SUBSTRATE PROCESSING APPARATUS AND SUBSTRATE PROCESSING METHOD

TECHNICAL FIELD

[0001] The present disclosure relates to a substrate processing apparatus and a substrate processing method.

BACKGROUND

[0002] In a semiconductor manufacturing apparatus, film formation processing is performed in an interior of a processing container by placing a substrate on a stage, supplying a gas from a gas supplier disposed to face the stage, and depressurizing the interior of the processing container, and the gas in the processing container is discharged through an exhaust path. In performing the film formation process on the substrate as described above, Patent Document 1 proposes a technique in which an exhaust conductance on an outer peripheral side of the substrate is adjusted by providing a conductance adjustment plate, thereby achieving uniformity of an internal pressure of a processing space during film formation.

[Prior Art Document]

[Patent Document]

[0003] Patent Document 1: Japanese Patent Laid-open Publication No. 2015-183211

SUMMARY

[0004] The present disclosure provides a technique capable of preventing a process gas from diffusing inside a processing container of a substrate processing apparatus in which a distance between a stage on which a substrate is placed and an upper structure disposed above the stage is changed inside the processing container.

[0005] According to one embodiment of the present disclosure, a substrate processing apparatus includes: a processing container; a stage on which a substrate is placed in the processing container; an exhaust port that is open in a bottom wall of the processing container at a location

outward of the stage in a plan view, and is configured to exhaust an interior of the processing container; a first gas supply configured to supply a process gas for processing the substrate placed on the stage into the processing container; an upper structure including a main body provided above the stage so as to face the stage, and a first annular portion extending downward from the main body to regulate a flow of the process gas and having a lower end positioned closer to an edge of the bottom wall than the exhaust port in a plan view; a driver configured to change a distance between the stage and the upper structure; a second annular portion extending upward from the bottom wall of the processing container so as to surround the first annular portion; and a second gas supply configured to supply an inert gas to a first gap, which is formed by the upper structure and the second annular portion and is in communication with the exhaust port.

[0006] According to the present disclosure, it is possible to prevent the process gas from diffusing inside the processing container of the substrate processing apparatus in which the distance between the stage on which the substrate is placed and the upper structure disposed above the stage is changed inside the processing container.

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. 1 is a vertical cross-sectional view illustrating a first embodiment of a substrate processing apparatus.

FIG. 2 is a vertical cross-sectional view illustrating the first embodiment of the substrate processing apparatus.

FIG. 3 is a plan view illustrating a configuration example of a processing container.

FIG. 4 is a vertical cross-sectional view illustrating a part of the first embodiment of the substrate processing apparatus.

FIG. 5 is a perspective view illustrating a part of a configuration example of an annular groove.

FIG. 6 is a vertical cross-sectional view illustrating a part of the first embodiment of the substrate processing apparatus.

FIG. 7 is a vertical cross-sectional view illustrating a part of a modification of the first embodiment of the substrate processing apparatus.

FIG. 8 is a vertical cross-sectional view illustrating a second embodiment of the substrate processing apparatus.

FIG. 9 is a vertical cross-sectional view illustrating the second embodiment of the substrate processing apparatus.

FIG. 10 is a vertical cross-sectional view illustrating a part of the second embodiment of the substrate processing apparatus.

FIG. 11 is a vertical cross-sectional view illustrating a part of a modification of the second embodiment of the substrate processing apparatus.

FIG. 12 is a vertical cross-sectional view illustrating a third embodiment of the substrate processing apparatus.

DETAILED DESCRIPTION

<First Embodiment of Substrate Processing Apparatus>

[0008] A configuration example of a substrate processing apparatus according to the present disclosure will be described with reference to FIGS. 1 and 2, taking, as an example, a case where the configuration example is applied to an apparatus that performs film formation processing by atomic layer deposition (ALD) on a semiconductor wafer (hereinafter referred to as "wafer") W, which is a substrate.

As illustrated in these drawings, a substrate processing apparatus 1 includes a processing container 11 configured to accommodate and process the wafer W therein. The processing container 11 is formed in, for example, a circular shape in a plan view, and includes a top wall 111, a sidewall 12, and a bottom wall 13, each formed of, for example, the same metallic material. Further, in the processing container 11, an upper structure 2 is provided below the top wall 111 so as to be spaced apart from the top wall 111.

[0009] The upper structure 2 is formed in, for example, a circular shape in a plan view, and a periphery thereof is surrounded by the sidewall 12 of the processing container 11. In this

example, the upper structure 2 is configured to be capable of being raised and lowered, and an upper surface thereof is formed as a flat surface. The upper structure 2 is configured to be positioned above a transfer port 18 when the upper structure 2 is located at a transfer position (a position illustrated in FIG. 2), which will be described later. Further, the sidewall 12 is formed perpendicular to the bottom wall 13 and is configured to extend vertically upward from an outer edge of the bottom wall 14. In this example, the sidewall 12 constitutes a second annular portion.

[0010] A stage 3 on which the wafer W is placed is provided on the bottom wall 13 of the processing container 11. The stage 3 is formed in, for example, a flat cylindrical shape, is formed of, for example, a ceramic material so as to withstand high temperatures, and includes a heater 31 embedded therein. Further, a support 32 configured to support the stage 3 on the bottom wall 13 is provided at a center of a lower surface of the stage 3 and extends downward. Furthermore, a central portion of the bottom wall 13 of the processing container 11 protrudes downward. A recess 131 is formed in the protruding portion to match a shape of the support 32, and the support 32 is provided inside the recess 131.

[0011] Further, an exhaust port 14 configured to exhaust an interior of the processing container 11 is formed to be open vertically upward in the bottom wall 13 of the processing container 11 at a location outward of the stage 3 in a plan view. In this example, as illustrated in FIG. 3, a plurality of, for example, eight exhaust ports 14 are arranged along a circumferential direction of the stage 3. The exhaust ports 14 are arranged around the stage 3 at positions equally spaced apart from one another. Each exhaust port 14 is connected to a common exhauster 16 via an exhaust path 15 extending downward from the exhaust port 14, and the exhauster 16 includes, for example, a vacuum pump and a valve for opening and closing the exhaust path 15.

[0012] The upper structure 2 is disposed so as to face the stage 3 from above, and is configured to supply a process gas for processing the wafer W toward the wafer W placed on the stage 3. The upper structure 2 includes a main body 21 provided above the stage 3 so as to face the stage 3, and a first annular portion 22 extending downward from the main body 21 outside the stage 3.

[0013] In this example, the main body 21 includes a circular recess 23 at a lower surface side

thereof. A bottom surface of the recess 23 (with the recess 23 being formed upside down, the bottom surface thereof constitutes a ceiling surface of the processing container 11) is a horizontal flat surface, and forms an opposing region 231 facing the wafer W placed on the stage 3. Further, an outer region 232, which is an outer region of an edge portion of the opening of the recess 23, is formed on the lower surface of the main body 21, as a wide horizontal annular flat surface positioned at a lower height than that of the opposing region 231. In a plan view, the first annular portion 22 is formed adjacent to an outer peripheral edge of the outer region 232.

[0014] The upper structure 2 further includes, for example, a process gas discharge port (second discharge port) 24 at a center of a lower surface thereof, and the second discharge port 24 is formed so as to be open into the opposing region 231. The upper structure 2 further includes a flow path 25 connected to the second discharge port 24, and a supply pipe 261 connected to the flow path 25. Further, a base end side of the supply pipe 261 penetrates the top wall 111 of the processing container 11 and is connected to a first gas supply 26. The first gas supply 26 is a mechanism for supplying the process gas into the processing container 11, and includes, for example, a process gas source, a valve for opening and closing the supply pipe 261, and a gas flow rate adjuster.

[0015] For example, in a case where two types of gases are alternately supplied into the processing container 11 as the process gas and film formation processing is performed on the wafer W by ALD, the first gas supply 26 includes a raw material gas source, a reaction gas source, and a replacement gas source. In this example, the process gas includes a raw material gas, a reaction gas, and a replacement gas.

In addition, the upper structure 2 is not limited to this example, and may be configured to have a large number of second discharge ports formed in the lower surface thereof and to discharge the process gas in a shower-like manner from the second discharge ports.

[0016] The upper structure 2 is configured such that a distance between the upper structure 2 and the stage 3 can be changed by a driver 27. Specifically, the upper structure 2 is configured to be capable of being raised and lowered in a vertical direction by the driver 27 between a processing position (*see* FIG. 1), at which the wafer W is processed in the interior of the

processing container 11, and a transfer position (*see* FIG. 2), which is located above the processing position and at which the wafer W is transferred into and out of the processing container 11. In this example, a state where the upper structure 2 is located at the processing position is a first state in which the distance between the upper structure 2 and the stage 3 is a first distance. Further, a state where the upper structure 2 is located at the transfer position is a second state in which the distance between the upper structure 2 and the stage 3 is a second distance, and the second distance is set to be greater than the first distance. Since the upper structure 2 is configured to be capable of being raised and lowered as described above, the supply pipe 261 in this example is raised and lowered together with the upper structure 2. At this time, the upper structure 2 and the supply pipe 261 are configured to be raised and lowered while maintaining airtightness of the processing container 11.

[0017] Before continuing to describe a detailed configuration of the upper structure 2, a reason why the upper structure 2 is raised and lowered as described above and an overview of the configuration of the substrate processing apparatus 1 will be described. In this description, a film forming apparatus in which the stage 3, instead of the upper structure 2, is raised and lowered inside the processing container 11 will be taken as a comparative apparatus. In the comparative apparatus, when transferring the wafer W to the stage 3, the stage 3 is disposed at a relatively lower position (a lower position) inside the processing container 11. Further, when processing the wafer W, the stage 3 is disposed at a processing position higher than the lower position, in order to supply the process gas to the wafer W in a sufficient amount and concentration.

[0018] By setting the processing position as described above, in the comparative apparatus, a relatively large space is created between the bottom wall 13 of the processing container 11 and the lower surface of the stage 3 located at the processing position. However, in order to suppress an influence on the processing of the wafer W, it is required to prevent components constituting the process gas from adhering to a side surface and the lower surface of the stage 3. Further, when the process gas flows around to a rear surface side of the stage 3, the process gas may diffuse and stay inside the processing container 11, and may leak out of the processing

container 11 from the transfer port when the wafer W is unloaded. Therefore, an inert gas is supplied as a purge gas to the lower surface and the side surface of the stage 3 to prevent the process gas from flowing around. However, as described above, a large space is created below the stage 3. Accordingly, in order to obtain a sufficient purging effect, a supply amount of the purge gas may become relatively large. Further, when the supply amount of the purge gas increases, the purge gas may dilute the process gas, which affects the processing of the wafer W, or the exhauster 16 needs to become large-scaled.

[0019] Therefore, in the substrate processing apparatus 1 of the present embodiment, a positional relationship between the stage 3 and the bottom wall 13 is fixed such that the lower surface of the stage 3 is close to the bottom wall 13 of the processing container 11 to form a relatively small gap. This reduces a flow rate of the inert gas supplied to the lower surface of the stage 3. In addition to fixing the position relationship between the stage 3 and the bottom wall 13 as such, the upper structure 2 is configured to be raised and lowered in order for both transferring the wafer W with respect to the stage 3 and supplying a sufficient amount of process gas to the wafer W. The inert gas supplied to the lower surface of the stage 3 flows to the exhaust ports 14 via a gap formed around the side surface of the stage 3. The gap around the side surface is also formed to be small, so as to reduce the flow rate of the inert gas to be used. The gaps at a lower surface side and a side surface side of the stage 3 correspond to a second gap 42, which will be described later.

[0020] With such a configuration in which the upper structure 2 is raised and lowered as described above, a gap is formed between an outer peripheral surface of the upper structure 2 and the sidewall of the processing container 11. In order to prevent the process gas from flowing around to a space above the upper structure 2 of the processing container 11 via the gap, diffusing and staying inside the processing container 11, and consequently leaking out when the wafer is unloaded, the upper structure 2 is provided with the first annular portion 22 for regulating a flow of the process gas and guiding the process gas to the exhaust ports 14. Further, an inert gas is supplied to this gap, and by utilizing a flow of this inert gas toward the exhaust ports 14 as well, the diffusion of the process gas inside the processing container 11 is

prevented. This gap corresponds to a first gap 41, which will be described later, and the first gap 41 is defined by respective outer peripheral surfaces of the main body 21 and the first annular portion 22 constituting the upper structure 2.

[0021] Returning to the description of the configuration of the upper structure 2, when the upper structure 2 is at the processing position (in the first state), a processing space 10 for the wafer W is formed between the recess 23 of the upper structure 2 and the stage 3, as illustrated in FIG. 1. At this time, the outer region 232 of the upper structure 2 forms a gas flow path 17 as a gap between the outer region 232 and an upper surface of the stage 3. The gas flow path 17 is formed at a lateral side of the wafer W to surround the wafer W when viewed from the wafer W on the stage 3.

A height of the gas flow path 17 when the upper structure 2 is located at the processing position, that is, a distance between a lower surface of the outer region 232 and the upper surface of the stage 3, is, for example, 1 mm.

[0022] The outer region 232 of the upper structure 2 is formed from a region facing the stage 3 and extends outward to a position facing the exhaust port 14, and as described above, the outer peripheral edge of the outer region 232 is connected to the first annular portion 22. The first annular portion 22 is formed by a peripheral portion of the main body 21, which includes a side surface of the main body 21, extending downward. In a plan view, the outer peripheral surface of the main body 21 and the outer peripheral surface of the first annular portion 22 are aligned with each other.

[0023] A base end side (upper side) of the first annular portion 22 is configured as an inclined portion 233, and an inner peripheral surface of the inclined portion 233 is configured as an inclined surface that is directed toward a peripheral side of the processing container 11 as it extends downward. Accordingly, the inclined portion 233 decreases in thickness as it extends downward. The inclined surface is positioned above a portion of the exhaust port 14 that is closer to a peripheral edge of the processing container 11, and serves to guide the process gas to the exhaust port 14 while preventing stay of the process gas.

[0024] The prevention of the stay will be further described. In a case where the inclined

portion 233 is not provided and an inner peripheral surface of the first annular portion 22 at the base end side is formed perpendicular to the lower surface of the main body 21, a region defined by these surfaces (i.e., a corner portion) would have a relatively small angle (=90 degrees). Therefore, the process gas may stay in this region. However, by providing the inclined portion 233, such a region having a relatively small angle is not formed, thereby preventing stay of the process gas. In addition, similarly to the inclined portion 233, in the recess 23 described above as well, a side surface of the recess 23 is formed as an inclined surface that is directed toward the peripheral side of the processing container 11 as it extends downward, with respect to the opposing region 231, which is the bottom surface of the recess 23, for the purpose of preventing stay of the process gas.

[0025] Returning to the description of the first annular portion 22, a lower end portion of the first annular portion 22 is configured to extend downward from the inclined portion 233 at a position closer to an edge of the bottom wall 13 than the exhaust ports 14, as illustrated in FIGS. 1 to 4. Specifically, the lower end portion of the first annular portion 22 is a cylinder extending in the vertical direction, and an upper end of an inner peripheral surface of the cylinder is connected to a lower end of the inclined surface described above. A lower end of the first annular portion 22 is configured as a horizontal annular flat surface. In a plan view, the lower end is positioned closer to an edge (peripheral edge) of the processing container 11 than the respective exhaust ports 14. More specifically, as illustrated in FIG. 3, in a plan view, an inner peripheral edge of the lower end of the first annular portion 22 is positioned closer to the peripheral side of the processing container 11 than the respective exhaust ports 14.

[0026] Further, the lower end portion of the first annular portion 22 has a flat surface facing the bottom wall 13 of the processing container 11, and in the first state where the upper structure 2 is located at the processing position, the lower end portion is positioned lower than the upper surface (a surface on which the wafer W is placed) of the stage 3. With this configuration, as will be described later in a description of the processing of the wafer W, the process gas flowing over the stage 3 toward the peripheral side inside the processing container 11 collides with the first annular portion 22 and is reliably guided to the exhaust ports 14.

[0027] Further, in the first state, the lower end portion of the first annular portion 22 is positioned close to the bottom wall 13 of the processing container 11. This suppresses an inflow of the process gas into the first gap 41, and reliably prevents the process gas from leaking out of the processing container 11 via the first gap 41. A distance between a lower surface of the first annular portion 22 and an upper surface of the bottom wall 13 of the processing container 11 in the first state may be set to, for example, 1 mm or more to 2 mm or less.

[0028] As described above, the sidewall 12 of the processing container 11 constitutes the second annular portion, and when viewed from the first annular portion 22, the second annular portion is formed so as to surround the first annular portion 22. A gap formed between the upper structure 2 and the second annular portion (sidewall 12) when the upper structure 2 is located at the processing position is the first gap 41. The inert gas is supplied to the first gap 41, and the first gap 41 is in communication with the exhaust ports 14 such that the inert gas flows toward the exhaust ports 14. Accordingly, in the following description, the term "first gap 41" refers to a state where the upper structure 2 is located in the first state, which is at the processing position.

In order to prevent diffusion of the process gas inside the processing container 11 via the first gap 41, for example, a size of the first gap 41 may be such that a width (a distance between the first annular portion 22 and the sidewall 12) of the first gap 41 is 1 mm or less.

[0029] Further, an annular groove 5 is formed in the sidewall 12 of the processing container 11, as illustrated in FIGS. 3 to 5. The annular groove 5 faces the first gap 41 and is formed along an entire circumference of the sidewall 12. The annular groove 5 in this example is configured by forming a recess 51 in an inner surface of the sidewall 12. In this example, as illustrated in FIG. 4, the annular groove 5 is shaped such that a vertical cross-section thereof is a rectangle that is open toward the first gap 41. The annular groove 5 serves as a diffusion space for allowing the supplied inert gas to be sufficiently distributed over an entire circumference of the first gap 41. In order to ensure sufficiently high diffusibility of the inert gas, for example, a depth of the annular groove 5 (a depth of the recess 51) is formed to be greater than the above-described width of the first gap 41. In addition, the annular groove 5 is omitted in FIGS. 1 and 2, for convenience of illustration.

[0030] A first discharge port 52 that is open into the annular groove 5 to discharge the inert gas is formed in the annular groove 5. For example, a flow path 531 is provided in the sidewall 12 of the processing container 11 so as to be in communication with the annular groove 5. The flow path 531 is formed, for example, so as to connect an outer surface and the inner surface of the sidewall 12, and a tip end thereof is open into the annular groove 5 from a lateral side to form the first discharge port 52.

[0031] Further, a base end side of the flow path 531 is connected to a second gas supply 53 via a supply pipe 532 provided outside the processing container 11. In this example, the annular groove 5 and the first discharge port 52 are formed so as to be open at a position higher than the first annular portion 22 in the first state. Accordingly, the first discharge port 52 is positioned higher than the inclined portion 233 constituting the first annular portion 22. As will be described later, for a purpose of preventing entry of the process gas by supplying N_2 gas to the first gap 41, the first discharge port 52 is open at a position lower than an upper end of the upper structure 2 (which is also an upper end of the main body 21) at the processing position. In addition, in this example, the first discharge port 52 is open at a height higher than a region surrounded by the main body 21 and the first annular portion 22 at the processing position, as illustrated in FIG. 1.

[0032] The second gas supply 53 is a mechanism for supplying the inert gas such as nitrogen (N_2) gas to the first gap 41, and includes, for example, a N_2 gas source, a valve for opening and closing the supply pipe 532, and a flow rate adjuster for adjusting a flow rate of the gas. In this example, as illustrated in FIGS. 3 and 5, a plurality of first discharge ports 52 are formed in the annular groove 5 at equal intervals in a circumferential direction, and the respective first discharge ports 52 are connected to the common second gas supply 53 via the flow path 531 and the supply pipe 532.

[0033] Further, a third annular portion 54 is formed so as to protrude upward from the bottom wall 13 of the processing container 11 at a position closer to the stage 3 than the exhaust ports 14. As illustrated in FIG. 4, the third annular portion 54 is erected on the bottom wall 13 and is provided so as to surround the side surface of the stage 3 with a slight gap therebetween. An

upper end portion of the third annular portion 54 decreases in thickness as it extends upward, so that an outer peripheral surface of the upper end portion forms an inclined surface 542 that is directed toward the peripheral side of the processing container 11 as it extends downward. The inclined surface 542 guides the process gas from above the stage 3 toward the exhaust ports 14. In addition, an upper end surface of the third annular portion 54 is configured as a flat surface 541 facing the outer region 232 of the upper structure 2.

[0034] In this example, the flat surface 541 is set to be positioned at a slightly lower height than that of the upper surface of the stage 3, so as not to interfere with the flow of the process gas from above the stage 3 toward the exhaust ports 14. With this configuration, when the upper structure 2 located at the processing position, the first annular portion 22 is provided on a side of the exhaust port 14 facing the sidewall 12, the third annular portion 54 is provided on a side of the exhaust port 14 facing the stage 3, and the exhaust ports 14 is open into a space surrounded by these annular portions 22 and 54. In addition, as illustrated in FIG. 3, the third annular portion 54, the first annular portion 22, and the sidewall 12 of the processing container 11 constituting the second annular portion are rings that are concentric with one another in a plan view, and a center of each of the annular portions is aligned with the center of the stage 3 in a plan view.

[0035] The stage 3 and the support 32 are disposed so as to form slight gaps with the bottom wall 13 and the recess 131, respectively. Further, a gap formed between the third annular portion 54 and the side surface of the stage 3 is configured to be in communication with the gap formed between the stage 3 and the bottom wall 13 and the gap formed between the support 32 and the recess 131. With this configuration, the second gap 42 is formed among the stage 3, the bottom wall 13, and the third annular portion 54. The second gap 42 is provided to extend along the lower surface and the side surface of the stage 3. As described above, in order to prevent the inflow of process gas while reducing the amount of inert gas to be supplied, the second gap 42 is formed to be relatively small. A size of the second gap 42 (a distance between the lower surface of the stage 3 and the upper surface of the bottom wall 13 and a distance between the side surface of the stage 3 and the third annular portion 54) is set to, for example, 1

mm or less, specifically 0.5 mm or less.

[0036] The second gap 42 formed as described above is configured such that the inert gas such as N_2 gas is supplied to the second gap 42 from a third gas supply 55. The second gap 42 is connected, via a flow path 551, to a supply pipe 552 provided outside the processing container 11, and a base end side of the supply pipe 552 is connected to the third gas supply 55. The third gas supply 55 includes, for example, a N_2 gas source, a valve for opening and closing the supply pipe 552, and a gas flow rate adjuster.

[0037] Further, the transfer port 18 is formed in the sidewall 12 of the processing container 11 for loading and unloading the wafer W with respect to the processing container 11 when the upper structure 2 is located at the transfer position. The transfer port 18 is configured to be opened and closed by a gate valve 19. Furthermore, the processing container 11 is provided with vertically movable delivery pins configured to deliver the wafer W between an external transfer mechanism (not illustrated) and the stage 3.

[0038] The substrate processing apparatus 1 having the above-described configuration includes a controller 100. The controller 100 is configured as a computer including a storage storing a program, a memory, and a CPU. The program is configured to cause the controller 100 to output, to individual components of the substrate processing apparatus 1, control signals for performing necessary control to process the wafer W.

The program is stored in the storage of the computer, such as a flexible disk, a compact disk, a hard disk, a magneto-optical (MO) disk, a non-volatile memory, or the like, and is read from the storage and installed in the controller 100. Start and stop of the supply of the process gas from the first gas supply 26 and the supply of the inert gas (N_2 gas) from the second gas supply 53 and the third gas supply 55, as well as adjustment of the flow rates thereof, are also executed based on commands issued from the controller 100.

<Substrate Processing Method>

[0039] An example of a substrate processing method performed in the substrate processing apparatus 1 will now be described. First, in the second state where the upper structure 2 is

located at the transfer position, the wafer W is loaded into the processing container 11 via the transfer port 18 and is placed on the stage 3. In this state, the process gas is not supplied into the processing container 11.

Subsequently, the upper structure 2 is lowered to the processing position to be set to the first state, and the interior of the processing container 11 is exhausted via the exhaust ports 14 and adjusted to a preset pressure. Further, the wafer W on the stage 3 is heated by the heater 31 to a preset processing temperature between 400 degrees C and 800 degrees C.

[0040] Thereafter, a raw material gas and a reaction gas are alternately supplied from the first gas supply 26 into the processing space 10 via the upper structure 2 in a sequential order of the raw material gas→ the replacement gas→ the reaction gas→ the replacement gas, thereby forming a thin film on the wafer W by ALD. At this time, the flow of the process gas is regulated by the first annular portion 22 of the upper structure 2 inside the processing container 11.

In addition, at least while the process gas is supplied into the processing container 11 from the first gas supply 26, N_2 gas is supplied from the second gas supply 53 and the third gas supply 55 to the first gap 41 and the second gap 42, respectively.

[0041] The flow of the gas inside the processing container 11 will be described with reference to FIG. 6. In this drawing, the process gas supplied from the first gas supply 26 is indicated by solid lines, while the N_2 gas supplied from the second gas supply 55 and the third gas supply 55 is indicated by dashed lines.

Since the interior of the processing container 11 is exhausted by the exhauster 16 via the exhaust ports 14, the process gas supplied into the processing space 10 flows from the gas flow path 17, which is formed so as to surround the stage 3 at the lateral side of the wafer W, toward the exhaust ports 14 surrounded by the first annular portion 22 and the third annular portion 54.

Further, although some of the process gas may travel straight above the exhaust ports 14 instead of moving toward the exhaust ports 14, such process gas collides with the first annular portion 22 and changes a direction thereof to move toward the exhaust ports 14.

[0042] Further, in the processing position at which the upper structure 2 is in the first state, the

lower end of the first annular portion 22 is positioned lower than the upper surface of the stage 3. Therefore, as described above, the process gas, which is supplied from the upper structure 2 toward the stage 3 and then flows outward of the stage 3, reliably collides with the first annular portion 22. With this configuration, the process gas flows directly into the exhaust ports 14, or changes its flow direction by the first annular portion 22 to flow into the exhaust ports 14.

[0043] The N_2 gas is supplied to the first gap 41 between the upper structure 2 and the sidewall 12 and to the second gap 42 between the stage 3 and the bottom wall 13, and this N_2 gas also flows toward the exhaust ports 14. The first gap 41 is formed along a side surface of the upper structure 2 so as to surround the upper structure 2. The N_2 gas supplied to the first gap 41 flows downward while diffusing in a circumferential direction along the side surface of the upper structure 2, and is then discharged from the exhaust ports 14 via a gap at the lower end of the first annular portion 22.

[0044] Further, the second gap 42 is formed so as to surround the stage 3, and the N_2 gas supplied to the second gap 42 flows upward while diffusing in the circumferential direction along the side surface of the stage 3, and then flows toward the exhaust ports 14 via a gap at the upper end of the third annular portion 54.

As described above, in the processing container 11, the N_2 gas is discharged toward the exhaust ports 14 from an entire circumference of the lower end of the first annular portion 22, while the N_2 gas is also discharged toward the exhaust ports 14 from an entire circumference of the stage 3.

[0045] The N_2 gas is continuously supplied to the first and second gaps 41 and 42 during a period in which the raw material gas, the reaction gas, and the replacement gas, which serve as the process gas, are supplied into the processing space 10. As a result, along with the flow of the N_2 gas continuously supplied to the first and second gaps 41 and 42, the process gas is guided toward the exhaust ports 14. With this configuration, the flow of the N_2 gas prevents the process gas from entering the first gap 41 and the second gap 42.

Since the first and second gaps 41 and 42 are relatively narrow spaces, a probability of the process gas entering the first and second gaps 41 and 42 instead of flowing toward the

exhaust ports 14 is inherently low. However, by supplying the N_2 gas as described above, the entry of the process gas into these gaps 41 and 42 can be reliably prevented.

[0046] The flow of the N_2 gas in the first gap 41 will be described in more detail. The N_2 gas supplied to the annular groove 5 via the first discharge ports 52 diffuses inside the annular groove 5. In other words, the N_2 gas flows in the circumferential direction along the annular groove 5 so as to surround the first gap 41. Thereafter, due to the exhaust from the exhaust ports 14, the N_2 gas flows downward from an entirety of the annular groove 5 into the first gap 41 and then flows from below the first annular portion 22 toward a central side of the processing container 11. Accordingly, by the annular groove 5, the N_2 gas is supplied with a high degree of uniformity over the entire circumferential direction of the first gap 41, thereby increasing an internal pressure of the first gap 41, and is also supplied at a sufficient flow rate from an entire region below the first annular portion 22.

[0047] For the reason described above, even in a case where the process gas flows into the first gap 41 and attempts to pass upward through the first gap 41, the process gas is prevented from passing through the first gap 41 over the entire circumferential direction of the first gap 41, and diffusion of the process gas inside the processing container 11 can be prevented. Therefore, the process gas does not diffuse and stay inside the processing container 11, and it is possible to reliably prevent the process gas from leaking out of the processing container 11 via the transfer port 18 when the wafer W is unloaded.

In this example, since the first discharge ports 52 are formed in the annular groove 5 at equal intervals along the circumferential direction, the N_2 gas can be supplied throughout the entire circumferential direction of the first gap 41 more reliably. Thus, it is possible to increase a pressure at each portion in the circumferential direction, and to prevent the process gas from passing through the first gap 41 as described above.

[0048] Further, in this example, in the first state, the first discharge ports 52 are open at the position higher than a region enclosed by the first annular portion 22 and the main body 21, and the N_2 gas flows over a relatively long distance before reaching the lower end of the first annular portion 22. Therefore, the N_2 gas diffuses from the first discharge ports 52 to the lower end of

the first annular portion 22 with a high degree of uniformity in the circumferential direction of the first annular portion 22, and is discharged from the entire circumference below the first annular portion 22 toward the central side of the processing container 11 with a high degree of uniformity. Accordingly, the inflow of the process gas into the first gap 41 is prevented more reliably.

[0049] In addition, by discharging the N_2 gas from the first discharge ports 52 as described above, some of the N_2 gas may move upward through the first gap 41 and diffuse inside the processing container 11, as illustrated in FIG. 6. However, most of the N_2 gas discharged from the first discharge ports 52 moves downward through the first gap 41 by the exhaust from the exhaust ports 14 as described above, and only a small amount of the N_2 gas moves upward. Further, since the N_2 gas is an inert gas, there is no effect caused by the N_2 gas leaking out of the processing container 11 when the wafer W is unloaded.

<Modification of First Embodiment>

[0050] A modification of the above-described embodiment will be described with reference to FIG. 7. In this example, an annular groove 5A is formed in the first annular portion 22 rather than in the sidewall 12 constituting the second annular portion. The annular groove 5A faces the first gap 41, and is formed along an entire circumference of the first annular portion 22. The annular groove 5A in this example is configured by forming a recess 510 in an outer surface of the first annular portion 22, and includes a first discharge port 521 that is open into the annular groove 5A. For example, the upper structure 2 is provided with a flow path 533 in communication with the annular groove 5A, and a tip end of the flow path 533 is open into the annular groove 5A to form the first discharge port 521. Further, a base end side of the flow path 533 is connected to the second gas supply 53 via a supply pipe 534 provided outside the processing container 11.

[0051] Even with this configuration, the N_2 gas is supplied to the first gap 41 via the annular groove 5A during at least a period in which the process gas is supplied into the processing container 11. Therefore, the annular groove 5A enables the N_2 gas to be sufficiently supplied to

each portion of the first gap 41 in the circumferential direction, thereby preventing the process gas from passing through that region. Therefore, the process gas can be prevented from diffusing inside the processing container 11 via the first gap 41 and leaking out of the processing container 11 when the wafer is unloaded.

[0052] In supplying the N_2 gas to the first gap 41 as described above, the N_2 gas may be supplied from either the first annular portion 22 or the second annular portion (the sidewall 12 of the processing container 11). However, in the example of FIG. 7, the supply pipe 534 for the N_2 gas connected to the upper structure 2 is raised and lowered together with the upper structure 2, which restricts a design of the apparatus and may increase costs. In this regard, it can be said that it is advantageous to provide the first discharge ports 52 in the sidewall 12 of the processing container 11, which does not undergo vertical movement.

[0053] According to the above-described embodiment, in the substrate processing apparatus 1 in which the distance between the upper structure 2 and the stage 3 is changed, the N_2 gas, which is an inert gas, is supplied to the first gap 41 formed between the first annular portion 22 of the upper structure 2 and the second wall portion constituted by the sidewall 12 of the processing container 11. Therefore, the process gas may be reliably prevented from diffusing inside the processing container 11 via the first gap 41.

Further, in the upper structure 2, by providing the first annular portion 22 such that the lower end thereof is positioned closer to the edge of the bottom wall than the exhaust ports 14, and by supplying the N_2 gas to the first gap 41 formed between the first annular portion 22 and the sidewall 12 (the second wall portion), exhausting the process gas can be promoted while preventing the process gas from flowing around into the first gap 41.

[0054] Furthermore, the first gap 41 formed between the upper structure 2 and the sidewall 12 of the processing container 11 is a narrow space, and the second gap 42 formed between the stage 3 and the bottom wall 13 of the processing container 11 can also be set as a narrow space by providing the upper structure 2 so as to be capable of being raised and lowered. Accordingly, since the N_2 gas is supplied to these narrow gaps 41 and 42, it is possible to prevent the process gas from flowing around into the gaps 41 and 42 and diffusing inside the processing container

11, while reducing the flow rate of the N_2 gas.

[0055] In a case where the exhaust ports 14 is open into the first gap 41, an exhaust flow rate at a portion of the first gap 41 where the exhaust ports 14 is open increases, thereby making it difficult to supply the N_2 gas to the first gap 41 with a high degree of uniformity in the circumferential direction as described above. Further, in order to prevent the process gas from flowing around into the first gap 41, the first annular portion 22 is configured to be positioned close to the bottom wall 13 of the processing container 11 at a position closer to the peripheral edge of the processing container 11 than the exhaust ports 14, such that a pressure loss of the process gas at that position increases. Therefore, the lower end of the first annular portion 22 is configured to be positioned closer to the edge of the bottom wall 13 than the exhaust ports 14 in a plan view, and this configuration will be further described below.

[0056] A layout of the above-described example is such that, in a plan view, the inner peripheral edge of the lower end of the first annular portion 22 is positioned closer to the peripheral side of the processing container 11 than the respective exhaust ports 14. However, the lower end of the first annular portion 22 being positioned closer to the edge of the bottom wall 13 than the exhaust ports 14 in a plan view is not limited to such a layout. For example, the first annular portion 22 may be formed with a greater width than in the above-described example, and the inner peripheral edge of the lower end of the first annular portion 22 may be positioned slightly closer to the central side of the processing container 11 than in the above-described example, such that the inner peripheral edge overlaps with the exhaust ports 14 in a plan view. In other words, a portion of the lower end of the first annular portion 22 may overlap with the exhaust ports 14 in a plan view, as long as the outer peripheral edge of the lower end of the first annular portion 22 is positioned outside the exhaust ports 14 in a plan view.

[0057] However, in order to more reliably achieve the effect of preventing the process gas from flowing around into the first gap 41, it is better for an area of the first annular portion 22 that is close to the bottom wall 13 to be larger. Therefore, the lower end of the first annular portion 22 may not overlap with the exhaust ports 14 in a plan view, as in the above-described example. In addition, portions of the first annular portion 22 other than the lower end thereof may overlap

with the exhaust ports 14 as exemplified by the inclined portion 233 of the first annular portion 22, or may not overlap with the exhaust ports 14. Further, in this example, in supplying the N_2 gas to the first gap 42, an entirety of each first discharge port 52 is open at a position lower than the upper end of the upper structure 2. However, a configuration in which only a lower portion of the first discharge port 52 is open below the upper end of the upper structure 2 may be adopted.

<Second Embodiment>

[0058] Next, a second embodiment of a substrate processing apparatus 1A will be described with reference to FIGS. 8 and 9. In this example, the stage 3 is configured to be raised and lowered by a driver 7 so as to change a distance between an upper structure 2A and the stage 3. However, in order to avoid the problems described with reference to the comparative example, a portion of a bottom wall 63 of a processing container 6 is also moved together with the stage 3. The following description focuses mainly on differences from the first embodiment, and components configured in the same manner as those of the first embodiment are denoted by the same reference numerals and detailed descriptions thereof are omitted.

[0059] The processing container 6 includes a top wall 61, a sidewall 62, and the bottom wall 63. The bottom wall 63 is divided into a first bottom wall 64 and a second bottom wall 65. In a plan view, the first bottom wall 64 and the second bottom wall 65 are formed in a circular shape and an annular shape, respectively, and are arranged concentrically. A region of the first bottom wall 64 other than a central portion of the first bottom wall 64 is disposed above the second bottom wall 65 so as to overlap with the second bottom wall 65 in a plan view, and a peripheral portion of the second bottom wall 65 is positioned outward of the first bottom wall 64. The sidewall 62 is erected on an edge portion of the second bottom wall 65. Further, a transfer port 621 for loading and unloading the wafer W is formed in the sidewall 62 so as to be opened and closed by a gate valve 622.

[0060] The first bottom wall 64 is provided with an exhaust port 66, a second annular portion 67, and the stage 3, and the stage 3 is configured in the same manner as in the first embodiment.

The first bottom wall 64 includes a planar portion 641 facing the second bottom wall 65 and a recess 642 formed so as to protrude downward from the planar portion 641 and surround the support 32 of the stage 3. The planar portion 641 extends along the lower surface of the stage 3 to an outside of the stage 3. With this configuration, the first bottom wall 64 is configured to cover a bottom surface of the stage 3 and a side surface of the support 32 with a gap therebetween, while supporting a bottom surface of the support 32. Further, the recess 642 is inserted through an opening formed in the second bottom wall 65, and a lower side of the recess 642 is positioned lower than the second bottom wall 65.

[0061] The exhaust port 66 is formed in the planar portion 641 of the first bottom wall 64 so as to be open outward of the stage 3 in a plan view. Although only one exhaust port 66 is illustrated in FIGS. 8 and 9, a plurality of exhaust ports 66 are provided in this example, along the circumferential direction of the stage 3. Each exhaust port 66 is connected, inside the processing container 6, to a bellows 68 provided at a lower surface of the second bottom wall 65 via an exhaust pipe 661 extending downward therefrom. A lower end side of the bellows 68 is connected to the exhauster 16 common to the respective exhaust ports 66 via the exhaust path 15. Further, in the first bottom wall 64, the second annular portion 67 is formed so as to extend upward from the first bottom wall 64 at a position closer to an edge of the first bottom wall 64 than the exhaust port 66 in a plan view, more specifically at a peripheral portion of the first bottom wall 64.

[0062] The recess 642 of the first bottom wall 64 is connected to the driver 7 below the processing container 11 and is configured to raise and lower the stage 3 via the first bottom wall 64. More specifically, the stage 3 and the first bottom wall 64 are raised and lowered in the vertical direction with respect to the second bottom wall 65 and the upper structure 2A. In this example, the driver 7 includes a ball screw mechanism, in which a ball screw 71 has an upper end in contact with the lower surface of the second bottom wall 65 and a lower end connected to a motor 72, and an elevator 73 provided in the ball screw 71 is connected to the recess 642.

[0063] Further, in a vicinity of the recess 642 of the first bottom wall 64, a lower surface of the first bottom wall 64 and an upper surface of the second bottom wall 65 are connected by a

bellows 74, serving as an extendable and contractible connector. With this configuration, the stage 3 is raised and lowered together with the first bottom wall 64 by the driver 7, and moves between a processing position (the first state) illustrated in FIG. 8 and a transfer position (the second state) illustrated in FIG. 9. At this time, the bellows 68 and 74 extend and contract in accordance with the vertical movement of the stage 3, thereby maintaining airtightness inside the processing container 11. As described above, the first bottom wall 64 and the second bottom wall 65 are connected to each other while maintaining airtightness inside the processing container 11, and constitute the bottom wall 63 of the processing container 6.

[0064] Further, the upper structure 2A is supported on the second bottom wall 65. The upper structure 2A is disposed below the top wall 61 of the processing container 6 so as to face the stage 3 and is spaced apart from the top wall 61. The upper structure 2A includes the main body 21, the first annular portion 22, and the second discharge port 24, which are configured in the same manner as in the first embodiment. In this example, in order to avoid influence of thermal expansion, which will be described later, the upper structure 2A including the first annular portion 22 and the first bottom wall 64 including the second annular portion 67 are formed of, for example, the same metallic material.

[0065] The upper structure 2A of this embodiment has a peripheral portion extending downward to form a support 28, and the support 28 is configured in an annular shape. The support 28 is positioned outward of the second annular portion 67, and a lower end thereof is connected to the second bottom wall 65. In addition, the support 28 is provided so as to be spaced apart from the sidewall 62 of the processing container 6, and is configured as a separate member from the sidewall 62. Further, an opening 281 for loading and unloading the wafer W is formed in the support 28 at a position that overlaps with the transfer port 621 of the processing container 6 in a side view.

[0066] In this example, the first annular portion 22 is provided to extend downward from the main body 21, so as to be positioned in a vicinity of an inner surface of the second annular portion 67. Further, the lower end of the first annular portion 22 is positioned closer to the edge of the first bottom wall 64 than the exhaust port 66 in a plan view. More specifically, in this

example, the inner peripheral edge of the lower end of the first annular portion 22 overlaps with an edge of the exhaust port 66 on the peripheral side of the processing container 6 in a plan view.

[0067] As illustrated in FIG. 8, when the stage 3 is at the processing position (in the first state), a first gap 81 is formed between the first annular portion 22 and the second annular portion 67. Further, as illustrated in FIG. 10, the first annular portion 22 is provided with, for example, an annular groove 83 facing the first gap 81 along the entire circumference of the first annular portion 22, and a first discharge port 82 is open into the annular groove 83. The first discharge port 82 is connected to the second gas supply 53 via a flow path 821 and the supply pipe 532. As described above, the N_2 gas is supplied from the second gas supply 53 to the first gap 81. In this example, the flow path 821 is formed in the support 28 and the second bottom wall 65.

[0068] Further, a third annular portion 84 is formed so as to protrude upward from the first bottom wall 64 at a position closer to the stage 3 than the exhaust port 66. The third annular portion 84 is provided so as to surround the stage 3 with a slight gap therebetween, and a second gap 85 is formed by the third annular portion 84, the first bottom wall 64, and the stage 3. The second gap 85 is configured such that the N_2 gas is supplied to the second gap 85 from the third gas supply 55 via the supply pipe 552 and the flow path 551. Sizes of the first gap 81 and the second gap 85 are set, for example, in the same manner as in the first embodiment.

[0069] Also in this embodiment, the stage 3 is located at the transfer position (in the second state), and the wafer W is loaded into the processing container 6 via the opening 281 and the transfer port 621 and placed on the stage 3. Thereafter, the stage 3 is set to the processing position (the first state), and the N_2 gas is supplied to the first gap 81 and the second gap 85 at least while the process gas is supplied into the processing container 11.

As described above, similarly to the first embodiment, the process gas is discharged from the processing container 6 via the exhaust ports 66 without entering the first gap 81 and the second gap 85. Therefore, diffusion of the process gas inside the processing container 6 through the first gap 81 and the second gap 85 is prevented, and the process gas is prevented from leaking out of the processing container 6 when the wafer is unloaded.

[0070] When the stage 3 reaches a relatively high temperature during processing of the wafer W,

the upper structure 2A and the first bottom wall 64 receive radiant heat from the stage 3 and undergo thermal expansion, such that respective peripheral edges thereof are displaced away from a center of the processing container 6 in a plan view.

In a case where the upper structure 2A is connected to a lower surface of the top wall 61 of the processing container 6 and the top wall 61 and the upper structure 2 are formed of different materials, an amount of displacement of the peripheral edge of the upper structure 2A is affected by a displacement caused by thermal expansion of the top wall 61. Further, it is conceivable that, since the top wall 61 is in contact with a space inside a temperature-controlled clean room in which the substrate processing apparatus 1A is installed, thermal expansion of the top wall 61 is suppressed, which may affect the amount of displacement of the peripheral edge of the upper structure 2A.

[0071] Even in a case where the top wall 61 is configured as the upper structure 2A as will be described later, thermal expansion thereof is similarly prevented due to the influence of a temperature of the clean room. However, as described above, the upper structure 2A is supported by the support 28, which is a separate member from the sidewall 62 of the processing container 6, and is therefore formed as a separate member from the top wall 61. Consequently, an amount of thermal expansion of the upper structure 2A is unlikely to be affected by the top wall 61 described above.

[0072] When displacement of the peripheral edges of the upper structure 2A and the first bottom wall 64 is generated due to thermal expansion, positions of the first annular portion 22 provided at the upper structure 2A and the second annular portion 67 provided at the first bottom wall 64 also change with respect to the center of the processing container 6 in a plan view. However, as described above, since the amount of thermal expansion of the upper structure 2A is unlikely to be affected by the top wall 61, and since the upper structure 2A and the first bottom wall 64 are formed of the same material and exhibit substantially the same amount of thermal expansion, amounts of change in respective positions of the first annular portion 22 and the second annular portion 67 are the same or substantially the same. Therefore, change in a width of the first gap 81 is suppressed, and the process gas is prevented from easily leaking out.

Further, in this embodiment, since the upper structure 2A is fixed to the second bottom wall 65, it is not necessary for the supply pipes 261 and 532 for the process gas and the N_2 gas to be raised and lowered, which increases a degree of freedom in apparatus design.

<Modification of Second Embodiment>

[0073] In this example, as illustrated in FIG. 11, the N_2 gas is supplied from the second annular portion 67 to the first gap 81. In this case, for example, the second annular portion 67 is provided with a first discharge port 86 configured to discharge the N_2 gas toward the first gap 81, and a flow path 861 for the N_2 gas. For example, the second bottom wall 65 is connected to the second gas supply 53 (not illustrated in FIG. 11) via the supply pipe 532, and a flow path 862 connected to the supply pipe 532 is formed in the second bottom wall 65 and the support 28.

[0074] Inside the processing container 6, the flow path 861 in the second annular portion 67 and the flow path 862 in the second bottom wall 65 and the support 28 are connected to each other by, for example, a flexible supply pipe 863, so as to supply the N_2 gas from the second gas supply 53 to the first discharge port 86. Since the N_2 gas is supplied to the first gap 81 while the process gas is supplied into the processing container 6 in this configuration as well, similarly to the above-described embodiment, the diffusion of the process gas inside the processing container 6 is prevented, and the process gas is prevented from leaking out of the processing container 6 when the wafer is unloaded.

<Third Embodiment>

[0075] Next, a third embodiment of a substrate processing apparatus 1B will be described with reference to FIG. 12. In this example, a processing container 9 is constituted by the upper structure 2A and the second bottom wall 65 of the second embodiment. In this configuration example, the upper structure 2A forms a top wall of the processing container 9, and the support 28 forms a sidewall of the processing container 9. A transfer port 91 for the wafer W is provided in the support 28 and is configured so as to be opened and closed by a gate valve 92. Other configurations are the same as those of the second embodiment, and the same reference

numerals are given to the same constituent members.

[0076] With this configuration as well, similarly to the second embodiment, the stage 3 is located at the transfer position (in the second state), and the wafer W is loaded into the processing container 9 through the transfer port 91 and placed on the stage 3. Thereafter, the stage 3 is set to the processing position (the first state), and the N_2 gas is supplied to the first gap 81 and the second gap 85 while the process gas is supplied into the processing container 11. Therefore, diffusion of the process gas inside the processing container 9 through the first gap 81 and the second gap 85 is prevented, and the process gas is prevented from leaking out of the processing container 9 when the wafer is unloaded.

[0077] This configuration, with the processing container 9 is constituted by the upper structure 2A and the second bottom wall 65, has a simpler structure than that of the second embodiment, and is advantageous in terms of manufacturing cost because the number of components is smaller. For the first annular portion 22 of the third embodiment, an example has been illustrated in which a portion of the first annular portion 22 overlaps with the exhaust port 66 in a plan view.

[0078] In the substrate processing apparatus of the present disclosure, it is not necessarily required to form the annular groove facing the first gap as described above. Instead of providing the annular groove, a plurality of first discharge ports facing the first gap may be arranged in the circumferential direction. That is, as long as the number and shape of the first discharge ports are appropriately set such that a gas can be sufficiently supplied over the entire circumferential direction of the first gap, the substrate processing apparatus is not limited to have a configuration in which the first discharge ports are open into the annular groove. Further, the annular groove is not limited to the shape described above and may be appropriately configured, for example, such that a vertical cross-section thereof is formed in a substantially semicircular shape.

[0079] Furthermore, the first annular portion is not limited to the shape described above, as long as a lower end thereof is positioned closer to the edge of the bottom wall of the processing container than the exhaust port in a plan view. For example, a surface of the first annular

portion facing the stage may be formed as an inclined surface. For example, the first annular portion may be configured to taper downward, such that the surface of the first annular portion facing the stage forms as an inclined surface that inclines toward a peripheral side of the processing container as it extends downward from an upper end to the lower end of the first annular portion.

[0080] Further, it is not necessarily required for the upper structure of the present disclosure to be configured as a gas supply, as long as a processing space for the wafer W is formed between the upper structure and the stage. For example, the upper structure may be configured as an upper electrode such that plasma is generated between the upper structure and the stage serving as a lower electrode. The apparatus may further be configured such that a process gas is supplied into the processing space formed by the upper structure and the stage, by using a gas nozzle or the like.

[0081] While the substrate processing apparatus is described as an apparatus that performs film formation processing by ALD in the above-described embodiments, the substrate processing apparatus may also be an apparatus that performs plasma ALD. Further, the substrate processing apparatus is not limited to an apparatus that performs film formation processing. Further, the shape of the processing space, the number of exhaust ports, and the layout of the processing container of the substrate processing apparatus described above are merely examples, and are not limited to the configurations described above.

In addition, an inert gas supplied to the first gap or a second gap is not limited to the N_2 gas, and argon gas (Ar) may be used. Further, the apparatus may be configured to supply the inert gas to the first gap or the second gap in a state where the upper structure and the stage are disposed in the first state (processing position) and the process gas is not supplied into the processing container, to promote exhaust of the interior of the processing container.

[0082] Although a wafer has been described as an example of a substrate in the above description, substrates to be processed in the processing container may include, in addition to the wafer, a substrate for manufacturing a flat panel display, a substrate for manufacturing an exposure mask used in photolithography, and a dummy substrate on which processing is

performed for the purpose of testing or setting processing parameters in the substrate processing apparatus.

[0083] The embodiments disclosed herein should be considered as illustrative and not restrictive in all respects. The above embodiments may be omitted, replaced, or modified in various ways without departing from the scope and spirit of the appended claims.

EXPLANATION OF REFERENCE NUMERALS

[0084] W: wafer, 1, 1A, 1B: substrate processing apparatus, 11, 6, 9: processing container, 13, 63: bottom wall, 14, 66: exhaust port, 3: stage, 26: first gas supply, 2, 2A: upper structure, 21: main body, 22: first annular portion, 27, 7: driver, 12, 67: second annular portion, 41, 81: first gap, 53: second gas supply

WHAT IS CLAIMED IS:

1. A substrate processing apparatus comprising:

a processing container;

a stage on which a substrate is placed in the processing container;

an exhaust port that is open in a bottom wall of the processing container at a location outward of the stage in a plan view, and is configured to exhaust an interior of the processing container;

a first gas supply configured to supply a process gas for processing the substrate placed on the stage into the processing container;

an upper structure including a main body provided above the stage so as to face the stage, and a first annular portion extending downward from the main body to regulate a flow of the process gas and having a lower end positioned closer to an edge of the bottom wall than the exhaust port in a plan view;

a driver configured to change a distance between the stage and the upper structure;

a second annular portion extending upward from the bottom wall of the processing container so as to surround the first annular portion; and

a second gas supply configured to supply an inert gas to a first gap, which is formed by the upper structure and the second annular portion and is in communication with the exhaust port.

2. The substrate processing apparatus of Claim 1, wherein the distance between the stage and the upper structure is changed by the driver between a first distance and a second distance greater than the first distance,

wherein the process gas is supplied from the first gas supply into the processing container in a first state in which the distance is set to the first distance, and

wherein the process gas is not supplied from the first gas supply into the processing container in a second state in which the distance is set to the second distance.

3. The substrate processing apparatus of Claim 2, wherein the lower end of the first annular portion is positioned lower than an upper surface of the stage in the first state.

4. The substrate processing apparatus of Claim 1, wherein an annular groove extending over an entire circumference of one annular portion of the first annular portion and the second annular portion is formed in the one annular portion so as to face the first gap, and

wherein a first discharge port configured to discharge the inert gas is provided so as to be open into the annular groove.

5. The substrate processing apparatus of Claim 1, wherein the second gas supply supplies the inert gas to the first gap at least during the supply of the process gas from the first gas supply into the processing container.

6. The substrate processing apparatus of Claim 1, wherein a third annular portion is provided so as to protrude upward from the bottom wall at a position closer to the stage than the exhaust port and surround the stage, and

wherein a third gas supply is provided to supply the inert gas to a second gap formed by the third annular portion, the bottom wall, and the stage.

7. The substrate processing apparatus of Claim 6, wherein the second annular portion constitutes a sidewall of the processing container,

wherein the upper structure includes a second discharge port configured to discharge the process gas, and

wherein the driver raises and lowers the upper structure with respect to the stage.

8. The substrate processing apparatus of Claim 7, wherein the distance between the stage and the upper structure is changed by the driver between a first distance and a second distance greater than the first distance,

wherein the process gas is supplied from the first gas supply into the processing container in a first state in which the distance is set to the first distance,

wherein the process gas is not supplied from the first gas supply into the processing container in a second state in which the distance is set to the second distance, and

wherein a first discharge port configured to discharge the inert gas is provided so as to be open at a position lower than an upper end of the main body in the first state.

9. The substrate processing apparatus of Claim 8, wherein the first discharge port is provided in the sidewall of the processing container.

10. The substrate processing apparatus of Claim 6, wherein the bottom wall of the processing container is divided into a first bottom wall and a second bottom wall,

wherein the exhaust port, the second annular portion, and the stage are provided on the first bottom wall,

wherein the upper structure including a second discharge port configured to discharge the process gas is supported on the second bottom wall,

wherein the driver raises and lowers the first bottom wall and the stage with respect to the upper structure and the second bottom wall, and

wherein a connector configured to be extendable and contractible is provided to connect the first bottom wall and the second bottom wall so as to make the interior of the processing container airtight.

11. The substrate processing apparatus of Claim 10, wherein the upper structure is provided separately from a top wall of the processing container to be spaced apart from the top wall, and is

supported on the second bottom wall by a support that is provided separately from a sidewall of the processing container.

12. A substrate processing method comprising:

placing a substrate on a stage provided in a processing container;

exhausting an interior of the processing container through an exhaust port that is open in a bottom wall of the processing container at a location outward of the stage in a plan view;

supplying a process gas into the processing container from a first gas supply to process the substrate placed on the stage;

regulating a flow of the process gas by a first annular portion of an upper structure, the upper structure including a main body provided above the stage so as to face the stage, and the first annular portion extending downward from the main body and having a lower end positioned closer to an edge of the bottom wall than the exhaust port in a plan view;

changing a distance between the stage and the upper structure by a driver; and

supplying an inert gas from a second gas supply to a first gap, which is formed by the upper structure and a second annular portion extending upward from the bottom wall of the processing container to surround the first annular portion, and is in communication with the exhaust port.