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VACUUM PROCESSING APPARATUS AND METHOD OF CONTROLLING VACUUM PROCESSING APPARATUS

Abstract

The present disclosure reduces deviation in the position and inclination of a stage due to the deformation of a processing container. A vacuum processing apparatus includes a processing container configured to be capable of maintaining an inside thereof in a vacuum atmosphere, a stage provided in the processing container such that a substrate is placed thereon, a support member passing through a hole in the bottom of the processing container to support the stage from the bottom side, a base member engaged with an end portion of the support member located outside the processing container to be movable integrally with the stage, and a plurality of actuators provided in parallel with each other between the bottom of the processing container and the base member and configured to adjust a position and an inclination of the stage by moving the base member relative to the bottom of the processing container.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] The present application is a division of U.S. patent application Ser. No. 18/918,374, filed Oct. 17, 2024, which is a continuation of U.S. patent application Ser. No. 17/304,973, filed Jun. 29, 2021 and issued as U.S. Pat. No. 12,165,908, which claims the benefit of priority from Japanese Patent Application No. 2020-116868, filed on Jul. 7, 2020, each of which is hereby incorporated herein by reference in its entirety.

TECHNICAL FIELD
[0002] The present disclosure relates to a vacuum processing apparatus and a method of controlling the vacuum processing apparatus.
BACKGROUND
[0003] Patent Document 1 discloses a structure in which an adjustment plate configured to adjust the inclination of a stage on which a substrate is placed is disposed below the bottom of a processing container, and the bottom of the processing container and the adjustment plate are fastened with bolts.
Prior Art Document
Patent Document
[0004] Patent Document 1: Japanese Laid-Open Patent Publication No. 2001-230307
SUMMARY
[0005] According to one embodiment of the present disclosure, there is provided a vacuum
[0006] processing apparatus including: a processing container configured to be capable of maintaining an inside of the processing container in a vacuum atmosphere; a stage provided in the processing container and having a substrate placed on the stage; a support member passing through a hole in a bottom of the processing container to support the stage from a bottom side of the stage; a base member engaged with an end portion of the support member located outside the processing container to be movable integrally with the stage; and a plurality of actuators provided in parallel with each other between the bottom of the processing container and the base member, and configured to adjust a position and an inclination of the stage by moving the base member relative to the bottom of the processing container.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0007] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the present disclosure, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the present disclosure.
[0008] FIG. **1** is a schematic plan view illustrating an exemplary configuration of a vacuum

processing system according to an embodiment.
[0009] FIG. **2** is an exploded perspective view illustrating an exemplary configuration of a vacuum processing apparatus according to an embodiment.
[0010] FIG. **3** is a plan view schematically illustrating an internal configuration of a vacuum processing apparatus according to an embodiment.
[0011] FIG. **4** is a schematic cross-sectional view illustrating an exemplary configuration of a vacuum processing apparatus according to an embodiment.
[0012] FIG. **5** is a view illustrating an exemplary configuration of a rotational driving mechanism and an adjustment mechanism according to an embodiment.
[0013] FIG. **6** is a view illustrating an exemplary configuration of the absorption mechanism illustrated in FIG. **5**.
[0014] FIG. **7** is a flowchart illustrating Example 1 of the flow of a method of controlling a vacuum processing apparatus according to an embodiment.
[0015] FIG. **8** is a flowchart illustrating Example 2 of the flow of a method of controlling a vacuum processing apparatus according to an embodiment.
[0016] FIG. **9** is a flowchart illustrating Example 3 of the flow of a method of controlling a vacuum processing apparatus according to an embodiment.
[0017] FIG. **10** is a flowchart illustrating Example 4 of the flow of a method of controlling a vacuum processing apparatus according to an embodiment.
[0018] FIG. **11** is a flowchart illustrating Example 5 of the flow of a method of controlling a vacuum processing apparatus according to an embodiment.

DETAILED DESCRIPTION

[0019] Reference will now be made in detail to various embodiments, examples of which are illustrated in the accompanying drawings. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. However, it will be apparent to one of ordinary skill in the art that the present disclosure may be practiced without these specific details. In other instances, well-known methods, procedures, systems, and components have not been described in detail so as not to unnecessarily obscure aspects of the various embodiments.
[0020] Hereinafter, embodiments of a vacuum processing apparatus and a method of controlling the vacuum processing apparatus disclosed herein will be described in detail with reference to the drawings. The vacuum processing apparatus and method of controlling the same disclosed herein are not limited by the following embodiments.
[0021] A processing container of a vacuum processing apparatus is deformed due to a pressure difference when the internal pressure thereof is switched from an atmospheric state to a vacuum state. The processing container is also deformed due to a temperature change. When the processing container is deformed, the stress due to the deformation of the processing container is transmitted to the stage, and the position and inclination of the stage may deviate from the desired position and inclination. For example, in the structure in which an adjustment plate is arranged below the bottom of the processing container as in Patent Document 1, the adjustment plate is moved using a bolt to reduce deviation in the inclination of the stage due to the deformation of the processing container. However, it is difficult to reduce or eliminate the deviation in the position of the stage. Therefore, there is a need for a technique for reducing or eliminating the deviation in the position and inclination of a stage due to the deformation of a processing container.

Embodiments

Configuration of Vacuum Processing System

[0022] FIG. **1** is a schematic plan view illustrating an exemplary configuration of a vacuum processing system according to an embodiment. A vacuum processing system **1** includes a carry-in/out port **11**, a carry-in/out module **12**, a vacuum transport module **13**, and a vacuum processing apparatus **2**. In FIG. **1**, the X direction will be referred to as a left-right direction, the Y direction will be referred to as a front-rear direction, the Z direction will be referred to as an up-down direction (height direction), and the side having the carry-in/out port **11** therein will be referred to as a front side in the front-rear direction. The carry-in/out port **11** is connected to the front side of the carry-in/out module **12**, and the vacuum transport module **13** is connected to the rear side of the carry-in/out module **12** in the front-rear direction.

[0023] A carrier C, which is a transport container accommodating substrates to be processed, is placed in the carry-in/out port **11**. The substrate is a wafer W, which is a circular substrate having a diameter of, for example, **300** mm. The carry-in/out module **12** is a module configured to perform carry-in/out of a wafer W between the carrier C and the vacuum transport module **13**. The carry-in/out module **12** includes a normal-pressure transport chamber **121** configured to transport a wafer W to and from the carrier C in a normal-pressure atmosphere by a transport mechanism **120**, and a load-lock chamber **122** configured to switch the atmosphere in which a wafer W is placed between a normal-pressure atmosphere and a vacuum atmosphere.

[0024] The vacuum transport module **13** has a vacuum transport chamber **14** in which a vacuum atmosphere is formed. A substrate transport mechanism **15** is arranged inside the vacuum transport chamber **14**. The vacuum transport chamber **14** is formed in, for example, a rectangular shape having long sides in the front-rear direction in a plan view. Among the four side walls of the vacuum transport chamber **14**, a plurality of (for example, three) vacuum processing apparatuses **2** are connected to each of the opposite long sides of the rectangle. In addition, among the four side walls of the vacuum transport chamber **14**, the load-lock chamber **122** installed in the carry-in/out module **12** is connected to the short side on the front side. Gate valves G are arranged between the normal-pressure transport chamber **121** and the load-lock chamber **122**, between the load-lock chamber **122** and the vacuum transport module **13**, and between the vacuum transport module **13** and each of the vacuum processing apparatuses **2**, respectively. Each gate valve G opens and closes the carry-in/out port of the wafer W provided in a corresponding one of the modules connected to each other.

[0025] The substrate transport mechanism **15** transports a wafer W between the carry-in/out module **12** and each of the vacuum processing apparatuses **2** in a vacuum atmosphere. The substrate transport mechanism **15** is configured as an articulated arm, and includes a substrate holder **16** configured to hold a wafer W. Each vacuum processing apparatus **2** collectively processes a plurality of (e.g., four) wafers W in a vacuum atmosphere using a processing gas. Therefore, the substrate holder **16** of the substrate transport mechanism **15** is configured to hold, for example, four wafers W such that the four wafers W are delivered together to the vacuum processing apparatuses **2**, respectively.

[0026] Specifically, the substrate transport mechanism **15** includes, for example, a base **151**, a horizontally extending first arm **152**, a horizontally extending second arm **153**, and a substrate holder **16**. The base side of the first arm **152** is provided on the base **151** and swivels around a vertical swivel axis on the base **151**. The base side of the second arm **153** is provided on the tip of the first arm **152**, and the second arm **153** swivels around a vertical swivel axis on the tip of the first arm **152**. The substrate holder **16** has a first substrate holder **161**, a second substrate holder **162**, and a connecting part **163**. The first substrate holder **161** and the second substrate holder **162** are configured in the shape of two elongated spatulas extending horizontally and parallel to each other. The connecting part **163** extends horizontally so as to be orthogonal to the direction of extension of the first and second substrate holders **161** and **162**, and connects the base ends of the first and second substrate holders **161** and **162** to each other. The central portion of the connecting part **163** in the length direction is provided on the tip of the second arm **153** and swivels around a vertical swivel axis on the tip of the second arm **153**. The first substrate holder **161** and the second substrate holder **162** will be described later.

[0027] The vacuum processing system **1** has a controller **8**. The controller **8** is, for example, a computer including a processor, a storage, an input device, a display device, and the like. The controller **8** controls each part of the vacuum processing system **1**. With the controller **8**, an operator may perform a command input operation or the like using the input device in order to manage the vacuum processing system **1**. In addition, in the controller **8**, the operating state of the vacuum processing system **1** may be visualized and displayed by the display device. In addition, the storage of the controller **8** stores a control program, recipe data, and the like for use by the processor in controlling various processes executed by the vacuum processing apparatus **1**. The processor of the controller **8** executes the control program and controls each part of the vacuum processing system **1** according to the recipe data, whereby desired substrate processing is executed in the vacuum processing system **1**.

Configuration of Vacuum Processing Apparatus

[0028] Next, an example in which the vacuum processing apparatus **2** is applied to, for example, a film forming apparatus that performs plasma chemical vapor deposition (CVD) processing on, for example, wafers W will be described with reference to FIGS. **2** to **4**. FIG. **2** is an exploded perspective view illustrating an exemplary configuration of a vacuum processing apparatus **2** according to an embodiment. FIG. **3** is a plan view schematically illustrating an internal configuration of the vacuum processing apparatus **2** according to the embodiment.

[0029] The six vacuum processing apparatuses **2** are configured in the same manner as each other, and the vacuum processing apparatuses **2** are capable of processing wafers W in parallel with each other. Each vacuum processing apparatus **2** includes a processing container (a vacuum container) **20** having a rectangular shape in a plan view. The processing container **20** is configured to maintain the inside thereof in a vacuum atmosphere. The processing container **20** is configured by providing concave open portions in the top surface of a container body **202** and covering the open portions with a ceiling member **201**. The processing container **20** has, for example, side wall portions **203** surrounding the periphery thereof. Among the four side wall portions **203**, the side wall portion **203** connected to the vacuum transport chamber **14** includes two carry-in/out ports **21** formed to be arranged in the front-rear direction (the Y′ direction in FIG. **2**). The carry-in/out ports **21** are opened and closed by a gate valve G.

[0030] As illustrated in FIGS. **2** and **3**, inside the processing container **20**, a first transport space T**1** and a second transport space T**2** extending in the horizontal direction from respective carry-in/out ports **21** are provided at positions adjacent to each other so as to transport wafers W therein. In addition, an intermediate wall portion **3** is provided between the first transport space T**1** and the second transport space T**2** in the processing container **20** along the direction of extension of the same (the X′ direction in FIG. **2**). Two processing spaces S**1** and S**2** are arranged in the first transport space T**1** along the direction of extension of the same, and two processing spaces S**3** and S**4** are arranged in the second transport space T**2** along the direction of extension thereof. Therefore, in the processing container **20**, a total of four processing spaces S**1** to S**4** are arranged in a 2×2 matrix when viewed from the top side. The horizontal direction referred to herein also includes the case in which wafers W are slightly tilted in the extension direction in a range where there is no influence such as contact between devices during a carry-in/out operation of the wafers W due to the influence of tolerance at the time of manufacturing.

[0031] FIG. **4** is a schematic cross-sectional view illustrating an exemplary configuration of a vacuum processing apparatus **2** according to an embodiment. The cross section of FIG. **4** corresponds to the cross section of the vacuum processing apparatus **2** taken along the line A-A in FIG. **3**. The four processing spaces S**1** to S**4** are configured in the same manner as each other, and are formed between stages **22**, on each of which a wafer W is placed, and gas supply parts **4** are arranged so as to face respective ones of the stages **22**. In other words, in the processing container **20**, a stage **22** and a gas supply part **4** are provided for each of the four processing spaces S**1** to S**4**. FIG. **4** illustrates a processing space S**1** of the first transport space T**1** and a processing space S**4** of the second transport space T**2**. Hereinafter, the processing space S**1** will be described as an example.

[0032] Each stage **22** also serves as a lower electrode, is made of, for example, a metal or aluminum nitride (AlN), in which a metal mesh electrode is embedded, and has a flat columnar shape. The stage **22** is supported by a support member **23** from the bottom side. The support member **23** is formed in a cylindrical shape, extends vertically downwards, and penetrates the bottom **27** of the processing container **20**. The lower end of the support member **23** is located outside the processing container **20**, and is connected to a rotational driving mechanism **600**. The support member **23** is rotated by the rotational driving mechanism **600**. The stage **22** is configured to be rotatable according to the rotation of the support member **23**. An adjustment mechanism **700** is provided at the lower end of the support member **23** to adjust the position and inclination of the stage **22**. The stage **22** is configured to be capable of being raised and lowered between a processing position and a delivery position using the support member **23** by the adjustment mechanism **700**. In FIG. **4**, the stage **22** located at the processing position is drawn with a solid line, and the stage **22** located at the delivery position is drawn with a broken line. The processing position is the position when substrate processing (e.g., film forming processing) is executed, and the delivery position is the position at which a wafer W is transported to and from a substrate transport mechanism **15**. The rotational driving mechanism **600** and the adjustment mechanism **700** will be described later.
[0033] A heater **24** is embedded in the stage **22**. The heater **24** heats each wafer W placed on the stage **22** to, for example, about 60 degrees C. to 600 degrees C. In addition, the stage **22** is connected to a ground potential.
[0034] In addition, the stage **22** is provided with a plurality of (e.g., three) pin through holes **26***a*, and lifter pins **26** are arranged inside these pin through holes **26***a*, respectively. The pin through holes **26***a* are provided so as to penetrate from the placement surface (top surface) of the stage **22** to the rear surface (bottom surface) with respect to the placement surface. The lifter pins **26** are slidably inserted into the pin through holes **26***a*. The upper ends of the lifter pins **26** are suspended at the placement surface sides of the pin through holes **26***a*. That is, the upper ends of the lifter pins **26** have a diameter larger than that of the pin through holes **26***a*, and recesses having a diameter and a thickness larger than those of the upper ends of the lifter pins **26** are formed in the upper ends of the pin through holes **26***a* to be capable of accommodating the upper ends of the lifter pins **26**, respectively. As a result, the upper ends of the lifter pins **26** are engaged with the stage **22** and suspended from the placement surface sides of the pin through holes **26***a*, respectively. In addition, the lower ends of the lifter pins **26** protrude from the rear surface of the stage **22** toward the bottom **27** side of the processing container **20**.
[0035] As illustrated in FIG. **4**, in the state in which the stage **22** is raised to the processing position, the upper ends of the lifter pins **26** are received in the recesses at the placement sides of the pin through holes **26***a*, respectively. From this state, when the stage **22** is lowered to the delivery position and the lifter pins **26** are raised by a lifting mechanism (not shown), the upper ends of the lifter pins **26** protrude from the placement surface of the stage **22**.
[0036] Here, the first and second substrate holders **161** and **162** will be described. The first substrate holder **161** is configured to support wafers W at positions corresponding to respective arrangement positions of the processing spaces S**1** and S**2** in the first transport space T**1** when the first substrate holder **161** enters the first transport space T**1**. The positions corresponding to respective arrangement positions of the processing spaces S**1** and S**2** in the first transport space T**1** are the positions set to deliver wafers W to the two stages **22** provided in the processing spaces S**1** and S**2** of the first transport space T**1**. In addition, the second substrate holder **162** is configured to support wafers W at positions corresponding to respective arrangement positions of the processing spaces S**3** and S**4** in the second transport space T**2** when the second substrate holder **162** enters the second transport space T**2**. The positions corresponding to respective arrangement positions of the processing spaces S**3** and S**4** in the second transport space T**2** are the positions set to deliver wafers W to the two stages **22** provided in the processing spaces S**3** and S**4** of the second transport space

T**2**.

[0037] For example, the width of each of the first and second substrate holders **161** and **162** is smaller than the diameter of the wafers W, and the rear surfaces of the wafers W are supported at an interval from each other on the tip side and the base end side of each of the first and second substrate holders **161** and **162**. The wafers W supported on the tip sides of the first and second substrate holders **161** and **162** are supported on the tips of the first and second substrate holders **161** and **162** at, for example, the centers thereof.

[0038] In this way, by the cooperative action of the substrate transport mechanism **15**, the lifter pins **26**, and the stage **22**, for example, the delivery of four wafers W between the substrate transport mechanism **15** and each stage **22** is collectively and concurrently performed.

[0039] The gas supply part **4** is provided above each stage **22** in the ceiling member **201** of the processing container **20** via a guide member **34** made of an insulating member. The gas supply part **4** has a function as an upper electrode. The gas supply part **4** includes a cover **42**, a shower plate **43** forming a facing surface provided to face the placement surface of the stage **22**, and a gas flow chamber **44** formed between the cover **42** and the shower plate **43**. A gas supply pipe **51** is connected to the cover **42**, and gas ejection holes **45** penetrating the shower plate **43** in the thickness direction are arranged vertically and horizontally in the shower plate **43** such that gas is ejected toward the stage **22** in a shower form.

[0040] Each gas supply part **4** is connected to a gas supply system **50** via a gas supply pipe **51**. The gas supply system **50** includes, for example, supply sources of a reaction gas (a film forming gas), a purge gas, or a cleaning gas, which are processing gases, a pipe, a valve V, a flow control part M, and the like.

[0041] A radio frequency power supply **41** is connected to the shower plate **43** via a matcher **40**. The shower plate **43** has a function as an upper electrode facing the stage **22**. When radio frequency power is applied between the shower plate **43**, which is the upper electrode, and the stage **22**, which is the lower electrode, it is possible to plasmatize a gas supplied from the shower plate **43** to the processing space S**1** (a reaction gas in this example) through capacitive coupling.

[0042] Next, an exhaust path and a confluent exhaust path formed in an intermediate wall portion **3** will be described. As illustrated in FIGS. **3** and **4**, the intermediate wall portion **3** includes exhaust paths **31** provided for the four processing spaces S**1** to S**4**, respectively, and a confluent exhaust path **32** at which these exhaust paths **31** merge. The confluent exhaust path **32** extends in the up-and-down direction in the intermediate wall portion **3**. The intermediate wall portion **3** includes a wall body **311** provided on the container body **202** side and an exhaust path forming member **312** provided on the side of the ceiling member **201**. The exhaust paths **31** are provided inside the exhaust path forming member **312**.

[0043] In addition, on the wall surface of the intermediate wall portion **3** located outside each of the processing spaces S**1** to S**4**, an exhaust port **33** is formed for each of the processing spaces S**1** to S**4**. Each exhaust path **31** is formed in the intermediate wall portion **3** so as to connect the exhaust port **33** and the confluent exhaust path **32** to each other. Each exhaust path **31** extends, for example, in the horizontal direction in the intermediate wall portion **3**, and is then bent downwards and extends in the up-and-down direction to be connected to the confluent exhaust path **32**. For example, the exhaust path **31** has a circular cross section (see FIG. **3**), the downstream end of each exhaust path **31** is connected to the upstream end of the confluent exhaust path **32**, and the upstream side of each exhaust path **31** is open to the outside of each of the processing spaces S**1** to S**4**, thereby serving as an exhaust port **33**.

[0044] A round each of the processing spaces S**1** to S**4**, a guide member **34** for exhaust is provided so as to surround each of the processing spaces S**1** to S**4**. The guide member **34** is, for example, an annular body provided so as to surround the area around the stage **22** at the processing position at an interval spaced apart from the stage **22**. The guide member **34** is configured to form therein a flow path **35** having, for example, a rectangular shape in vertical cross-sectional view and annular shape in a plan view. FIG. **3** schematically illustrates the processing spaces S**1** to S**4**, the guide members **34**, the exhaust paths **31**, and the confluent exhaust path **32**.

[0045] As illustrated in FIG. **4**, each guide member **34** has, for example, a U shape in the vertical cross section, and is arranged such that the opening portion of the U shape is directed downwards. The guide members **34** are fitted into respective recesses **204** formed in the intermediate wall portion **3** and closer to the side wall portions **203** of the container body **202**, and form flow paths **35** between the intermediate wall portion **3** and the members constituting the side wall portions **203**.

[0046] The guide members **34** fitted into the respective recesses **204** form slit-shaped slit exhaust ports **36** that are open toward respective processing spaces S**1** to S**4**. In this way, a slit exhaust port **36** is formed in the side peripheral portion of each of the processing spaces S**1** to S**4** along the circumferential direction. An exhaust port **33** is connected to each of the flow paths **35**, and the processing gas exhausted from the slit exhaust ports **36** is allowed to flow toward the exhaust port **33**.

[0047] Attention is now to be paid to a set of two processing spaces S**1** and S**2** arranged along the extension direction of the first transport space T**1** and a set of two processing spaces S**3** and S**4** arranged along the extension direction of the second transport space T**2**. As illustrated in FIG. **3**, the sets of processing spaces S**1** and S**2** and spaces S**3** and S**4** are arranged rotationally symmetrically by 180 degrees around the confluent exhaust path **32** when viewed from the side of the top surface.

[0048] As a result, the flow paths for a processing gas extending from respective processing spaces S**1** to S**4** to the confluent exhaust path **32** via the slit exhaust ports **36**, the flow paths **35** in the guide members **34**, the exhaust ports **33**, and the exhaust paths **31** surround the confluent exhaust path **32**, and are formed rotationally symmetrically by 180 degrees around the confluent exhaust path **32**. Paying attention only to the flow paths, excluding the positional relationships with the first and second transport spaces T**1** and T**2** and the intermediate wall portion **3**, these flow paths may be said to be formed rotationally symmetrically by 90 degrees around the confluence exhaust path **32**.

[0049] The confluent exhaust path **32** is connected to exhaust pipes **61** via a confluent exhaust port **205** formed in the bottom **27** of the processing container **20**. Each exhaust pipe **61** is connected to a vacuum pump **62** forming a vacuum exhaust mechanism via a valve mechanism **7**. For example, one vacuum pump **62** is provided in one processing container **20** (see FIG. **1**), and the exhaust pipes **61** on the downstream sides of each vacuum pump **62** merge and are connected to, for example, a factory exhaust system.

[0050] The valve mechanism **7** opens and closes the flow path of the processing gas formed in each exhaust pipe **61**, and has, for example, a casing **71** and an opening/closing portion **72**. A first opening **73** connected to the exhaust pipe **61** on the upstream side is formed in the top surface of the casing **71**, and a second opening **74** connected to the exhaust pipe **61** on the downstream side is formed in the side surface of the casing **71**.

[0051] The opening/closing portion **72** has, for example, an opening/closing valve **721** formed to have a size that closes the first opening **73**, and a lifting mechanism **722** provided outside the casing **71** so as to raise and lower the opening/closing valve **721** inside the casing **71**. The opening/closing valve **721** is configured to be capable of being raised and lowered between a closing position for closing the first opening **73** indicated by the one-dot chain line in FIG. **4** and an opening position retracted downwards from the first and second openings **73** and **74** indicated by the solid line in FIG. **4**. When the opening/closing valve **721** is located at the closing position, the downstream end of the confluent exhaust port **205** is closed, and the exhaust in the processing container **20** is stopped. In addition, when the opening/closing valve **721** is located at the opening position, the downstream end of the confluent exhaust port **205** is opened and the inside of the processing container **20** is exhausted.

[0052] Next, a processing gas supply system will be described with reference to FIG. **2** by taking the case in which two types of reaction gases are used as an example. A gas supply pipe **51** is connected to each gas supply part **4** at substantially the center of the top surface thereof. The gas supply pipe **51** is connected to a first reaction gas supply source **541** and a purge gas supply source **55** via a first common gas supply path **521** by a first gas supply pipe **511**. In addition, the gas supply pipe **51** is connected to a second reaction gas supply source **542** and the purge gas supply source **55** via a second common gas supply path **522** by a second gas supply pipe **512**. In FIG. **4**, for convenience, the first common gas supply path **521** and the second common gas supply path **522** are collectively illustrated as a gas supply path **52**. In addition, the first reaction gas supply source **541** and the second reaction gas supply source **542** are collectively illustrated as a reaction gas supply source **54**. In addition, the first gas supply pipe **511** and the second gas supply pipe **512** are collectively illustrated as a gas supply pipe **510**. A valve V**2** and a flow control part M**2** serve to supply a reaction gas, and the valve V**3** and the flow control part M**3** serve to supply a purge gas.
[0053] In addition, the gas supply pipe **51** is connected to a cleaning gas supply source **53** by a cleaning gas supply path **532** via a remote plasma unit (RPU) **531**. The cleaning gas supply path **532** branches into four systems on the downstream side of the RPU **531** so as to be connected to each gas supply pipe **51**. A valve V**1** and a flow control part M**1** are provided on the upstream side of the RPU **531** in the cleaning gas supply path **532**. In addition, valves V**11** to V**14** are provided for respective branched pipes on the downstream side of the RPU **531**, and the corresponding valves V**11** to V**14** are open during cleaning. For convenience, only valves V**11** and V**14** are illustrated in FIG. **4**. Taking the case in which an insulating oxide film (SiO.sub.2) is formed through CVD as an example, as the reaction gas, for example, tetraethoxysilane (TEOS) or oxygen (O.sub.2) gas is used, and as the purge gas, for example, an inert gas such as nitrogen (N.sub.2) gas is used. When TEOS and O.sub.2 gas are used as the reaction gas, the TEOS is supplied from, for example, the first reaction gas supply source **541**, and O.sub.2 gas is supplied from the second reaction gas supply source **542**. As the cleaning gas, for example, nitrogen trifluoride (NF.sub.3) gas is used.
[0054] In view of the processing gas distributed from the common gas supply path **52**, respective processing gas paths leading to the gas supply part **4** from respective gas supply pipes **51** are formed such that the conductances thereof are uniform with each other. For example, as illustrated in FIG. **2**, the downstream side of the first common gas supply path **521** branches into two systems, and each gas supply path branch further branches into two systems such that first gas supply pipes **511** are formed in a tournament shape. On the downstream side of the valves V**11** to V**14** for cleaning gas, the first gas supply pipes **511** are connected to the gas supply pipes **51**, respectively. In addition, the downstream side of the second common gas supply path **522** branches into two systems, and each gas supply path branch further branches into two systems such that second gas supply pipes **512** are formed in a tournament shape. On the downstream side of the valves V**11** to V**14** for cleaning gas, the second gas supply pipes **512** are connected to the gas supply pipes **51**, respectively.
[0055] Each first gas supply pipe **511** is formed such that the length and inner diameter from the upstream end (the end connected to the first common gas supply paths **521**) to the downstream end (the end connected to the gas supply part **4** or the gas supply pipe **51**) are formed to be uniform for all of the first gas supply pipes **511**. In addition, each second gas supply pipe **512** is formed such that the length and inner diameter from the upstream end (the end connected to the second common gas supply paths **522**) to the downstream end are formed to be uniform for all of the second gas supply pipes **512**. In this way, in view of the processing gas distributed from the first common gas supply path **521**, respective gas processing paths leading to the confluent exhaust path **32** via the first gas supply pipes **511**, the gas supply part **4**, the processing spaces S**1** to S**4**, and the exhaust paths **31** are formed such that conductances thereof are uniform with each other. In addition, in view of the processing gas distributed from the second common gas supply path **522**, respective

gas processing paths leading to the confluent exhaust path **32** via the second gas supply pipes **512**, the gas supply part **4**, the processing spaces S**1** to S**4**, and the exhaust paths **31** are formed such that conductances thereof are uniform with each other.

[0056] The vacuum processing apparatus **2** is connected to the controller **8** of the vacuum processing system **1**. The controller **8** controls each part of the vacuum processing apparatus **2**. With the controller **8**, an operator may perform a command input operation or the like using the input device in order to manage the vacuum processing apparatus **2**. In addition, in the controller **8**, the operating state of the vacuum processing apparatus **2** may be visualized and displayed by the display device. Furthermore, the storage of the controller **8** stores a control program and recipe data for controlling various processes, which are executed by the vacuum processing apparatus **2**, by the processor. The processor of the controller **8** executes the control program and controls each part of the vacuum processing apparatus **2** according to the recipe data, whereby desired processing is executed in the vacuum processing apparatus **2**. For example, the controller **8** controls each part of the vacuum processing apparatus **2** to execute substrate processing such as etching processing or film forming processing on a substrate carried into the vacuum processing apparatus **2**.

Configuration of Rotational Driving Mechanism and Adjustment Mechanism

[0057] FIG. **5** is a view illustrating an exemplary configuration of a rotational driving mechanism **600** and an adjustment mechanism **700** according to an embodiment. A hole **27***a* is formed in the bottom **27** of the processing container **20** at a position corresponding to a position for supporting the stage **22**. A support member **23** is inserted into the hole **27***a* to support the stage **22** from the bottom side. The rotational driving mechanism **600** is connected to the lower end portion **23***a* of the support member **23** located outside the processing container **20**.

[0058] The rotational driving mechanism **600** has a rotation shaft **610**, a motor **620**, and a vacuum seal **630**.

[0059] The rotation shaft **610** is connected to the lower end portion **23***a* of the support member **23**, and is configured to be integrally rotatable with the support member **23**. A slip ring **621** is provided at the lower end of the rotation shaft **610**. The slip ring **621** has an electrode, and is electrically connected to various wiring lines for supplying power to parts around the stage **22**. For example, the slip ring **621** is electrically connected to a wiring line for supplying power to the heater **24** embedded in the stage **22**. For example, when an electrostatic chuck configured to electrostatically attract a wafer W is provided on the stage **22**, the slip ring **621** is electrically connected to a wiring line of a DC voltage applied to the electrostatic chuck.

[0060] The motor **620** is connected to the rotation shaft **610**, and rotates the rotation shaft **610**. When the rotation shaft **610** rotates, the stage **22** rotates via the support member **23**. When the rotation shaft **610** rotates, the slip ring **621** also rotates together with the rotation shaft **610**, but the electrical connection between the slip ring **621** and various wiring lines for supplying power to the parts around the stage **22** is maintained.

[0061] The vacuum seal **630** is, for example, a magnetic fluid seal, and is provided around the rotation shaft **610** so as to allow rotation of the rotation shaft **610** be maintained while airtightly sealing the rotation shaft **610**.

[0062] In addition, the adjustment mechanism **700** is engaged with the lower end portion **23***a* of the support member **23** via the vacuum seal **630**.

[0063] The adjustment mechanism **700** includes a base member **710**, a plurality of (e.g., six) actuators **720**, an absorption mechanism **730**, and a bellows **740**.

[0064] The base member **710** is engaged with the lower end portion **23***a* of the support member **23** located outside the processing container **20** via the vacuum seal **630**, and is configured to be integrally movable with the stage **22**. For example, the base member **710** has therein a hole **711** formed to have a diameter larger than that of the lower end portion **23***a* of the support member **23**. The support member **23** passes through the hole **711**, and the lower end portion **23***a* is connected to the rotation shaft **610**. The vacuum seal **630** is provided around the rotation shaft **610** connected to the lower end portion **23***a* of the support member **23**, and the base member **710** is fixed to the top surface of the vacuum seal **630**. As a result, the base member **710** is connected to the stage **22** via the vacuum seal **630**, the rotation shaft **610**, the support member **23**, and the like, and is movable integrally with the stage **22**.

[0065] The plurality of actuators **720** are provided in parallel with each other between the bottom **27** of the processing container **20** and the base member **710**, and relatively move the base member **710** with respect to the bottom **27** of the processing container **20** to adjust the position and inclination of the stage **22**. The actuators **720** are expandable and contractible, are rotatably and slidably connected to the base member **710** via universal joints, respectively, and are rotatably and slidably connected to the bottom **27** side of the processing container **20** via universal joints, respectively. The actuators **720** and the base member **710** form parallel link mechanisms, each of which is movable in the directions of the X′, Y′, and Z′ axes illustrated in FIG. **5**, the rotation direction around the X′ axis, the rotation direction around the Y′ axis, and the rotation direction around the Z′ axis. A moving coordinate system of the parallel link mechanism formed by the plurality of actuators **720** and the base member **710** is adjusted in advance so as to match the coordinate system of the processing container **20**. By connecting the bottom **27** of the processing container and the base member **710** via the parallel link mechanism, the plurality of actuators **720** are capable of moving the base member **710** relative to the bottom **27** of the processing container **20**. Thereby, it is possible to adjust the position and inclination of the stage **22**. For example, the plurality of actuators **720** adjust the position of the stage **22** by moving the base member **710** in a direction orthogonal to the outer wall surface of the bottom **27** of the processing container **20** (e.g., the Z′ axis direction in FIG. **5**). In addition, for example, the plurality of actuators **720** adjust the position of the stage **22** by moving the base member **710** in a direction following the outer wall surface of the bottom **27** of the processing container **20** (e.g., the X′ axis direction and the Y′ axis direction in FIG. **5**). Furthermore, for example, the plurality of actuators **720** adjust the inclination of the stage **22** by tilling the base member **710** in a predetermined direction (e.g., the rotation direction around the X′ axis and the rotation direction around the Y′ axis in FIG. **5**) relative to the outer wall surface of the bottom **27** of the processing container **20**.

[0066] It is possible to specify the position and inclination of the stage **22** adjusted by the plurality of actuators **720** by detecting the position and inclination of the base member **710** using various detectors. Examples of the detectors may include a linear encoder, a gyro sensor, a 3-axis acceleration sensor, a laser tracker, and the like.

[0067] In the vacuum processing apparatus **2**, when the pressure inside the processing container **20** is switched from the atmospheric state to the vacuum state, the processing container **20** is deformed due to the pressure difference. In addition, the temperature of the processing container **20** is changed due to the heat transferred thereto during the substrate processing carried out in the processing container **20**, and the processing container **20** is also deformed by the temperature change. When the processing container **20** is deformed, stress due to the deformation of the processing container **20** is transmitted to the stage **22**, and the position or inclination of the stage **22** may change.

[0068] Therefore, in the vacuum processing apparatus **2** according to the present embodiment, the plurality of actuators **720** are provided between the bottom **27** of the processing container **20** and the base member **710**, which is integrally movable with the stage **22**. The plurality of actuators **720** adjust the position or inclination of the stage **22** by relatively moving the base member **710** relative to the bottom **27**. As a result, even when the position or inclination of the stage **22** changes due to the deformation of the processing container **20**, it is possible to adjust the position and inclination of the stage **22** to the original position and inclination. As a result, the vacuum processing apparatus **2** according to the present embodiment is capable of reducing or eliminating deviation in the position and inclination of the stage **22** due to the deformation of the processing container **20**. As a result, it is possible to improve in-plane uniformity in substrate processing such as film-forming processing.

[0069] The absorption mechanism **730** is provided on the bottom **27** of the processing container **20**, and absorbs the deformation of the bottom of the processing container **20**. A hole **731** is formed in the absorption mechanism **730** to communicate with the inside of the processing container **20** through the hole **27***a* in the bottom **27** of the processing container **20**. The plurality of actuators **720** are connected to the absorption mechanism **730**, rather than being directly connected to the bottom **27** of the processing container **20**. As a result, even when the bottom **27** of the processing container **20** is deformed, stress due to the deformation of the bottom **27** of the processing container **20** is absorbed by the absorption mechanism **730** and is not transmitted to the plurality of actuators **720**. Thus, it is possible to suppress degradation in the adjustment accuracy of the position or inclination of the stage **22**. Details of the absorption mechanism **730** will be described later.

[0070] The bellows **740** is provided so as to surround the support member **23**. The upper end of the bellows **740** is connected to the bottom **27** of the processing container **20** through the hole **731** formed in the absorption mechanism **730**, and the lower end is connected to the base member. As a result, the bellows **740** airtightly seals the space between the bottom **27** of the processing container **20** and the base member **710**. The bellows **740** is configured to be expandable and contractible according to the movement of the base member **710**. For example, when the base member **710** moves in a direction orthogonal to the outer wall surface of the bottom **27** of the processing container **20** (e.g., the Z′ axis direction in FIG. **5**), the bellows **740** expands and contracts in the Z′ axis direction. Further, for example, when the base member **710** moves in the direction following the outer wall surface of the bottom **27** of the processing container **20** (e.g., the X′ axis direction and the Y′ axis direction in FIG. **5**), the bellows **740** expands and contracts in the X′ axis direction and the Y′ axis direction. Further, for example, when the base member **710** moves in a predetermined direction relative to the outer wall surface of the bottom **27** of the processing container **20** (e.g., the rotation direction around the X′ axis and the rotation direction around the Y′ axis in FIG. **5**), the bellows **740** expands and contracts in the rotation direction around the X′ axis and the rotation direction around the Y′ axis. In the vacuum processing apparatus **2**, since the bellows **740** expands and contracts even when the base member **710** is moved, air is not introduced into the processing container **20** through the space between the bottom **27** of the processing container **20** and the base member **710**, the hole **731**, and the hole **27***a*.

[0071] Here, an exemplary configuration of the absorption mechanism **730** will be described with reference to FIG. **6**. FIG. **6** is a view illustrating an exemplary configuration of the absorption mechanism **730** illustrated in FIG. **5**. The absorption mechanism **730** includes a plate member **732** and a rod member **733**.

[0072] The plate member **732** is formed in a disk shape and arranged below the bottom **27** of the processing container **20**. The plate member **732** is arranged at a distance from the outer wall surface of the bottom **27** of the processing container **20** from the viewpoint of blocking the transfer of heat and vibrations from the processing container **20**.

[0073] One end of the rod member **733** is rotatably and slidably connected to the bottom **27** of the processing container **20**, and the other end is rotatably and slidably connected to the plate member **732**. That is, a recess **27***b* is formed in the outer wall surface of the bottom **27** of the processing container **20**, and a spherical bearing **27***c*, which is freely rotatable and slidable, is installed in the recess **27***b*. One end **733***a* of the rod member **733** is rotatably and slidably connected to the bottom **27** of the processing container **20** by being connected to the spherical bearing **27***c*. Meanwhile, a recess **732***a* is formed in the top surface of the plate member **732** at a position corresponding to the recess **27***b*, and a spherical bearing **732***b*, which is freely rotatable and slidable, is installed in the recess **732***a*. The other end **733***b* of the rod member **733** is rotatably and slidably connected to the plate member **732** by being connected to the spherical bearing **732***b*. The rod member **733** rotates in a direction corresponding to the deformation of the bottom **27** of the processing container **20**, thereby suppressing the transfer of the deformation to the plate member **732**. For example, when the bottom **27** of the processing container **20** is deformed in the direction indicated by the arrow in FIG. **6**, the rod member **733** is stressed by the deformation of the bottom **27** but is rotated together with the bottom **27** in the direction indicated by the arrow in FIG. **6**, thereby suppressing the transfer of the deformation to the plate member **732**. The plurality of actuators **720** is connected to the plate member **732**. As a result, since the stress due to the deformation of the bottom **27** of the processing container **20** is not transmitted to the plurality of actuators **720** via the plate member **732**, it is possible to suppress the degradation in the adjustment accuracy of the position or inclination of the stage **22**.

[0074] In addition, rod members **733** are arranged at a plurality of positions in the circumferential direction of the plate member **732**. For example, three rod members **733** are provided at a plurality of positions inside the edge along the circumferential direction of the plate member **732** at equal intervals. Four or more rod members **733** may be provided at equal intervals along the circumferential direction of the plate member **732**.

Specific Example of Flow of Method of Controlling Vacuum Processing Apparatus

[0075] Next, a specific example of a flow of a method of controlling the vacuum processing apparatus **2** according to an embodiment will be described. FIG. **7** is a flowchart illustrating Example 1 of the flow of a method of controlling the vacuum processing apparatus **2** according to an embodiment.

[0076] The controller **8** controls the substrate transport mechanism **15** to transport a wafer W toward the vacuum processing apparatus **2** (step S**101**).

[0077] The controller **8** calculates the deviation amount when the wafer W is transported by the substrate transport mechanism **15** as the correction amount of the position of the wafer W (step S**102**). The correction amount of the position of the wafer W is calculated by detecting, for example, the deviation amount between the wafer W and the target position of the transport by the substrate transport mechanism **15** using a position detection sensor provided at an arbitrary position on the transport path of the wafer W. The position detection sensor is provided, for example, in the vacuum transport chamber **14** in which the substrate transport mechanism **15** is arranged. In addition, the position detection sensor may be provided in the carry-in/out port **21** of the vacuum processing apparatus **2**. The target position is a wafer W placement position on the stage **22**, for example, a position at which the center of the stage **22** and the center of the wafer W coincide with each other.

[0078] The controller **8** controls the plurality of actuators **720** such that the base member **710** moves from a predetermined reference position by the correction amount calculated in step S**102** (step S**103**). The reference position is, for example, a position at which the center of the stage **22** and the center of the processing container **20** coincide with each other. As the base member **710** moves, the stage **22** also moves from the reference position by the correction amount.

[0079] When the substrate transport mechanism **15** reaches the vacuum processing apparatus **2**, the controller **8** controls the substrate transport mechanism **15** to transport a wafer W to a position above the target position in the processing container **20**. Then, the controller **8** causes the wafer W to be delivered between the stage **22** and the substrate transport mechanism **15** (step S**104**). In this step, the center of the stage **22** and the center of the wafer W coincide with each other. It is possible to implement the delivery of the wafer W in step S**104** using the method of FIG. **8**, to be described later.

[0080] The controller **8** controls a plurality of actuators **720** such that the base member **710** moves to the reference position (step S**105**). When the base member **710** moves, the stage **22** also moves to the reference position. At this step, the center of the stage **22**, the center of the wafer W, and the center of the processing container **20** coincide with each other.

[0081] In this way, in the vacuum processing apparatus **2**, instead of moving the substrate transport mechanism **15** by the correction amount, the base member **710** and the stage **22** are integrally moved by the correction amount to deliver the wafer W. Therefore, it is possible to reduce the transport load of the substrate transport mechanism **15**. As a result, it is possible to improve the throughput of the entire vacuum processing system **1**.

[0082] In FIG. **7**, the processes of steps S**103** to S**105** are executed in parallel for each of the four processing spaces S**1** to S**4** in the processing container **20**. As a result, when the substrate transport mechanism **15** collectively transports four wafers W to the four processing spaces S**1** to S**4** in the processing container **20**, it is possible to realize a collective delivery of the wafers W between the stage **22** and the substrate transport mechanism **15** (step S**104**). As a result, it is possible to further improve the throughput of the entire vacuum processing system **1**.

[0083] FIG. **8** is a flowchart illustrating Example **2** of the flow of a method of controlling the vacuum processing apparatus **2** according to an embodiment. The control method illustrated in FIG. **8** is applied to, for example, the delivery of a wafer W in step S**104** of FIG. **7**. In the initial stage, it is assumed that the stage **22** is located at the processing position.

[0084] The controller **8** controls the plurality of actuators **720** such that the base member **710** moves downwards together with the stage **22** (that is, the negative direction of the Z′ axis in FIG. **5**) (step S**201**). As a result, the stage **22** starts to be lowered.

[0085] The controller **8** causes the lower ends of the lifter pins **26** to come into contact with the bottom **27** of the processing container **20** as the stage **22** moves downwards, whereby the upper ends of the lifter pins **26** protrude from the placement surface of the stage **22** (Step S**202**). In this step, the stage **22** is in the state of being lowered from the processing position to the delivery position.

[0086] The controller **8** controls the plurality of actuators **720** such that the base member **710** moves upwards together with the stage **22** (that is, the positive direction of the Z′ axis in FIG. **5**) (step S**203**). As a result, the stage **22** starts to be raised.

[0087] The controller **8** causes the lower ends of the lifter pins **26** to be separated from the bottom **27** of the processing container **20** when the stage **22** moves upwards, whereby the upper ends of the lifter pins **26** are received at the placement surface sides of the pin through holes **26***a* (step S**204**). In this step, the stage **22** is in the state of being raised to the processing position.

[0088] In this way, in the vacuum processing stage **2**, it is possible to cause the lifter pin **26** to protrude and retract by raising and lowering the base member **710**. Therefore, it is possible to omit a lifter pin driving mechanism for driving the lifter pins **26**, and it is possible to reduce the number of components in the processing container **20**. Here, in the processing container **20**, substrate processing may be performed on a wafer W by generating plasma. In this case, the components in the processing container **20** are consumed by plasma, and the particles generated from the consumed components may deteriorate processing characteristics of the wafer W. In contrast, in the vacuum processing apparatus **2**, it is possible to reduce the number of components in the processing container **20** by omitting the lifter pin driving mechanism. Thus, it is possible to reduce the risk of particle generation. In addition, it is possible to raise and lower the stage **22** using the adjustment mechanism **700**, without providing a separate mechanism for raising and lowering the stage **22**.

[0089] FIG. **9** is a flowchart illustrating Example **3** of the flow of a method of controlling the vacuum processing apparatus **2** according to an embodiment. In the following description, it is assumed that a film thickness sensor is arranged around the shower plate **43**. The film thickness sensor is configured to be able to detect the film thickness on a wafer W located within a predetermined detection range in a non-contact manner.

[0090] The controller **8** controls the plurality of actuators **720** such that the base member **710** moves until the wafer W placed on the stage **22** moves into the detection range of the film thickness sensor (step S**301**). For example, the controller **8** controls the plurality of actuators **720** to tilt the base member **710** until the wafer W placed on the stage **22** moves into the detection range of the film thickness sensor.

[0091] In this way, in the vacuum processing apparatus **2**, it is possible to move the wafer W placed on the stage **22** into the detection range of the film thickness sensor. As a result, the vacuum processing apparatus **2** is capable of detecting the film thickness in real time during the execution of substrate processing even when the film thickness sensor is arranged around the shower plate **43** facing the stage **22**.

[0092] FIG. **10** is a flowchart illustrating Example **4** of the flow of a method of controlling the vacuum processing apparatus **2** according to an embodiment. In the control method illustrated in FIG. **10**, a distance measurement substrate capable of measuring the distance between the stage **22** and the shower plate **43** (hereinafter, appropriately referred to as a “gap”) is used at each of a plurality of positions on the placement surface of the stage **22**. The distance measurement substrate has a wireless communication function of transmitting a gap measured for each of the plurality of positions in the placement surface of the stage **22** to the controller **8** as a measurement result.

[0093] The controller **8** arranges the distance measurement substrate on the stage **22** (step S**401**). The controller **8** instructs the distance measurement substrate to measure the gap. The distance measurement substrate informs the controller **8** of a gap measured at each of the plurality of positions in the circumferential direction of the stage **22** as a measurement result.

[0094] Based on the result of measurement by the distance measurement substrate, the controller **8** controls the plurality of actuators **720** such that the base member **710** moves to a position at which distances (i.e., gaps) at a plurality of positions in the placement surface of the stage **22** fall within a predetermined range (step S**402**).

[0095] As described above, in the vacuum processing apparatus **2**, it is possible to make the gaps uniform at a plurality of positions in the placement surface of the stage **22** without opening the processing container **20**. As a result, the vacuum processing apparatus **2** is capable of improving the in-plane uniformity of substrate processing on the wafer W while maintaining the vacuum state of the processing container **20**.

[0096] FIG. **11** is a flowchart illustrating Example **5** of the flow of a method of controlling the vacuum processing apparatus **2** according to an embodiment.

[0097] The controller **8** acquires measurement data indicating the position and the inclination of the stage **22** relative to the state of the wafer W that satisfy a predetermined condition and are measured for each substrate process executed in the processing container **20** (step S**501**). For example, the controller **8** reads measurement data from the storage of the controller **8** and acquires the measurement data. The state of the wafer W is, for example, a numerical value representing the quality of a film formed on the wafer W through substrate processing. When the measurement data is stored in another device, the controller **8** may acquire the measurement data from the other device via a network. In addition, the controller **8** may generate and acquire measurement data through machine learning based on the position and inclination of the stage **22** relative to the state of the wafer W for each substrate process.

[0098] The controller **8** executes the substrate processing in the processing container **20** (step S**502**).

[0099] The controller **8** determines whether the time for switching the substrate processing being executed has arrived (step S**503**). When the time of switching has not arrived yet (step S**503**: No), the controller **8** continues the substrate processing currently being executed.

[0100] Meanwhile, when the switching time has arrived (step S**503**: Yes), the controller **8** determines whether the execution of all the substrate processing has been completed (step S**404**). When the execution of all substrate processing has not been completed (step S**504**: No), the controller **8** controls the plurality of actuators **720** based on the measurement data acquired in step S**501** (step S**505**). That is, the controller **8** refers to the measurement data and obtains the position and inclination of the stage **22** corresponding to the next substrate process to be performed at a switching destination. Then, the controller **8** controls the plurality of actuators **720** to move the base member **710** such that the position and inclination of the stage **22** become the obtained position and inclination. After moving the base member **710**, the controller **8** returns the processing to step S**502**, and executes the next substrate process at the switching destination in the processing container **20**.

[0101] Meanwhile, when execution of all of the substrate processing is completed (step S**504**: Yes), the controller **8** terminates the processing.

[0102] In this way, the vacuum processing apparatus **2** is capable of dynamically adjusting the position and inclination of the stage **22** for each substrate process. As a result, the vacuum processing apparatus **2** is capable of obtaining an optimum processing result for each substrate process when the substrate processing is continuously and sequentially executed.

Effect of Embodiment

[0103] As described above, the vacuum processing apparatus **2** according to the embodiment includes a processing container **20**, a stage **22**, a support member **23**, a base member **710**, and a plurality of actuators **720**. The processing container **20** is configured to be capable of maintaining the inside thereof in a vacuum atmosphere. The stage **22** is provided in the processing container **20** such that a wafer W (substrate) is placed thereon. The support member **23** penetrates the hole in the bottom **27** of the processing container **20** and supports the stage **22** from the bottom side thereof. The base member **710** is configured to be integrally movable with the stage **22** by being engaged with the end portion of the support member **23** located outside the processing container **20**. The plurality of actuators **720** are provided parallel each other between the bottom **27** of the processing container **20** and the base member **710**, and move the base member **710** relative to the bottom **27** of the processing container **20** to adjust the position and inclination of the stage **22**. As a result, the vacuum processing apparatus **2** is capable of reducing or eliminating deviation in the position and inclination of the stage **22** due to the deformation of the processing container **20**.

[0104] In addition, the plurality of actuators **720** and the base member **710** form parallel link mechanisms, each of which is capable of moving the base member **710** in the directions of a plurality of axes and the rotation directions around respective axes. The plurality of actuators **720** and the base member **710** connect the bottom **27** of the processing container **20** and the base member **710** via the parallel link mechanisms. As a result, the vacuum processing apparatus **2** is capable of reducing or eliminating deviation in the position and inclination of the stage **22** by moving the base member **710** relative to the bottom **27** of the processing container **20** using the operation of the parallel link mechanisms.

[0105] In addition, the plurality of actuators **720** adjust the position of the stage **22** by moving the base member **710** in a direction orthogonal to the outer wall surface of the bottom **27** of the processing container **20**. As a result, the vacuum processing apparatus **2** is capable of reducing or eliminating deviation in the position of the stage **22** in a direction orthogonal to the outer wall surface of the bottom **27** of the processing container **20**.

[0106] In addition, the plurality of actuators **720** adjust the position of the stage **22** by moving the base member **710** in a direction following the outer wall surface of the bottom **27** of the processing container **20**. As a result, the vacuum processing apparatus **2** is capable of reducing or eliminating deviation in the position of the stage **22** in a direction following the outer wall surface of the bottom **27** of the processing container **20**.

[0107] In addition, the plurality of actuators **720** adjust the inclination of the stage **22** by tilting the base member **710** relative to the outer wall surface of the bottom **27** of the processing container **20**. As a result, the vacuum processing apparatus **2** is capable of reducing or eliminating deviation in the inclination of the stage **22** relative to the bottom **27** of the processing container **20**.

[0108] In addition, the vacuum processing apparatus **2** further includes an expandable and contractible bellows **740** (an expandable and contractible member) provided around the support member **23** to airtightly seal the space between the bottom **27** of the processing container **20** and the base member **710** and to be expandable and contractible according to the movement of the base member **710**. As a result, the vacuum processing apparatus **2** is capable of preventing the inflow of air into the processing container **20** even when the base member **710** is moved.

[0109] Further, the vacuum processing apparatus **2** further includes an absorption mechanism **730** configured to absorb the deformation of the bottom **27** of the processing container **20**. The plurality of actuators are connected to the absorption mechanism **730**. As a result, stress due to the deformation of the bottom **27** of the processing container **20** is absorbed by the absorption mechanism **730** and is not transmitted to the plurality of actuators **720**. Thus, the vacuum processing apparatus **2** is capable of suppressing degradation in the accuracy of adjustment of the position and inclination of the stage **22**.

[0110] In addition, the absorption mechanism **730** includes a plate member **732** and a rod member **733**. One end of the rod member **733** is rotatably and slidably connected to the bottom **27** of the processing container **20**, and the other end is rotatably and slidably connected to the plate member **732**. The rod member **733** rotates in a direction corresponding to the deformation of the bottom **27** of the processing container **20**, thereby suppressing the transfer of deformation to the plate member **732**. The plurality of actuators **720** are connected to the plate member **732**. As a result, stress due to the deformation of the bottom **27** of the processing container **20** is absorbed by the plate member **732** and is not transmitted to the plurality of actuators **720**. Thus, the vacuum processing apparatus **2** is capable of suppressing degradation in the accuracy of adjustment of the position and inclination of the stage **22**.

[0111] In addition, the plate member **732** is arranged at a distance from the outer wall surface of the bottom **27** of the processing container **20**. As a result, the vacuum processing apparatus **2** is capable of blocking the transfer of heat and vibrations from the processing container **20** to the plate member **732**.

[0112] In addition, a method of controlling the vacuum processing apparatus **2** according to the embodiment includes a step of calculating a deviation amount when a wafer W (a substrate) is transported by the substrate transport mechanism **15** (a transport mechanism) as a correction amount of the position of the wafer W, a step of controlling a plurality of actuators **720** such that the base member **710** moves from a predetermined reference position by the correction amount, a step of delivering the wafer W between the stage **22** moved together with the base member **710** and the substrate transport mechanism **15**, and a step of controlling the plurality of actuators **720** such that the base member **710** moves to a reference position after the wafer W is delivered. As a result, the vacuum processing apparatus **2** is capable of improving the throughput of the entire vacuum processing system **1**.

[0113] In addition, pin through holes **26***a* are formed in the stage **22** to penetrate the placement surface of the stage **22** and the rear surface with respect to the placement surface. The vacuum processing apparatus **2** further includes lifter pins **26** slidably inserted into respective pin through holes **26***a* such that the upper end of each of the lifter pins is suspended from the placement surface side of the stage **22** of the corresponding one of the pin through holes **26***a* and the lower end thereof protrudes from the rear surface of the stage **22** to the side of the bottom **27** of the processing container **20**. A method of controlling the vacuum processing apparatus **2** according to the embodiment may include a step of controlling the plurality of actuators **720** such that the base member **710** moves downwards together with the stage **22**, a step of causing the upper end of each of the lifter pins **26** to protrude from the placement surface of the stage **22** by causing the lower end of each of the lifter pins **26** to come into contact with the bottom **27** of the processing container **20** as the stage **22** moves downwards, a step of controlling the plurality of actuators such that the base member **710** moves upwards together with the stage **22**, and a step of separating the lower end of each of the lifter pins **26** from the bottom **27** of the processing container **20** when the stage **22** moves upwards so as to cause the upper ends of the lifter pins **26** to be received in respective pin through holes **26***a* at the placement surface side of the stage **22**. As a result, in the vacuum processing apparatus **2**, it is possible to reduce the number of components in the processing container **20** by omitting the lifter pin driving mechanism. Thus, it is possible to reduce the risk of particle generation.

[0114] In addition, the vacuum processing apparatus **2** further includes a shower plate **43** (an upper electrode) arranged in the processing container **20** to face the above-mentioned stage **22** in the processing container **20**, and a film thickness sensor arranged around the shower plate **43** to be capable of detecting the film thickness of a wafer W located within a predetermined detection range in a non-contact manner. A method of controlling the vacuum processing apparatus **2** according to an embodiment may include a step of controlling the plurality of actuators **720** such that the base member **710** moves until the wafer W mounted on the stage **22** moves into the detection range of the film thickness sensor. As a result, the vacuum processing apparatus **2** is capable of detecting the film thickness in real time during the execution of substrate processing even when the film thickness sensor is arranged around the shower plate **43** facing the stage **22**.
[0115] In addition, a method of controlling the vacuum processing apparatus **2** according to an embodiment includes a step of arranging a distance measurement substrate capable of measuring the distance between the stage **22** and the shower plate **43** (an upper electrode) at each of a plurality of positions in the placement surface of the stage **22** and a step of controlling the plurality of actuators **720** such that the base member **710** moves to a position at which the distances at the plurality of positions in the placement surface of the stage **22** fall within a predetermined range based on the result of measurement by the distance measurement substrate. As a result, the vacuum processing apparatus **2** is capable of improving the in-plane uniformity of substrate processing on the wafer W while maintaining the vacuum state in the processing container **20**.
[0116] In addition, a method of controlling the vacuum processing apparatus **2** according to an embodiment includes a step of acquiring measurement data indicating the position and inclination of the stage **22** with respect to the state of a wafer W (a substrate) satisfying a predetermined condition measured for each substrate process executed in the processing container **20**, a step of sequentially executing the substrate processing in the processing container **20**, and a step of controlling the plurality of actuators **720** based on the measurement data whenever the time for switching the substrate processing arrives. As a result, the vacuum processing apparatus **2** is capable of obtaining an optimum processing result for each substrate process when the substrate processing is continuously and sequentially executed.
[0117] Although embodiments have been described above, it should be considered that the embodiments disclosed herein are illustrative and are not restrictive in all respects. In addition, the embodiments described above may be omitted, replaced, or modified in various forms without departing from the scope and spirit of the claims.
[0118] For example, in the embodiments described above, an example in which the vacuum processing apparatus **2** is an apparatus that performs plasma CVD processing as substrate processing has been described, but the technique disclosed herein may be applied to any apparatus that performs other substrate processing, such as plasma etching.
[0119] In addition, in the embodiments described above, an example in which the plurality of actuators **720** are rotatably and slidably connected to the base member **710** via respective universal joints and are rotatably and slidably connected to the bottom **27** side of the processing container **20** (i.e., the absorption mechanism **730** in FIG. **5**) via respective universal joints has been described as an example. However, the technique disclosed herein is not limited thereto. The absorption mechanism **730** may be omitted, and one end of each of the actuators **720** may be rotatably and slidably connected to the bottom **27** of the processing container **20** via a universal joint. In addition, the base member **710** may be omitted, and the other end of the actuator **720** may be rotatably and slidably connected to a portion of the vacuum seal **630** via a universal joint. In this case, the vacuum seal **630** functions as a base member.
[0120] According to the present disclosure, it is possible to reduce or eliminate deviation in the position and inclination of a stage due to the deformation of a processing container.
[0121] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the disclosures. Indeed, the

embodiments described herein may be embodied in a variety of other forms. Furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the disclosures. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the disclosures.

Claims

1. A substrate mounting table for mounting a substrate in a processing container, comprising: a stage; a support for supporting the stage from a bottom side of the stage; a base engaged with the support and configured to be integrally movable with the stage; and six actuators provided in an expandable manner between a bottom of the processing container and the base.
2. The substrate mounting table of claim 1, wherein the six actuators are connected to the base and the bottom of the processing container via universal joints.
3. The substrate mounting table of claim 1, wherein the six actuators adjust at least one of position and inclination of the stage by moving the base relative to the bottom of the processing container.
4. The substrate mounting table of claim 2, wherein the six actuators adjust at least one of position and inclination of the stage by moving the base relative to the bottom of the processing container.
5. The substrate mounting table of claim 1, wherein the stage includes a pin through hole that penetrates a placement surface of the stage and a rear surface of the stage with reference to the placement surface, and a lifter pin slidably inserted into the pin through hole.
6. The substrate mounting table of claim 2, wherein the stage includes a pin through hole that penetrates a placement surface of the stage and a rear surface of the stage with reference to the placement surface, and a lifter pin slidably inserted into the pin through hole.
7. The substrate mounting table of claim 3, wherein the stage includes a pin through hole that penetrates a placement surface of the stage and a rear surface of the stage with reference to the placement surface, and a lifter pin slidably inserted into the pin through hole.
8. The substrate mounting table of claim 4, wherein the stage includes a pin through hole that penetrates a placement surface of the stage and a rear surface of the stage with reference to the placement surface, and a lifter pin slidably inserted into the pin through hole.