United States Patent Application Publication	20250259873
Kind Code	A1
Publication Date	August 14, 2025
Inventor(s)	TAKEBAYASHI; Yuji et al.

SUBSTRATE PROCESSING APPARATUS, ELEVATOR AND METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE

Abstract

A technique is capable of improving uniformity of film thickness on substrates. According to one aspect thereof, a substrate processing apparatus includes: a process chamber for processing a plurality of substrates; a substrate support supporting the substrates; a partition plate support supporting a plurality of partition plates arranged between the substrates; a driver that changes a distance between each of the substrates and partition plates by moving one of the substrate support and partition plate support in a vertical direction; a gas supplier with a hole for supplying a gas to the plurality of substrates; and a controller for controlling the driver and the gas supplier such that the gas is supplied to the substrates and one of a relative vertical position of each of the substrates and a relative vertical position of each of the partition plates with respect to the hole is changed by the driver.

Inventors: **TAKEBAYASHI; Yuji (Toyama-shi, JP), HIRANO; Makoto (Toyama-shi, JP), SHIBATA; Koji (Toyama-shi, JP), OKAJIMA; Yusaku (Toyama-shi, JP)**

Applicant: **KOKUSAI ELECTRIC CORPORATION** (Tokyo, JP)

Family ID: **1000008563589**

Assignee: **KOKUSAI ELECTRIC CORPORATION (Tokyo, JP)**

Appl. No.: **19/098328**

Filed: **April 02, 2025**

Related U.S. Application Data

parent US continuation 17691641 20220310 parent-grant-document US 12293932 child US 19098328
parent WO continuation PCT/JP2019/038175 20190927 PENDING child US 17691641

Publication Classification

Int. Cl.: **H01L21/677** (20060101); **C23C16/40** (20060101); **C23C16/44** (20060101); **C23C16/458** (20060101); **C23C16/52** (20060101); **H01L21/02** (20060101)

U.S. Cl.:

CPC **H01L21/67757** (20130101); **C23C16/402** (20130101); **C23C16/4412** (20130101); **C23C16/4584** (20130101); **C23C16/52** (20130101); H01L21/02164 (20130101); H01L21/0217 (20130101); H01L21/02186 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED PATENT APPLICATION [0001] This application is a continuation of U.S. patent application Ser. No. 17/691,641, filed on Mar. 10, 2022, which is a bypass continuation application of PCT International Application No. PCT/JP2019/038175, filed on Sep. 27, 2019, in the WIPO, the entire contents of which are hereby incorporated by reference.

BACKGROUND
1. Field
[0002] The present disclosure relates to a substrate processing apparatus capable of processing a substrate in a manufacturing process of a semiconductor device, an elevator and a method of manufacturing a semiconductor device.
2. Related Art
[0003] In a heat treatment process of a substrate (also referred to as a “wafer”) in a manufacturing process of a semiconductor device, for example, a substrate processing apparatus such as a vertical type substrate processing apparatus may be used. In the vertical type substrate processing apparatus, a plurality of substrates are charged into a substrate retainer of the vertical type substrate processing apparatus and supported in the vertical direction by the substrate retainer, and the substrate retainer is loaded into a process chamber of the vertical type substrate processing apparatus. Thereafter, a process gas is introduced into the process chamber while the process chamber is heated to perform a substrate processing such as a film-forming process on the plurality of substrates. For example, according to some related arts, a substrate processing apparatus provided with a gas ejection port through which a gas such as the process gas is ejected into the process chamber is disclosed. The gas ejection port is of a slot shape so as to span at least a plurality of substrates including the substrate in a direction perpendicular to a processing surface of the substrate.
SUMMARY
[0004] According to the present disclosure, there is provided a technique capable of improving a thickness uniformity of a film formed on each of a plurality of substrates when the plurality of substrates are processed simultaneously.
[0005] According to one or more embodiments of the present disclosure, there is provided a substrate processing apparatus including: a process chamber in which a plurality of substrates are processed; a substrate support configured to support the plurality of substrates; a partition plate support configured to support a plurality of partition plates arranged between the plurality of substrates; a driver configured to change a distance between each of the plurality of substrates supported by the substrate support and each of the plurality of partition plates supported by the partition plate support by moving one of the substrate support and the partition plate support in a vertical direction; a gas supplier provided with a hole through which a gas is supplied to the

plurality of substrates; and a controller configured to be capable of controlling the driver and the gas supplier such that the gas is supplied to the plurality of substrates and one of a relative vertical position of each of the plurality of substrates and a relative vertical position of each of the plurality of partition plates with respect to the hole is changed by driving the driver, wherein the driver includes: a rotational driver configured to rotate the substrate support; a substrate support vertical driver configured to move the substrate support in the vertical direction with respect to the partition plate support; and a partition plate support vertical driver configured to move the partition plate support in the vertical direction with respect to the substrate support.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a cross-sectional view of a process chamber and a storage chamber schematically illustrating a state in which a boat in which a plurality of substrates are accommodated is transferred into a transfer chamber of a substrate processing apparatus according to a first embodiment of the present disclosure.

[0007] FIG. **2** is a cross-sectional view of the process chamber and the storage chamber schematically illustrating a state in which the boat in which the plurality of substrates are accommodated is elevated and transferred into the process chamber of the substrate processing apparatus according to the first embodiment.

[0008] FIGS. **3**A through **3**C are cross-sectional views of a substrate and a partition plate schematically illustrating a distance between the substrate and the partition plate in the process chamber of the substrate processing apparatus according to the first embodiment.

[0009] FIG. **4** is a graph schematically illustrating a distribution of a concentration of a material gas on a surface of the substrate when the distance between the substrate and the partition plate is switched in the process chamber of the substrate processing apparatus according to the first embodiment.

[0010] FIG. **5** is a perspective view of the substrate schematically illustrating the distribution of the concentration of the material gas on the surface of the substrate when the distance between the substrate and the partition plate is set to a long distance as shown in FIG. **3**C, in a diagram schematically visualizing the distribution of the concentration of the material gas on the surface of the substrate in the process chamber of the substrate processing apparatus according to the first embodiment.

[0011] FIG. **6** is a block diagram schematically illustrating an exemplary configuration of a controller and related components of the substrate processing apparatus according to the first embodiment.

[0012] FIG. **7** is a flow chart schematically illustrating a manufacturing process of a semiconductor device according to the first embodiment.

[0013] FIG. **8** is a table schematically illustrating an exemplary list of items in a process recipe read by a CPU of the substrate processing apparatus according to the first embodiment.

[0014] FIG. **9** is a cross-sectional view schematically illustrating a configuration of a substrate processing apparatus according to a second embodiment of the present disclosure.

[0015] FIG. **10** is a cross-sectional view schematically illustrating a configuration of a substrate processing apparatus according to a third embodiment of the present disclosure.

[0016] FIG. **11** is a cross-sectional view schematically illustrating a configuration of a substrate processing apparatus according to a fourth embodiment of the present disclosure.

DETAILED DESCRIPTION

[0017] The present disclosure relates to a substrate processing apparatus including: a boat in which a plurality of substrates are accommodated; a plurality of partition plates configured separately from the boat and provided above the plurality of substrates accommodated in the boat, respectively; a partition plate support including a support configured to support the plurality of partition plates; a first elevator configured to elevate and lower the boat; and a second elevator configured to change a positional relationship between a substrate among the plurality of substrates and a partition plate among the plurality of partition plates in a vertical direction.

[0018] Hereinafter, one or more embodiments (also simply referred to as "embodiments") according to the technique of the present disclosure will be described with reference to the drawings. In the drawings for explaining the embodiments, like reference numerals represent like components, and redundant descriptions related thereto will be omitted in principle.

[0019] However, the technique of the present disclosure is not construed as being limited to the contents of the embodiments described below. Those skilled in the art will easily understand that specific configurations of the technique of the present disclosure can be changed without departing from the idea and the purpose of the technique of the present disclosure.

First Embodiment

[0020] A configuration of a substrate processing apparatus according to a first embodiment of the technique of the present disclosure will be described with reference to FIGS. **1** and **2**.

<Substrate Processing Apparatus **100**>

[0021] The substrate processing apparatus **100** includes: a reaction tube **110** of a cylindrical shape extending in the vertical direction; a heater **101** serving as a heating structure (furnace body) installed on an outer periphery of the reaction tube **110**; and a gas supply nozzle **120** constituting a gas supplier (which is a gas supply structure or a gas supply system). For example, the heater **101** is constituted by a zone heater which is vertically divided into a plurality of heater structures (blocks) and a temperature of each heater structure can be set individually.

[0022] For example, the reaction tube **110** is made of a material such as quartz and silicon carbide (SiC). An inner atmosphere of the reaction tube **110** is exhausted by an exhaust component (not shown) through an exhaust pipe **130** constituting an exhauster (which is an exhaust structure or an exhaust system). An inside of the reaction tube **110** is hermetically sealed with respect to an outside air by a component such as a seal (not shown).

[0023] The technique of the present disclosure can also be applied when a second reaction tube (not shown) is provided at an inner side of the reaction tube **110** described herein.

[0024] The gas supply nozzle (hereinafter, also simply referred to as a "nozzle") **120** is provided with a plurality of holes including a hole **121** through which a gas is supplied into the reaction tube **110**. Hereinafter, the plurality of holes including the hole **121** may also be referred to as "holes **121**".

[0025] A source gas, a reactive gas and an inert gas (which is a carrier gas) are introduced into the reaction tube **110** through the holes **121** provided at the nozzle **120**.

[0026] Flow rates of the source gas, the reactive gas and the inert gas (carrier gas) supplied from a source gas supply source (not shown), a reactive gas supply source (not shown) and an inert gas supply source (not shown), respectively, are adjusted by mass flow controllers (MFCs) (not shown), respectively, and then are supplied into the reaction tube **110** through the holes **121** provided at the nozzle **120**.

[0027] The inner atmosphere of the reaction tube **110** is vacuum-exhausted by the exhaust component (not shown) through the exhaust pipe **130** provided at a manifold **111**.

<Chamber **180**>

[0028] A chamber **180** is provided under the reaction tube **110** via the manifold **111**, and includes a storage chamber **500**. In the storage chamber **500**, a substrate **10** may be placed (mounted) on a substrate support (which is a boat) **300** by a transfer device (not shown) via a substrate loading/unloading port **310**, or the substrate **10** is transferred from the substrate support (hereinafter, may also be simply referred to as the "boat") **300** by the transfer device.

[0029] In the present embodiment, the chamber **180** is made of a metal material such as stainless

steel (SUS) and aluminum (Al).
[0030] Inside the chamber **180**, a vertical driver **400** constituting a first driver capable of driving the substrate support (boat) **300**, a partition plate support **200** or both of the substrate support (boat) **300** and the partition plate support **200** (collectively referred to as a “substrate retainer”) in the vertical direction and a rotational direction is provided.
<Substrate Support Structure>
[0031] A substrate support structure is constituted by at least the substrate support (boat) **300**. The substrate **10** is transferred into the storage chamber **500** by the transfer device (not shown) via the substrate loading/unloading port **310**, and a process of forming a film on a surface of the substrate **10** is performed on the substrate **10** by further transferring the substrate **10** into the reaction tube **110**. In addition, the substrate support structure may further include the partition plate support **200**.
[0032] As shown in FIGS. **1** and **2**, in the partition plate support **200**, a plurality of partition plates including a partition plate **203** of a disk shape are fixed at a predetermined pitch to a support column **202** supported between a base **201** and a top plate **204**. Hereinafter, the plurality of partition plates including the partition plate **203** may also be referred to as “partition plates **203**”. As shown in FIGS. **1** and **2**, the substrate support (boat) **300** includes a configuration in which a plurality of support rods **302** are supported at a base **301**, and a plurality of substrates including the substrate **10** are supported by the plurality of support rods **302** at a predetermined interval. Hereinafter, the plurality of substrates including the substrate **10** may also be referred to as “substrates **10**”.
[0033] In the substrate support (boat) **300**, the plurality of substrates **10** are supported at the predetermined interval by the plurality of support rods **302** at the base **301**. The plurality of substrates **10** supported by the plurality of support rods **302** are partitioned by the plurality of partition plates **203** of a disk shape fixed (supported) to the support columns **202** supported by the partition plate support **200** at a predetermined pitch (interval). According to the present embodiment, the partition plate **203** is arranged on either or both of an upper portion and a lower portion of the substrate **10**.
[0034] The predetermined interval between the plurality of substrates **10** accommodated in the substrate support (boat) **300** is the same as a vertical pitch (interval) of the partition plates **203** fixed to the partition plate support **200**. Further, a diameter of the partition plate **203** is set to be greater than a diameter of the substrate **10**.
[0035] The boat **300** is configured to support the substrates (for example, five substrates) **10** by the plurality of support rods **302** in a multistage manner in the vertical direction. For example, a vertical interval (distance) between the substrates **10** supported in a multistage manner in the vertical direction is set to about 60 mm. For example, the base **301** and the plurality of support rods **302**, which constitute the boat **300**, are made of a material such as quartz and SiC. Further, while the present embodiment will be described by way of an example in which the five substrates **10** are supported in the boat **300**, the present embodiment is not limited thereto. For example, the boat **300** may be configured to support about 5 substrates to 50 substrates as the substrates **10**. In addition, the partition plates **203** of the partition plate support **200** may also be referred to as “separators”.
[0036] The partition plate support **200** and the substrate support (boat) **300** are moved (driven) by the vertical driver **400** in the vertical direction between the reaction tube **110** and the storage chamber **500** and in the rotational direction around a center of the substrate **10** supported by the substrate support (boat) **300**.
[0037] As shown in FIGS. **1** and **2**, the vertical driver **400** constituting the first driver includes a vertical driving motor **410**, a rotational driving motor **430**, which serve as driving sources, and a boat vertical driver **420** provided with a linear actuator serving as a substrate support elevator capable of driving the substrate support (boat) **300** in the vertical direction.
[0038] The vertical driving motor **410** serving as a partition plate support elevator is configured to rotationally drive a ball screw **411** to move a nut **412** screwed to the ball screw **411** in the vertical

direction along the ball screw **411**. As a result, the partition plate support **200** and the substrate support (boat) **300** are driven in the vertical direction between the reaction tube **110** and the storage chamber **500** together with a base plate **402** fixing the nut **412**. The base plate **402** is also fixed to a ball guide **415** engaged with a guide shaft **414**, and is configured to be capable of moving smoothly in the vertical direction along the guide shaft **414**. Upper ends and lower ends of the ball screw **411** and the guide shaft **414** are fixed to fixing plates **413** and **416**, respectively. In addition, the partition plate support elevator may include a structure for transmitting the power of the vertical driving motor **410**.
[0039] The rotational driving motor **430** and the boat vertical driver **420** provided with the linear actuator constitute a second driver, and are fixed to a base flange **401** serving as a lid supported by a side plate **403** at the base plate **402**. By using the side plate **403**, it is possible to suppress a diffusion of particles generated by a component such as a vertical driver such as the boat vertical driver **420** and a rotator (which is a rotating structure) such as the rotational driving motor **430**. The side plate **403** is of a cover shape (in a cylindrical shape or a columnar shape) so as to cover the component such as the vertical driver and the rotator. A hole (not shown) through which a transfer chamber is in communication with the side plate **403** of the cover shape is provided at the side plate **403** on a part of the side plate **403** or on a bottom surface of the side plate **403**. By the hole through which the transfer chamber is in communication with the side plate **403** of the cover shape, an inner pressure of the side plate **403** of the cover shape can be set to be substantially equal to an inner pressure of the transfer chamber.
[0040] On the other hand, a support column may be used instead of the side plate **403**. In such a case, it is possible to easily perform a maintenance operation on the component such as the vertical driver and the rotator.
[0041] The rotational driving motor **430** is configured to drive a rotation transmission belt **432** engaging with a tooth portion **431** attached to a front end (tip) of the rotational driving motor **430**, and to rotate (rotationally drive) a support **440** engaging with the rotation transmission belt **432**. The support **440** is configured to support the partition plate support **200** by the base **201**, and to be driven by the rotational driving motor **430** via the rotation transmission belt **432** to rotate the partition plate support **200** and the boat **300**.
[0042] The support **440** is separated from an inner cylinder portion **4011** of the base flange **401** by a vacuum seal **444**, and a lower portion thereof is rotatably guided with respect to the inner cylinder portion **4011** of the base flange **401** by a bearing **445**.
[0043] The boat vertical driver **420** provided with the linear actuator is configured to drive a shaft **421** in the vertical direction. A plate **422** is attached to a front end (tip) of the shaft **421**. The plate **422** is connected to a support structure **441** fixed to the base **301** of the boat **300** via a bearing **423**. By connecting the support structure **441** to the plate **422** via the bearing **423**, it is possible to rotate the boat **300** together with the partition plate support **200** when the partition plate support **200** is rotated (rotationally driven) by the rotational driving motor **430**.
[0044] On the other hand, the support structure **441** is supported by the support **440** via a linear guide bearing **442**. With such a configuration, when the shaft **421** is driven in the vertical direction by the boat vertical driver **420** provided with the linear actuator, it is possible to drive the support structure **441** fixed to the boat **300** relatively in the vertical direction with respect to the support **440** fixed to the partition plate support **200**.
[0045] By configuring the support **440** and the support structure **441** concentrically as described above, it is possible to simplify a structure of the rotator using the rotational driving motor **430**. Further, it is possible to easily control a synchronization of a rotation between the boat **300** and the partition plate support **200**.
[0046] However, the present embodiment is not limited thereto, and the support **440** and the support structure **441** may be arranged separately rather than concentrically.
[0047] The support **440** fixed to the partition plate support **200** and the support structure **441** fixed

to the boat **300** are connected by a vacuum bellows **443**.

[0048] An O-ring **446** for vacuum sealing is installed on an upper surface of the base flange **401** serving as the lid, and as shown in FIG. **2**, by driving the vertical driving motor **410** to elevate the upper surface of the base flange **401** to a position where the upper surface of the base flange **401** is pressed against the chamber **180**, it is possible to airtightly maintain the inside of the reaction tube **110**.

[0049] The O-ring **446** for vacuum sealing may be omitted, and by pressing the upper surface of the base flange **401** against the chamber **180** without using the O-ring **446** for vacuum sealing, it is possible to airtightly maintain the inside of the reaction tube **110**. Further, the vacuum bellows **443** may be omitted.

[0050] In the configuration described above, by driving the vertical driving motor **410** to elevate the upper surface of the base flange **401** until the upper surface of the base flange **401** is pressed against the chamber **180** as shown in FIG. **2** such that the substrate support structure is inserted into the reaction tube **110**, the source gas, the reactive gas or the inert gas (carrier gas) is introduced into the reaction tube **110** through the holes **121** provided at the gas supply nozzle **120**.

[0051] A pitch of the holes **121** provided at the gas supply nozzle **120** is substantially the same as the vertical interval of the substrates **10** accommodated in the boat **300** and the vertical pitch (interval) of the partition plates **203** fixed to the partition plate support **200**.

[0052] According to the present embodiment, when the upper surface of the base flange **401** is pressed against the chamber **180**, a height position (that is, a position in the vertical direction) of the partition plates **203** fixed to the support column **202** of the partition plate support **200** is fixed, and a height position of the substrate **10** supported by the boat **300** with respect to the partition plate **203** may be changed by driving the boat vertical driver **420** provided with the linear actuator so as to elevate or lower the support structure **441** fixed to the base **301** of the boat **300**. Since a position of the hole **121** provided at the gas supply nozzle **120** is also fixed, the height position (relative position) of the substrate **10** supported by the boat **300** with respect to the hole **121** may also be changed.

[0053] That is, by adjusting the position (height position) of the substrate **10** supported by the boat **300** in the vertical direction by driving the boat vertical driver **420** provided with the linear actuator with respect to a reference positional relationship of a transfer operation as shown in FIG. **3**A, it is possible to adjust positional relationships of the substrate **10** with respect to the hole **121** provided at the nozzle **120** and the partition plate **203** such that a distance between an upper partition plate **2032** and the substrate **10** is narrowed (that is, a narrowed gap G**1** is formed between the upper partition plate **2032** and the substrate **10**) as shown in FIG. **3**B by setting the position of the substrate **10** to be higher than a transfer position (home position) **10-1**, or such that the distance between the upper partition plate **2032** and the substrate **10** is widened (that is, a widened gap G**2** is formed between the upper partition plate **2032** and the substrate **10**) as shown in FIG. **3**C by setting the position of the substrate **10** to be lower than the transfer position (home position) **10-1**.

[0054] By changing the position of the substrate **10** with respect to the hole **121** provided at the nozzle **120** as described above, it is possible to change a positional relationship between a gas flow **1211** ejected through the hole **121** and the substrate **10**.

[0055] FIG. **4** schematically illustrates a simulation result of a distribution of the film formed on the surface of the substrate **10** (or a distribution of a concentration of a material gas such as silicon dichloride gas (SiCl.sub.2 gas) on the surface of the substrate **10**) when the SiCl.sub.2 gas is supplied through the hole **121** provided at the nozzle **120** in a state in which the position of the substrate **10** is elevated to form the narrowed gap G**1** between the substrate **10** and the upper partition plate **2032** as shown in FIG. **3**B and a state in which the position of the substrate **10** is lowered to form the widened gap G**2** between the substrate **10** and the upper partition plate **2032** as shown in FIG. **3**C.

[0056] A point sequence **510** indicated by “Narrow” in FIG. **4** schematically illustrates a case where the film is formed in the state shown in FIG. **3**B, that is, the state in which the position of the substrate **10** is elevated to form the narrowed gap G**1** between the substrate **10** and the upper partition plate **2032**, and the position of the substrate **10** is set to be higher than a position of the gas flow **1211** ejected through the hole **121**. In such a case, a relatively thick film is formed on a peripheral portion of the substrate **10**. As a result, it is possible to obtain a concave thickness distribution of the film in which a thickness of the film formed on a central portion of the substrate **10** is thinner than that of the film formed on the peripheral portion of the substrate **10**.

[0057] On the other hand, a point sequence **521** indicated by “Wide” in FIG. **4** schematically illustrates a case where the film is formed in the state shown in FIG. **3**C, that is, the state in which the position of the substrate **10** is lowered to form the widened gap G**2** between the substrate **10** and the upper partition plate **2032**, and the position of the substrate **10** is set to be lower than the position of the gas flow **1211** ejected through the hole **121**. In such a case, it is possible to obtain a convex thickness distribution of the film in which the film is relatively thicker on the central portion of the substrate **10** than on the peripheral portion of the substrate **10**.

[0058] It can be seen that, by changing the position of the substrate **10** as described above, the distribution of the film formed on the surface of the substrate **10** can be changed.

[0059] FIG. **5** schematically illustrates a simulation result of a distribution of a partial pressure of the SiCl.sub.2 gas (or the distribution of the concentration of the SiCl.sub.2 gas) on the surface of the substrate **10** when the silicon dichloride gas (SiCl.sub.2 gas) is supplied along a direction of an arrow **611** in a case where the positional relationships of the substrate **10** with respect to the upper partition plate **2032** and the hole **121** provided at the nozzle **120** are set as shown in FIG. **3**C. The thickness distribution of the film in FIG. **4** corresponds to the thickness distribution of the film in a cross-section taken along the line a-a′ of FIG. **5**.

[0060] As shown in FIG. **5**, when the positional relationships of the substrate **10** with respect to the upper partition plate **2032** and the hole **121** provided in the nozzle **120** are set as shown in FIG. **3**C, the partial pressure of the SiCl.sub.2 gas is relatively high in portions illustrated in dark color on the substrate **10** extending from a portion close to the hole **121** provided at the nozzle **120** to the central portion of the substrate **10**. On the other hand, the partial pressure of the SiCl.sub.2 gas is relatively low in the peripheral portion of the substrate **10** far from the hole **121** provided at the nozzle **120**.

[0061] In such a state, by rotationally driving the support **440** by driving the rotational driving motor **430** so as to rotate the partition plate support **200** and the boat **300**, the substrate **10** accommodated in the boat **300** are rotated. Thereby, it is possible to reduce a variation in the thickness of the film (in the thickness distribution of the film) in a circumferential direction of the substrate **10**.

<Controller>

[0062] As shown in FIG. **1**, the substrate processing apparatus **100** is connected to a controller **260** configured to control operations of components constituting the substrate processing apparatus **100**.

[0063] The controller **260** is schematically illustrated in FIG. **6**. The controller **260** serving as a control apparatus (control structure) is constituted by a computer including a CPU (Central Processing Unit) **260***a*, a RAM (Random Access Memory) **260***b*, a memory **260***c* and an I/O port **260***d*. The RAM **260***b*, the memory **260***c* and the I/O port **260***d* may exchange data with the CPU **260***a* through an internal bus **260***e*. For example, an input/output device **261** configured by a component such as a touch panel and an external memory **262** may be connected to the controller **260**.

[0064] The memory **260***c* is configured by a component such as a flash memory and a hard disk drive (HDD). For example, a control program configured to control the operation of the substrate processing apparatus **100**, a process recipe containing information on sequences and conditions of a substrate processing described later, or a database may be readably stored in the memory **260***c*.

[0065] The process recipe is obtained by combining steps of the substrate processing described later such that the controller **260** can execute the steps to acquire a predetermined result, and functions as a program.

[0066] Hereafter, the process recipe and the control program may be collectively or individually referred to as a “program”. Thus, in the present specification, the term “program” may refer to the process recipe alone, may refer to the control program alone, or may refer to both of the process recipe and the control program. In addition, the RAM **260***b* functions as a memory area (work area) where a program or data read by the CPU **260***a* is temporarily stored.

[0067] The I/O port **260***d* is electrically connected to the components such as the substrate loading/unloading port **310**, the vertical driving motor **410**, the boat vertical driver **420** provided with the linear actuator, the rotational driving motor **430**, the heater **101**, the mass flow controllers (not shown), a temperature regulator (not shown) and a vacuum pump (not shown).

[0068] In addition, in the present specification, “electrically connected” means that the components are connected by physical cables or the components are capable of communicating with one another to transmit and receive signals (electronic data) to and from one another directly or indirectly. For example, a device for relaying the signals or a device for converting or computing the signals may be provided between the components.

[0069] The CPU **260***a* is configured to read and execute the control program from the memory **260***c* and read the process recipe from the memory **260***c* in accordance with an instruction such as an operation command inputted from the controller **260**. The CPU **260***a* is configured to be capable of controlling various operations in accordance with the process recipe such as an opening and closing operation of the substrate loading/unloading port **310**, a driving operation of the vertical driving motor **410**, a driving operation of the boat vertical driver **420** provided with the linear actuator, a rotating operation of the rotational driving motor **430** and an operation of supplying electrical power to the heater **101**.

[0070] The controller **260** is not limited to a dedicated computer, and the controller **260** may be embodied by a general-purpose computer. For example, the controller **260** according to the present embodiment may be embodied by preparing the external memory **262** (e.g., a magnetic tape, a magnetic disk such as a flexible disk and a hard disk, an optical disk such as a CD and a DVD, a magneto-optical disk such as an MO, a semiconductor memory such as a USB memory and a memory card) in which the above-described program is stored, and installing the program onto the general-purpose computer using the external memory **262**.

[0071] The method of providing the program to the computer is not limited to the external memory **262**. For example, the program may be directly provided to the computer by a communication instrument such as a network **263** (Internet and a dedicated line) instead of the external memory **262**. The memory **260***c* and the external memory **262** may be embodied by a non-transitory computer-readable recording medium. Hereinafter, the memory **260***c* and the external memory **262** are collectively or individually referred to as a recording medium. Thus, in the present specification, the term “recording medium” may refer to the memory **260***c* alone, may refer to the external memory **262** alone, or may refer to both of the memory **260***c* and the external memory **262**.

<Substrate Processing (Film-Forming Process)>

[0072] Hereinafter, the substrate processing (film-forming process) of forming the film on the substrate **10** using the substrate processing apparatus **100** described with reference to FIGS. **1** and **2** will be described with reference to FIG. **7**.

[0073] Although the technique of the present disclosure can be applied to one or both of the film-forming process and an etching process, the present embodiment will be described based on a step of forming a silicon oxide (SiO.sub.2) film on the substrate **10**, which is an example of a step of forming the film, as a part of a manufacturing process of a semiconductor device. The step of forming the film such as the SiO.sub.2 film is performed in the reaction tube **110** of the substrate processing apparatus **100** described above. As described above, by executing the program by the

CPU **260***a* of the controller **260** of FIG. **6**, the manufacturing process is performed.

[0074] In the substrate processing (the manufacturing process of the semiconductor device) according to the present embodiment, first, by driving the vertical driving motor **410** to elevate the upper surface of the base flange **401** until the upper surface of the base flange **401** is pressed against the chamber **180** as shown in FIG. **2**, the substrate support structure is inserted into the reaction tube **110**.

[0075] Subsequently, in such a state, by driving the shaft **421** in the vertical direction by the boat vertical driver **420** provided with the linear actuator, the height (distance) of the substrate **10** accommodated in the boat **300** with respect to the partition plate **203** can be set from an initial state shown in FIG. **3**A to a state in which the narrowed gap G**1** is formed between the partition plate **203** and the substrate **10** as shown in FIG. **3**B by elevating the substrate **10** or to a state in which the widened gap G**2** is formed between the partition plate **203** and the substrate **10** as shown in FIG. **3**C by lowering the substrate **10**. Thereby, the height of the substrate **10** with respect to the partition plate **203** (that is, the distance between the partition plate **203** and the substrate **10**) is adjusted to a desired value.

[0076] In such a state, the step of forming the SiO.sub.2 film including: (a) a step of supplying Si.sub.2Cl.sub.6 (disilicon hexachloride) gas through the gas supply nozzle **120** to the substrate **10** accommodated in the reaction tube **110**; (b) a step of removing a residual gas in the reaction tube **110**; (c) a step of supplying O.sub.2 (oxygen) (or O.sub.3 (ozone) or H.sub.2O (water)) through the gas supply nozzle **120** to the substrate **10** accommodated in the reaction tube **110**; and (d) a step of removing a residual gas in the reaction tube **110** is performed. The steps (a) to (d) described above are performed a plurality of times to form the SiO.sub.2 film on the substrate **10**.

[0077] Further, while the steps (a) to (d) are performed the plurality of times or in the steps (a) and (c) described above, with rotationally driving the support **440** connected to the rotational driving motor **430** through the rotation transmission belt **432** by the rotational driving motor **430**, the height (distance) of the substrate **10** with respect to the partition plate **203** is periodically changed between the state in which the narrowed gap G**1** is formed between the partition plate **203** and the substrate **10** as shown in FIG. **3**B by elevating the substrate **10** and the state in which the widened gap G**2** is formed between the partition plate **203** and the substrate **10** as shown in FIG. **3**C by lowering the substrate **10**. As a result, it is possible to uniformize the thickness of the film (that is, the SiO.sub.2 film) formed on the surface of the substrate **10**.

[0078] Further, in the present specification, the term “substrate” may refer to “a substrate itself” or may refer to “a substrate and a stacked structure (aggregated structure) of predetermined layers or films formed on a surface of the substrate”. That is, the term “substrate” may collectively refer to the substrate and the layers or the films formed on the surface of the substrate. In addition, in the present specification, the term “a surface of a substrate” may refer to “a surface (exposed surface) of a substrate itself” or may refer to “a surface of a predetermined layer or a film formed on the substrate, i.e. a top surface (uppermost surface) of the substrate as the stacked structure”. In addition, in the present specification, the terms “substrate” and “wafer” may be used as substantially the same meaning.

[0079] Subsequently, a specific example of the film-forming process will be described with reference to a flow chart shown in FIG. **7**.

<Process Conditions Setting Step: S**701**>

[0080] First, the CPU **260***a* reads the process recipe and the related database stored in the memory **260***c* and sets process conditions. Instead of the memory **260***c*, the process recipe and the related database may be obtained via the network.

[0081] FIG. **8** schematically illustrates an example of a process recipe **800** read by the CPU **260***a*. The process recipe **800** may include main items such as a “gas flow rate” **810**, a “temperature data” **820**, the “number of process cycles” **830**, a “boat height” **840** and an “adjustment interval” **850** for the boat height.

[0082] The gas flow rate **810** may include items such as a “source gas flow rate” **811**, a “reactive gas flow rate” **812** and a “carrier gas flow rate” **813**. The temperature data **820** may include an item such as a “heating temperature” **821** in the reaction tube **110** by the heater **101**.

[0083] The boat height **840** may include items such as preset values of a minimum value (that is, the narrowed gap G**1**) and a maximum value (that is, the widened gap G**2**) of the distance between the substrate **10** and the partition plate **203** described with reference to FIGS. **3**B and **3**C.

[0084] The adjustment interval **850** for the boat height may include an item such as a switching time interval between a time duration of maintaining the distance between the substrate **10** and the partition plate **203** at the minimum value as shown in FIG. **3**B and a time duration of maintaining the distance between the substrate **10** and the partition plate **203** at the maximum value as shown in FIG. **3**C. That is, the film is formed on the substrate **10** by processing the substrate **10** while alternately switching between the case in which the distance between the surface of the substrate **10** and the partition plate **203** (that is, the position of the substrate **10** with respect to the position of the hole **121** of the gas supply nozzle **120**) is set as shown in FIG. **3**B and the case in which the distance between the surface of the substrate **10** and the partition plate **203** is set as shown in FIG. **3**C. As a result, it is possible to form the film such that a flat thickness distribution of the film in which the thickness of the film formed on the central portion on the surface of the substrate **10** is substantially the same as that of the film formed on the outer peripheral portion on the surface of the substrate **10** can be obtained.

<Substrate Loading Step: S**702**>

[0085] With the boat **300** accommodated in the storage chamber **500**, the vertical driving motor **410** is driven to rotationally drive the ball screw so as to transfer the boat **300** by pitch feeding such that new substrates including a new substrate **10** are transferred (loaded or charged) into the boat **300** one by one through the substrate loading/unloading port **310** of the storage chamber **500**. Hereinafter, the new substrates including the new substrate **10** may also be simply referred to as “new substrates **10**” or “substrates **10**”, and the new substrate **10** may also be simply referred to as the “substrate **10**”.

[0086] When the charging of the new substrates **10** into the boat **300** is completed, by driving the vertical driving motor **410** to rotationally drive the ball screw **411** in a state where the substrate loading/unloading port **310** is closed and an inside of the storage chamber **500** is hermetically sealed with respect to an outside of the storage chamber **500**, the boat **300** is elevated. As a result, the boat **300** is transferred (loaded) into the reaction tube **110** from the storage chamber **500**.

[0087] When the boat **300** is being loaded, the height of the boat **300** elevated by the vertical driving motor **410** is set based on the process recipe read in the step S**701** such that a positional difference between the substrate **10** accommodated in the boat **300** and an ejection position (which corresponds to the height of the front end of the nozzle **120**) of the gas supplied into the reaction tube **110** through the nozzle **120** via a hole (not shown) provided in a tube wall of the reaction tube **110** can be set as shown in FIG. **3**B or FIG. **3**C.

<Pressure Adjusting Step: S**703**>

[0088] With the boat **300** loaded in the reaction tube **110**, the inner atmosphere of the reaction tube **110** is vacuum-exhausted by the vacuum pump (not shown) through the exhaust pipe **130** such that an inner pressure of the reaction tube **110** reaches and is maintained at a desired pressure.

<Temperature Adjusting Step: S**704**>

[0089] In a state where the inner atmosphere of the reaction tube **110** is vacuum-exhausted by the vacuum pump (not shown), the heater **101** heats the reaction tube **110** based on the recipe read in the step S**701** such that an inner temperature of the reaction tube **110** reaches and is maintained at a desired temperature. When heating the reaction tube **110**, an amount of the electric current supplied to the heater **101** is feedback-controlled based on temperature information detected by a temperature sensor (not shown) such that a desired temperature distribution of the inner temperature of the reaction tube **110** can be obtained. The heater **101** continuously heats the reaction tube **110** until at least a processing of the substrate **10** is completed. Further, when a temperature of the substrate **10** is elevated by heating by the heater **101**, the pitch (that is, a distance between a back surface of the substrate **10** and the partition plate **203** below the substrate **10**) is narrowed (the state shown in FIG. **3**C). Narrowing the pitch is performed at least before a supply of the source gas. After the supply of the source gas, the pitch is widened. In addition, the pitch during the supply of the source gas may be set to be different from the pitch during a supply of the reactive gas. Further, the pitch may be changed during the supply of the source gas (or the reactive gas). In addition, an operation timing at which the substrate support **300** and the partition plate support **200** move relatively in the vertical direction can be set appropriately.

<SiO.SUB.2 .Film Forming Step: S**705**>

[0090] Subsequently, a step of forming the film such as the SiO.sub.2 film serving as a first film (that is, the SiO.sub.2 film forming step) is performed. For example, a source gas supply step S**7051**, a source gas exhaust step S**7052**, a reactive gas supply step S**7053**, a reactive gas exhaust step S**7054** and a determination step S**7055** are performed as the SiO.sub.2 film forming step S**705**.

<Source Gas Supply Step S**7051**>

[0091] First, by rotationally driving the rotational driving motor **430** to rotate the support **440** via the rotation transmission belt **432**, the partition plate support **200** and the boat **300** supported by the support **440** are rotated.

[0092] While the boat **300** is being rotated, the Si.sub.2Cl.sub.6 gas serving as the source gas whose flow rate is adjusted is supplied into the reaction tube **110** through the hole **121** of the nozzle **120**. A part of the source gas supplied into the reaction tube **110**, which did not contribute to a reaction on the surface of the substrate **10**, is exhausted through the exhaust pipe **130**.

[0093] In the source gas supply step S**7051**, by elevating and lowering the boat **300** at a predetermined time interval by operating the boat vertical driver **420** provided with the linear actuator to drive the shaft **421** in the vertical direction based on the process recipe read in the step S**701**, the relative position (height position) of the surface of the substrate **10** accommodated in the boat **300** with respect to the hole **121** of the nozzle **120** and the partition plate **203** of the partition plate support **200** can be switched between a plurality of positions (for example, the position shown in FIG. **3**B and the position shown in FIG. **3**C).

[0094] By introducing the Si.sub.2Cl.sub.6 gas into the reaction tube **110** through the hole **121** of the nozzle **120**, the Si.sub.2Cl.sub.6 gas is supplied to the substrate **10** accommodated in the boat **300**. For example, the flow rate of the Si.sub.2Cl.sub.6 gas supplied into the reaction tube **110** may be set within a range from 0.002 slm (standard liter per minute) to 1 slm, and more preferably, within a range from 0.1 slm to 1 slm.

[0095] When supplying the Si.sub.2Cl.sub.6 gas, as the carrier gas, the inert gas such as nitrogen (N.sub.2) gas and argon (Ar) gas is supplied into the reaction tube **110** together with the Si.sub.2Cl.sub.6 gas, and is exhausted through the exhaust pipe **130**. Specifically, a flow rate of the carrier gas may be set within a range from 0.01 slm to 5 slm, and more preferably, within a range from 0.5 slm to 5 slm.

[0096] The carrier gas such as the N.sub.2 gas is supplied into the reaction tube **110** through the nozzle **120**, and is exhausted through the exhaust pipe **130**. When the carrier gas is supplied and exhausted, a temperature of the heater **101** is set such that the temperature of the substrate **10** is within a range from, for example, 250° C. to 550° C.

[0097] In the source gas supply step S**7051**, the Si.sub.2Cl.sub.6 gas and the carrier gas such as the N.sub.2 gas are supplied into the reaction tube **110** without any other gas being supplied into the reaction tube **110** together with the Si.sub.2Cl.sub.6 gas and the carrier gas. By supplying the Si.sub.2Cl.sub.6 gas into the reaction tube **110**, a silicon-containing layer whose thickness is, for example, within a range from less than a single atomic layer to several atomic layers is formed on the substrate **10** (that is, on a base film on the surface of the substrate **10**).

<Source Gas Exhaust Step: S**7052**>

[0098] After the silicon-containing layer is formed on the surface of the substrate **10** by supplying the Si.sub.2Cl.sub.6 gas serving as the source gas into the reaction tube **110** through the nozzle **120** for a predetermined time, a supply of the Si.sub.2Cl.sub.6 gas is stopped. In the source gas exhaust step S**7052**, the inner atmosphere of the reaction tube **110** is vacuum-exhausted by the vacuum pump (not shown) to remove a residual gas in the reaction tube **110** such as the Si.sub.2Cl.sub.6 gas which did not react or which contributed to the formation of the silicon-containing layer out of the reaction tube **110**.
[0099] In the source gas exhaust step S**7052**, the N.sub.2 gas serving as the carrier gas is continuously supplied into the reaction tube **110** through the nozzle **120**. The N.sub.2 gas serves as a purge gas, which improves the efficiency of removing the residual gas in the reaction tube **110** such as the Si.sub.2Cl.sub.6 gas which did not react or which contributed to the formation of the silicon-containing layer out of the reaction tube **110**.
<Reactive Gas Supply Step: S**7053**>
[0100] After the residual gas in the reaction tube **110** is removed out of the reaction tube **110**, while the boat **300** is being rotated by driving the rotational driving motor **430**, O.sub.2 gas serving as the reactive gas is supplied into the reaction tube **110** through the nozzle **120**, and a part of the O.sub.2 gas which did not contribute to the reaction on the surface of the substrate **10** is exhausted through the exhaust pipe **130**. Thereby, the O.sub.2 gas is supplied to the substrate **10**. Specifically, a flow rate of the O.sub.2 gas may be set within a range from 0.2 slm to 10 slm, and more preferably, within a range from 1 slm to 5 slm.
[0101] When supplying the O.sub.2 gas, a supply of the N.sub.2 gas is stopped in order to prevent the N.sub.2 gas from being supplied into the reaction tube **110** together with the O.sub.2 gas. That is, the O.sub.2 gas is supplied into the reaction tube **110** without being diluted with the N.sub.2 gas. As a result, it is possible to improve a film-forming rate of the SiO.sub.2 film. In the reactive gas supply step S**7053**, the temperature of the heater **101** is set to substantially the same temperature as that of the source gas supply step S**7051**.
[0102] In the reactive gas supply step S**7053**, similar to the source gas supply step S**7051**, by elevating and lowering the boat **300** at a predetermined time interval by operating the boat vertical driver **420** provided with the linear actuator to drive the shaft **421** in the vertical direction based on the process recipe read in the step S**701**, the relative position (height position) of the surface of the substrate **10** accommodated in the boat **300** with respect to the hole **121** of the nozzle **120** and the partition plate **203** of the partition plate support **200** can be switched between the plurality of positions (for example, the position shown in FIG. **3**B and the position shown in FIG. **3**C).
[0103] In the reactive gas supply step S**7053**, the O.sub.2 gas is supplied into the reaction tube **110** without any other gas being supplied into the reaction tube **110** together with the O.sub.2 gas. A substitution reaction occurs between the O.sub.2 gas and at least a portion of the silicon-containing layer formed on the substrate **10** in the source gas (Si.sub.2Cl.sub.6 gas) supply step S**7051**. During the substitution reaction, silicon (Si) contained in the silicon-containing layer and oxygen (O) contained in the O.sub.2 gas are bonded together. As a result, an SiO.sub.2 layer containing silicon and oxygen is formed on the substrate **10**.
<Reactive Gas Exhaust Step: S**7054**>
[0104] After the SiO.sub.2 layer is formed, a supply of the O.sub.2 gas into the reaction tube **110** through the nozzle **120** is stopped. Then, a residual gas in the reaction tube **110** such as the O.sub.2 gas which did not react or which contributed to the formation of the SiO.sub.2 layer and reaction by-products are removed out of the reaction tube **110** in the same manners as in the source gas exhaust step S**7052**.
<Performing a Predetermined Number of Times>
[0105] By performing a cycle in which the step S**7051** through the step S**7055** described above are sequentially performed in this order one or more times (that is, a predetermined number of times (n times)), the SiO.sub.2 film of a predetermined thickness (for example, 0.1 nm to 2 nm) is formed

on the substrate **10**. It is preferable that the cycle described above is repeatedly performed a plurality of times, for example, preferably about 10 times to 80 times, and more preferably about 10 times to 15 times.

[0106] As described above, the source gas supply step S**7051** and the reactive gas supply step S**7053** are repeatedly performed while the relative position of the surface of the substrate **10** with respect to the hole **121** and the partition plate **203** is being switched between the plurality of positions (for example, the position shown in FIG. **3**B and the position shown in FIG. **3**C) by elevating and lowering the boat **300** at the predetermined time interval by operating the boat vertical driver **420** provided with the linear actuator to drive the shaft **421** in the vertical direction based on the process recipe read in the step S**701**. As a result, it is possible to form the film with a uniform thickness distribution on the surface of the substrate **10**.

[0107] In addition, while the present embodiment is described by way of an example in which the boat **300** accommodating the substrates **10** is rotated by the rotational driving motor **430** in the source gas supply step S**7051** and the reactive gas supply step S**7053**, the boat **300** may be continuously rotated by the rotational driving motor **430** during the source gas exhaust step S**7052** and the reactive gas exhaust step S**7054**.

<After-Purge Step (Purge and Returning to Atmospheric Pressure Step): S**706**>

[0108] After repeatedly performing the step S**7051** through the step S**7055** of the step S**705** the predetermined number of times, the N.sub.2 gas is supplied into the reaction tube **110** through the nozzle **120**, and is exhausted through the exhaust pipe **130**. The N.sub.2 gas serves as the purge gas, and the inner atmosphere of the reaction tube **110** is purged with the N.sub.2 gas serving as the inert gas. Thereby, the residual gas in the reaction tube **110** or the reaction by-products remaining in the reaction tube **110** are removed out of the reaction tube **110**. Then, the N.sub.2 gas is filled in the reaction tube **110** until the inner pressure of the reaction tube **110** reaches an atmospheric pressure.

<Substrate Unloading Step: S**707**>

[0109] Thereafter, the vertical driving motor **410** is driven to rotate the ball screw **411** in an opposite direction such that the partition plate support **200** and the boat **300** are lowered from the reaction tube **110**. As a result, the boat **300** accommodating the substrate **10** on which the film of a predetermined thickness is formed on the surface thereof is transferred (unloaded) to the storage chamber **500**.

[0110] The substrate **10** with the film formed on the surface thereof is transferred (discharged) out of the boat **300** through the substrate loading/unloading port **310** so as to be taken out of the storage chamber **500**. Thereby, the processing of the substrate **10** is completed.

[0111] While the present embodiment is described by way of an example in which the SiO.sub.2 film is formed on the substrate **10**, the present embodiment is not limited thereto. For example, instead of the SiO.sub.2 film, the present embodiment may also be applied when a silicon nitride film (Si.sub.3N.sub.4 film) or a titanium nitride film (TiN film) is formed. In addition, the present embodiment may also be applied to form another film other than the films described above. For example, the present embodiment may also be applied to form a film containing an element such as tungsten (W), tantalum (Ta), ruthenium (Ru), molybdenum (Mo), zirconium (Zr), hafnium (H), aluminum (Al), silicon (Si), germanium (Ge) and gallium (Ga), a film containing an element of the same family as the elements described above, a compound film of one or more elements described above and nitrogen (that is, a nitride film) or a compound film of one or more elements described above and oxygen (that is, an oxide film). Further, when forming the films described above, a halogen-containing gas or a gas containing at least one of a halogen element, an amino group, a cyclopentane group, oxygen (O), carbon (C) or an alkyl group may be used.

[0112] According to the present embodiment, in accordance with a surface area of the substrate **10** or a type of the film to be formed, it is possible to form the film while changing the positional relationship between the substrate **10** and the hole **121** of the nozzle **120** through which a film-forming gas (that is, the source gas and the reactive gas) is supplied based on pre-set conditions. As a result, it is possible to improve a uniformity of the thickness distribution of the film formed on the surface of the substrate **10** accommodated in the boat **300**.

[0113] While the technique of the present disclosure is described by way of an example in which the film-forming process is performed, the technique of the present disclosure is not limited thereto. For example, the technique of the present disclosure may also be applied when the etching process is performed.

[0114] When the technique of the present disclosure is applied to the etching process, by supplying an etching gas in the state in which the distance between the substrate **10** and the partition plate **203** above the substrate **10** (that is, the upper partition plate **2032**) is narrowed as shown in FIG. **3**B by operating the boat vertical driver **420** provided with the linear actuator to drive the shaft **421** in the vertical direction, it is possible to perform an "E process" of a DED (Deposition-Etch-Deposition) process. In the present specification, the term "DED process" refers to a process of repeatedly performing the film-forming process ("Deposition") and the etching process ("Etch") to form a predetermined film. The "E process" described above refers to the etching process.

[0115] Further, by widening the distance between the substrate **10** and the partition plate **203** above the substrate **10** (that is, the upper partition plate **2032**) as shown in FIG. **3**C while supplying the etching gas, it is possible to adjust a uniformity of etching on the surface of the substrate **10**.

[0116] According to the technique of the present disclosure, a parameters for adjusting the distance between the substrate **10** and the partition plate **203** above the substrate **10** (that is, the upper partition plate **2032**) may include the thickness distribution of the film, a temperature, a flow rate of the gas, a pressure, a time, a type of the gas, the surface area of the substrate **10**. When information about the thickness distribution of the film is used as the parameter, a film thickness measuring apparatus is provided in the substrate processing apparatus **100**, and the distance between the substrate **10** and the partition plate **203** above the substrate **10** (that is, the upper partition plate **2032**) may be changed based on the result of measuring the thickness of the film.

[0117] Further, a decomposition amount of the gas may be detected by a sensor (not shown), and the distance between the substrate **10** and the partition plate **203** above the substrate **10** (that is, the upper partition plate **2032**) may be changed based on data on the decomposition amount.

Second Embodiment

[0118] FIG. **9** schematically illustrates a configuration of a substrate processing apparatus **900** according to a second embodiment of the present disclosure. The same components as those of the first embodiment will be denoted by like reference numerals, and detailed descriptions thereof will be omitted. Further, in the configuration of the substrate processing apparatus **900** according to the second embodiment, components such as the heater **101**, the reaction tube **110**, the gas supply nozzle **120**, the manifold **111**, the exhaust pipe **130** and the controller **260** described in the first embodiment are similarly provided. Since the components described above are substantially the same as those in the first embodiment, the components described above are omitted in FIG. **9**.

[0119] According to the present embodiment, similar to the first embodiment, the partition plate support **200** and the substrate support (boat) **300** are driven by the vertical driver **400** in the vertical direction between the reaction tube **110** and the storage chamber **500**, a support **9440** is rotationally driven by a rotational driving motor **9451** in the rotational direction around the center of the substrate **10** supported by the substrate support (boat) **300**, a support structure **9441** fixed to the boat **300** is driven relatively in the vertical direction with respect to the support **9440** fixed to the partition plate support **200** by driving a plate **9422** in the vertical direction by a boat vertical driver **9420** provided with the linear actuator via a shaft **9421**.

[0120] The configuration of the substrate processing apparatus **900** according to the present embodiment is different from the configuration of the substrate processing apparatus **100** described in the first embodiment in that a structure capable of independently adjusting the heights of the partition plate support **200** and the substrate support (boat) **300** is provided. The structure is capable of independently adjusting the heights of the partition plate support **200** and the substrate support (boat) **300** in a state where the partition plate support **200** and the substrate support (boat) **300** are elevated by the vertical driver **400** and a base flange **9401** is pressed against the chamber **180** via the O-ring **446**.

[0121] That is, as shown in FIG. **9**, the substrate processing apparatus **900** according to the present embodiment include a boat vertical driver **9460** provided with a second linear actuator capable of independently elevating and lowering the partition plate support **200** with respect to the substrate support (boat) **300**. By the boat vertical driver **9460** provided with the second linear actuator, a plate **9462** is driven in the vertical direction via a shaft **9461** so as to elevate or lower the partition plate support **200** in the vertical direction independently of the substrate support (boat) **300**.

[0122] The plate **9462** is connected to the support **9440** supporting the base **201** of the partition plate support **200** by the base **201** via a rotary seal structure **9423**.

[0123] The boat vertical driver **9420** provided with the linear actuator and the boat vertical driver **9460** provided with the second linear actuator are fixed to the base flange **9401** serving as a lid supported by a side plate **9403** at a base plate **9402**.

[0124] The rotational driving motor **9451** is attached to the plate **9462** driven in the vertical direction by the boat vertical driver **9460** provided with the second linear actuator.

[0125] The rotational driving motor **9451** is configured to drive a rotation transmission belt **9432** engaging with a tooth portion **9431** attached to a front end (tip) of the rotational driving motor **9451**, and to rotationally drive the support **9440** engaging with the rotation transmission belt **9432**. The support **9440** is configured to support the partition plate support **200** by the base **201**, and to be driven by the rotational driving motor **9451** via the rotation transmission belt **9432** to rotate the partition plate support **200** and the boat **300**.

[0126] According to the configuration of the substrate processing apparatus **900** according to the present embodiment, it is possible to independently adjust the height position of the substrate **10** accommodated in the boat **300** and the height position of the partition plate **203** fixed to the partition plate support **200** with respect to the hole **121** provided at the nozzle **120** shown in FIGS. **1** and **2**.

[0127] Thereby, according to the present embodiment, in accordance with the surface area of the substrate **10** or the type of the film to be formed, it is possible to form the film while independently adjusting the height position of the substrate **10** accommodated in the boat **300** and the height position of the partition plate **203** fixed to the partition plate support **200** with respect to the hole **121** provided at the nozzle **120**. As a result, it is possible to improve the uniformity of the thickness distribution of the film formed on the surface of the substrate **10** accommodated in the boat **300**.

Third Embodiment

[0128] FIG. **10** schematically illustrates a configuration of a substrate processing apparatus **1000** according to a third embodiment of the present disclosure. The same components as those of the first embodiment will be denoted by like reference numerals, and detailed descriptions thereof will be omitted.

[0129] The configuration of the substrate processing apparatus **1000** according to the present embodiment is different from the configuration of the substrate processing apparatus **100** described in the first embodiment in that, contrary to the description in the first embodiment, a structure capable of independently elevating and lowering a substrate support (boat) **3001** with respect to a partition plate support **2001** is provided.

[0130] According to the present embodiment, similar to the first embodiment, the partition plate support **2001** and the substrate support (boat) **3001** are driven by the vertical driver **400** in the vertical direction between the reaction tube **110** and the storage chamber **500** and in the rotational direction around the center of the substrate **10** supported by the substrate support (boat) **3001**, and a support structure **1441** fixed to the boat **3001** is driven relatively in the vertical direction with respect to the support **1440** fixed to the partition plate support **2001** by driving a plate **1422** in the vertical direction by a boat vertical driver **1420** provided with the linear actuator via a shaft **1421**.

[0131] That is, according to the present embodiment, the boat vertical driver **1420** provided with the linear actuator is configured to independently elevate or lower the substrate support (boat) **3001** with respect to the partition plate support **2001**.
[0132] The boat vertical driver **1420** provided with the linear actuator is configured to drive the shaft **1421** in the vertical direction. The plate **1422** is attached to a front end (tip) of the shaft **1421**. The plate **1422** is connected to the support structure **1441** fixed to a base **3011** of the boat **3001** via a bearing **1423**.
[0133] On the other hand, the support structure **1441** is supported by the support **1440** via a linear guide bearing **1442**. An upper surface of the support **1440** is connected to the base **3011** of the substrate support (boat) **3001**. The support **1440** is separated from an inner cylinder portion **14011** of a base flange **1401** by a vacuum seal **1444**, and a lower portion thereof is rotatably guided with respect to the inner cylinder portion **14011** of the base flange **1401** by a bearing **1445**.
[0134] With such a configuration, when the shaft **1421** is driven in the vertical direction by the boat vertical driver **1420** provided with the linear actuator, it is possible to drive a partition plate **2031** fixed to the partition plate support **2001** relatively in the vertical direction with respect to the support structure **1441** fixed to the boat **3001**.
[0135] In addition, by connecting the support structure **1441** to the plate **1422** via the bearing **1423**, it is possible to rotate the boat **3001** together with the partition plate support **2001** when the boat **3001** is rotationally driven by a rotational driving motor **1430**.
[0136] The support **1440** fixed to the partition plate support **2001** and the support structure **1441** fixed to the boat **3001** are connected by a vacuum bellows **1443**.
[0137] According to the configuration of the substrate processing apparatus **1000** according to the present embodiment, with the height of the substrate **10** accommodated in the boat **3001** constant (fixed) with respect to the hole **121** provided at the nozzle **120**, it is possible to adjust the height position of the partition plate **2031** fixed to the partition plate support **2001**.
[0138] Thereby, according to the present embodiment, in accordance with the surface area of the substrate **10** or the type of the film to be formed, it is possible to form the film while changing the positional relationship between the partition plate **2031** capable of covering an upper surface or a lower surface of the substrate **10** and the hole **121** of the nozzle **120** through which the film-forming gas is supplied based on the pre-set conditions. As a result, it is possible to improve the uniformity of the thickness distribution of the film formed on the surface of the substrate **10** accommodated in the boat **3001**.
Fourth Embodiment
[0139] FIG. **11** schematically illustrates a configuration of a substrate processing apparatus **1100** according to a fourth embodiment of the present disclosure. The same components as those of the first embodiment will be denoted by like reference numerals, and detailed descriptions thereof will be omitted.
[0140] The substrate processing apparatus **1100** according to the present embodiment is provided with a structure capable of vacuum-exhausting an inner atmosphere of a storage chamber **5001** by using a vacuum exhaust structure (not shown) with respect to the configuration of the substrate processing apparatus **100** described in the first embodiment. Thereby, it is possible to eliminate the vacuum sealing between the reaction tube **110** and the storage chamber **500** using the O-ring **446** as described with reference to FIG. **2** in the first embodiment, and it is also possible to change a height of the base flange **401** during the substrate processing.
[0141] As a result, according to the present embodiment, in addition to being capable of changing the height of the substrate support (boat) **300** with respect to the partition plate support **200** during the processing of the substrate **10** as described in the first embodiment, it is possible to change the height positions of the substrate support (boat) **300** and the partition plate support **200** together with respect to the hole **121** provided at the gas supply nozzle **120**.
[0142] The same components as those of the first embodiment described with reference to FIGS. **1**

and **2** will be denoted by like reference numerals, and detailed descriptions thereof will be omitted.

[0143] According to the present embodiment, as shown in FIG. **11**, a vertical driver **4001** is arranged outside the storage chamber **5001**, and a plate **4021** fixed to the vertical driver **4001** and displaced in the vertical direction by the vertical driver **4001** is connected to the storage chamber **5001** via a vacuum bellows **417** such that an inside of the storage chamber **5001** can be hermetically closed and vacuum-sealed.

[0144] That is, a structure capable of securing an airtightness of the inside of the storage chamber **5001** is provided by covering a space between the base flange **401** and the plate **422** with a side wall **4031**, and a vacuum state inside of the storage chamber **5001** can be maintained while a space surrounded by the base flange **401**, the plate **422** and the side wall **4031** is set to an atmospheric pressure through pipes **4023** and **4022** extending from the side wall **4031**. A structure surrounded by the base flange **401**, the plate **422** and the side wall **4031** may also be referred to as a "container".

[0145] Using the space provided by covering the space between the base flange **401** and the plate **422** with the side wall **4031**, for example, it is possible to provide a configuration (not shown) of connecting electrical wirings of the elevators or the rotator described above or a configuration (not shown) of providing (connecting) cooling water for protecting the vacuum sealing (not shown).

[0146] According to the present embodiment, in addition to being capable of changing the height of the substrate support (boat) **300** with respect to the partition plate support **200** during the processing of the substrate **10**, it is possible to change the height positions of the substrate support (boat) **300** and the partition plate support **200** together with respect to the hole **121** provided at the gas supply nozzle **120**. As a result, during the processing of the substrate **10**, it is possible to individually control the height of the partition plate **203** fixed to the partition plate support **200** and the height of the substrate **10** accommodated in the substrate support (boat) **300** with respect to the hole **121** provided at the gas supply nozzle **120**.

[0147] Thereby, according to the present embodiment, it is possible to improve the uniformity of the thickness distribution of the film formed on the surface of the substrate **10** accommodated in the boat **300**.

[0148] As described above, according to the technique of the present disclosure, it is possible to uniformly form the film while changing the positional relationship between the substrate **10** and the hole **121** of the nozzle **120** through which the film-forming gas is supplied in accordance with the surface area of the substrate **10** or the type of the film to be formed.

[0149] In addition, according to the technique of the present disclosure, the nozzle through which the film-forming gas is supplied is fixed with respect to a reaction chamber (that is, the reaction tube), and the substrate support (boat) in which the substrates are provided in a multistage manner is configured to be elevated or lowered by the vertical driver. When it is preferable to partition the reaction chamber in which the film-forming process is performed and the storage chamber located below the reaction chamber so as to shut off the gas or to shut off the pressure, the reaction chamber and the storage chamber are separated using a sealing by the O-ring, and are sealed with a elastic seal structure (bellows) corresponding to a stroke of a vertical movement of the substrate support (that is, a change in a relative position of the nozzle). On the other hand, when a pressure of a loading region (inside the storage chamber **500**) is substantially the same as a pressure of the reaction chamber (inside the reaction tube **110**), the sealing by the O-ring is not performed, and the reaction chamber and the vacuum loading region (inside the storage chamber **500**) are in communication with each other. In such a case, the inert gas is supplied through the vacuum loading region so as to form a pressure gradient. Thereby, it is possible to shut off the gas.

[0150] In addition, according to the technique of the present disclosure, by rotating the substrate during the film-forming process, it is possible to supply the film-forming gas ejected through the nozzle through which the film-forming gas is supplied while changing a flow velocity of the gas (film-forming gas) at a surface layer of the substrate by adjusting the distance between the nozzle and the surface of the substrate. It is also possible to adjust a decomposition state of the film-forming gas, which easily undergoes a gas phase reaction, until the film-forming gas reaches the surface layer of the substrate and contributes to the film-forming process.

[0151] As described above, according to the technique of the present disclosure, there is provided a method of manufacturing a semiconductor device of forming a film on a plurality of substrates by accommodating a substrate support into a reaction tube by driving the substrate support by a vertical driver in a state where a plurality of substrates are supported by the substrate support at intervals in a vertical direction; heating the plurality of substrates supported by the substrate support accommodated in the reaction tube by a heater provided around the reaction tube; and repeatedly performing (a) supplying a source gas to the plurality of substrates supported by the substrate support accommodated in the reaction tube through a plurality of holes provided at a gas supply nozzle and exhausting the supplied source gas from the reaction tube and (b) supplying the reactive gas to the plurality of substrates through the plurality of holes provided at a gas supply nozzle and exhausting the supplied reactive gas from the reaction tube, wherein (a) and (b) are performed in a state where a height of each of the plurality of partition plates accommodated in the reaction tube is adjusted by the vertical driver and a distance (height) between each of the plurality of substrates accommodated in the substrate support and each of the plurality of holes of the gas supply nozzle is adjusted in accordance with pre-set conditions.

[0152] In addition, according to the technique of the present disclosure, the source gas and the reactive gas are supplied through the holes of the nozzle through which the gas is supplied, wherein the holes are arranged at the nozzle in the vertical direction at the same interval as that of the substrates accommodated in the substrate support.

[0153] In addition, according to the technique of the present disclosure, the supply of the source gas and the supply of the reactive gas through the holes of the nozzle through which the gas is supplied are repeatedly performed while controlling the height of the substrate support accommodated in the reaction tube by the vertical driver and changing the distance (height) between each of the plurality of substrates accommodated in the substrate support and each of the holes of the nozzle through which the gas is supplied.

Preferable Examples of Present Disclosure

[0154] Hereinafter, preferable examples of the technique of the present disclosure are described.

<Supplementary Note 1>

[0155] Provided is a substrate processing apparatus including: [0156] a substrate support in which a plurality of substrates are accommodated; [0157] a plurality of partition plates configured separately from the substrate support and provided above the plurality of substrates accommodated in the substrate support, respectively; [0158] a partition plate support including a support configured to support the plurality of partition plates; [0159] a substrate support elevator configured to elevate and lower the substrate support; and [0160] a controller configured to be capable of controlling the substrate support elevator so as to change a positional relationship between each of the plurality of substrates and each of the plurality of partition plates in a vertical direction.

<Supplementary Note 2>

[0161] In the apparatus of Supplementary Note 1, further comprises [0162] a partition plate support elevator configured to elevate and lower the partition plate support.

<Supplementary Note 3>

[0163] In the apparatus of Supplementary Note 2, the controller is further configured to be capable of changing the positional relationship between each of the plurality of substrates and each of the plurality of partition plates in the vertical direction by elevating or lowering either the substrate support elevator or the partition plate support elevator.

<Supplementary Note 4>

[0164] In the apparatus of Supplementary Note 2, an elevating shaft of the substrate support elevator and an elevating shaft of the partition plate support elevator are configured to be concentric with each other. By configuring each elevating shaft to be concentric with each other as above, it is possible to simplify a structure of a rotator. Further, it is possible to easily control a synchronization of a rotation between the substrate support and the partition plate support. Further, the elevating shaft of the substrate support elevator may refer to the support structure **9441** described above. Further, the elevating shaft of the partition plate support elevator may refer to the support **9440** described above.

<Supplementary Note 5>

[0165] In the apparatus of Supplementary Note 2, an elevating shaft of the substrate support elevator is disposed in an elevating shaft of the partition plate support elevator.

<Supplementary Note 6>

[0166] In the apparatus of Supplementary Note 2, an elevating shaft of the partition plate support elevator is disposed in an elevating shaft of the substrate support elevator.

<Supplementary Note 7>

[0167] In the apparatus of Supplementary Note 2, a driver of the substrate support elevator is also configured to elevate or lower a driver of the partition plate support elevator.

<Supplementary Note 8>

[0168] In the apparatus of Supplementary Note 2, a transfer chamber is provided below a process chamber, and a lower end portion of the transfer chamber is hermetically sealed by the substrate support elevator and the partition plate support elevator.

<Supplementary Note 9>

[0169] In the apparatus of Supplementary Note 2, the apparatus further comprises a lid configured to support the partition plate support, and a lower end of a process chamber in which the substrate is processed is closed by the lid.

<Supplementary Note 10>

[0170] In the apparatus of Supplementary Note 2, the apparatus further comprises a lid configured to support the substrate support, and a lower end of a process chamber in which the substrate is processed is closed by the lid.

<Supplementary Note 11>

[0171] In the apparatus of Supplementary Note 1, a diameter of the partition plate is set to be greater than a diameter of the substrate.

<Supplementary Note 12>

[0172] In the apparatus of Supplementary Note 1, an area of the partition plate is set to be greater than an area of the substrate.

<Supplementary Note 13>

[0173] In the apparatus of Supplementary Note 1, the controller is further configured to be capable of controlling one or both of the substrate support elevator and a partition plate support elevator based on distance data between the substrate and the partition plate. In the Supplementary Note 13, the distance data refers to, for example, an actual distance or n times of a predetermined distance. In the Supplementary Note 13, the distance data may be recorded in the RAM **260***b*, the memory **260***c* described above, or the like.

<Supplementary Note 14>

[0174] In the apparatus of Supplementary Note 1, the controller is further configured to be capable of changing a distance between an upper surface of the substrate and the partition plate by driving one or both of the substrate support elevator and a partition plate support elevator based on pre-set film thickness data. In the Supplementary Note 14, the pre-set film thickness data may include at least one of film thickness information, a thickness distribution of a film, a thickness uniformity of the film, a thickness difference of the film (±X %) between a center and an outer periphery of the film, actual thickness data of the film, or the like, and is different from recipe data. The data described above may be obtained via a network. In addition, a relationship between the pre-set film thickness data and the distance may be determined by referring to a data table indicating at least a relationship between the thickness of the film (data such as a temperature, a flow rate of a gas, a pressure, a supply time, a type of the gas, a surface area of the substrate and the like) and a pitch. Alternatively, it may be calculated using a predetermined function. In such a case, the pitch (position of a first elevator) is calculated based on the pre-set film thickness data and the related data. Data such as the pre-set film thickness data and the data table shown in the Supplementary Note 14 may be recorded in the RAM **260***b*, the memory **260***c* described above, or the like.

<Supplementary Note 15>

[0175] In the apparatus of Supplementary Note 1, the controller is further configured to be capable of controlling one or both of the substrate support elevator and a partition plate support elevator such that a distance between an upper surface of the substrate and the partition plate is smaller than a distance between a transfer position (home position) and the partition plate.

<Supplementary Note 16>

[0176] In the apparatus of Supplementary Note 1, the controller is further configured to be capable of controlling one or both of the substrate support elevator and a partition plate support elevator such that a distance between an upper surface of the substrate and the partition plate is greater than a distance between a transfer position (home position) and the partition plate.

<Supplementary Note 17>

[0177] In the apparatus of Supplementary Note 1, a pitch is changed when a temperature of the substrate is elevated. In such a case, when the temperature of the substrate is elevated by being heated by the heater **101**, the pitch (that is, a distance between the back surface of the substrate **10** and the partition plate **203** below the substrate **10**) is narrowed (the state shown in FIG. **3**C). Narrowing the pitch is performed at least before the supply of the source gas. In addition, the pitch during the supply of the source gas may be set to be different from the pitch during the supply of the reactive gas. Further, the pitch may be changed during the supply of the source gas (or the reactive gas). In addition, the operation timing of the substrate support and the partition plate support can be set appropriately.

<Supplementary Note 18>

[0178] In the apparatus of Supplementary Note 17, the distance between the back surface of the substrate and the partition plate below the substrate is shorter while the temperature of the substrate is being elevated than while the substrate is being processed.

<Supplementary Note 19>

[0179] In the apparatus of Supplementary Note 17, the partition plate is provided with a notch of the substrate support, and the partition plate may support the substrate.

[0180] According to some embodiments of the present disclosure, it is possible to control the distribution of the concentration of the gas on the surface of each of the plurality of substrates, and also possible to improve the thickness uniformity of the film formed on each of the plurality of substrates when the plurality of substrates are processed simultaneously.

[0181] Further, according to some embodiments of the present disclosure, by processing the plurality of substrates by controlling the distribution of the concentration of the gas on the surface of each of the plurality of substrates when the plurality of substrates are processed simultaneously, it is possible to improve the efficiency of the material gas to be supplied, and also possible to reduce the cost by reducing a waste of the material gas.

Claims

1. A substrate processing apparatus comprising: a process chamber in which a plurality of substrates are processed; a substrate support configured to support the plurality of substrates; a partition plate support configured to support a plurality of partition plates arranged between the plurality of substrates; a driver configured to change a distance between each of the plurality of substrates supported by the substrate support and each of the plurality of partition plates supported by the partition plate support by moving one of the substrate support and the partition plate support in a vertical direction; a gas supplier provided with a hole through which a gas is supplied to the plurality of substrates; and a controller configured to be capable of controlling the driver and the gas supplier such that the gas is supplied to the plurality of substrates and one of a relative vertical position of each of the plurality of substrates and a relative vertical position of each of the plurality of partition plates with respect to the hole is changed by driving the driver, wherein the driver comprises: a rotational driver configured to rotate the substrate support; a substrate support vertical driver configured to move the substrate support in the vertical direction with respect to the partition plate support; and a partition plate support vertical driver configured to move the partition plate support in the vertical direction with respect to the substrate support.

2. The substrate processing apparatus of claim 1, wherein a height of each of the plurality of substrates with respect to the hole is changed by the substrate support vertical driver.

3. The substrate processing apparatus of claim 1, wherein a height of each of the plurality of partition plates with respect to the hole is changed by the partition plate support vertical driver.

4. The substrate processing apparatus of claim 1, wherein the substrate support and the partition plate support are connected by a vacuum bellows.

5. The substrate processing apparatus of claim 4, wherein the driver is disposed under an atmospheric pressure.

6. The substrate processing apparatus of claim 5, further comprising: a storage chamber configured to accommodate a substrate retainer after being lowered from the process chamber.

7. The substrate processing apparatus of claim 6, wherein an inside of the storage chamber is hermetically sealed with respect to an outside of the storage chamber, and wherein the driver is provided inside the storage chamber while accommodated in a container at the atmospheric pressure hermetically sealed with respect to the storage chamber.

8. The substrate processing apparatus of claim 6, further comprising: a vertical driver configured to load and unload the substrate retainer into and out of the process chamber.

9. The substrate processing apparatus of claim 8, wherein the storage chamber is further configured to accommodate the vertical driver.

10. The substrate processing apparatus of claim 7, wherein the driver is further configured to move in the vertical direction by a vertical driver disposed outside of the storage chamber.

11. The substrate processing apparatus of claim 1, further comprising: a substrate retainer comprising the substrate support and the partition plate support.

12. An elevator comprising: a substrate support configured to support a plurality of substrates; and a partition plate support configured to support a plurality of partition plates arranged between the plurality of substrates; and a driver configured to rotate the substrate support in a state where the substrate support and the partition plate support are inserted in a process chamber and to change relative positions of the substrate support and the partition plate support in the vertical direction, wherein the driver comprises: a rotational driver configured to rotate the substrate support; a substrate support vertical driver configured to move the substrate support in the vertical direction with respect to the partition plate support; and a partition plate support vertical driver configured to move the partition plate support in the vertical direction with respect to the substrate support.

13. A substrate processing method, comprising: (a) accommodating a substrate support configured to support a plurality of substrates and a partition plate support configured to support a plurality of partition plate supports arranged between the plurality of substrates, into a process chamber by moving the substrate retainer by a first driver, wherein the substrate retainer comprises: a substrate support configured to support a plurality of substrates at intervals in a vertical direction; and a partition plate support configured to support a plurality of partition plates arranged between the plurality of substrates supported by the substrate support; (b) heating the plurality of substrates; and (c) supplying a gas to the plurality of substrates through a plurality of gas supply holes provided at a gas supplier, wherein the second driver comprises: a rotational driver configured to rotate the substrate support and the partition plate support; a substrate support vertical driver configured to move the substrate support in the vertical direction with respect to the partition plate support; and a partition plate support vertical driver configured to move the partition plate support in the vertical direction with respect to the substrate support, and wherein, in (c), one of a height of each of the plurality of substrates and a height of each of the plurality of partition plates with respect to each of the plurality of gas supply holes is adjusted by (i) rotating the substrate support by a rotational driver, (ii) moving the substrate support in the vertical direction with respect to the partition plate support by a substrate support vertical driver, and (iii) moving the partition plate support in the vertical direction with respect to the substrate support by a partition plate support vertical driver.

14. The method of claim 13, wherein the height of each of the plurality of substrates with respect to each of the plurality of gas supply holes is changed by the substrate support vertical driver.

15. The method of claim 13, wherein the height of each of the plurality of partition plates with respect to each of the plurality of gas supply holes is changed by the partition plate support vertical driver.

16. The method of claim 13, wherein the height of each of the plurality of substrates with respect to each of the plurality of gas supply holes is changed by the substrate support vertical driver, and the height of each of the plurality of partition plates with respect to each of the plurality of gas supply holes is changed by the partition plate support vertical driver.

17. A method of manufacturing a semiconductor device, comprising: processing the plurality of substrates by using the method of claim 13.

18. A non-transitory computer-readable recording medium storing a program that causes, by a computer, a substrate processing apparatus to perform: the method of claim 13.