower surface of the disc portion of the protective plate having a disc shape is in contact with an upper surface of the lid;

a side wall portion extending vertically from an outer peripheral end of the disc portion;

a groove having a loop shape and formed in the lower surface of the disc portion; and

a stepped portion formed to be closer to the outer peripheral end of the disc portion than the groove, a predetermined clearance being formed between the upper surface of the lid and the stepped portion,

supplying a gas from a supply port formed in the lid to the groove, and

forming a flow of the gas running through a gap between the lid and the stepped portion, and then supplied to an outside of the side wall portion.