

SUBSTRATE HOLDING APPARATUS, SUBSTRATE POLISHING APPARATUS,
ELASTIC MEMBER, AND MANUFACTURING METHOD OF SUBSTRATE HOLDING
APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001]

This application claims the benefit of Japanese Priority Patent Application JP 2018-97314 filed on May 21, 2018, the entire contents of which are incorporated herein by reference.

FIELD

[0002]

The present disclosure relates to a substrate holding apparatus, a substrate polishing apparatus, an elastic member, and a manufacturing method of a substrate holding apparatus.

BACKGROUND

[0003]

In a substrate polishing apparatus (for example, JP 3705670 B2), a substrate is transferred from a substrate transport apparatus to a top ring (substrate holding apparatus), and the substrate is polished in a state in which the top ring holds the substrate. The top ring has a structure where a membrane is provided below a top ring main body (base plate) and a lower surface of the membrane adsorbs the substrate.

[0003]

JP 3705670 B2 discloses a substrate adsorption

determination method that determines whether or not a substrate is adsorbed to the membrane. In this method, a convex portion facing up is provided to the membrane. This method uses a feature where there is a gap between a lower surface of the top ring main body and the convex portion of the membrane when the substrate is not adsorbed, and when the substrate is adsorbed, the substrate presses the membrane upward, so that the convex portion of the membrane comes into contact with the lower surface of the top ring main body and the gap disappears.

[0004]

However, a surface of the membrane may be wet due to a polishing slurry and/or top ring cleaning. Further, the substrate itself may be wet due to polishing processing. When the membrane and/or the substrate are wet in this way, even when the substrate is adsorbed, a force where the substrate presses the membrane is dispersed, so that the convex portion of the membrane may not be sufficiently in contact with the lower surface of the top ring main body. In this case, there is a risk that an erroneous determination is made, where it is determined that the substrate is not adsorbed although the substrate is adsorbed.

[0005]

Therefore, it is also considered to reduce the gap between the convex portion of the membrane and the top ring in advance. However, when doing so, there is a problem that when polishing is performed in a state where the membrane adsorbs the substrate, only a polishing rate of a portion of the substrate

corresponding to the convex portion increases, and it is difficult to perform uniform polishing.

[0006]

Therefore, a substrate holding apparatus and a manufacturing method of the substrate holding apparatus, which can more correctly determine that the substrate is adsorbed while suppressing unevenness of polishing rate, a substrate polishing apparatus including such a substrate holding apparatus, and an elastic member for such a substrate holding apparatus are required.

SUMMARY

[0007]

According to one embodiment, provided is a substrate holding apparatus comprising: a top ring main body; an elastic film comprising a first surface and a second surface, the first surface forming a plurality of areas between the first surface and the top ring main body, the second surface being located opposite to the first surface and capable of holding a substrate; a first line that communicates with a first area among the plurality of areas and can pressurize the first area; a second line that communicates with the first area and can exhaust air from the first area; a measuring instrument whose measurement value varies based on a flow rate of the first area; a third line that communicates with a second area different from the first area among the plurality of areas and can depressurize the second area; and an elastic member provided between the

first line and the second line so as to be separated from the first surface of the elastic film when the second surface of the elastic film does not hold a substrate and be in contact with the first surface of the elastic film when the second surface of the elastic film holds a substrate.

[0008]

According to another embodiment, provided is a substrate polishing apparatus comprising: the above-mentioned substrate holding apparatus; and a polishing table configured to polish a substrate held by the substrate holding apparatus.

[0009]

According to another embodiment, provided is an elastic member for a substrate holding apparatus, wherein the substrate holding apparatus comprises: a top ring main body, an elastic film comprising a first surface and a second surface, the first surface forming a plurality of areas between the first surface and the top ring main body, the second surface being located opposite to the first surface and capable of holding a substrate; a first line that communicates with a first area among the plurality of areas and can pressurize the first area, a second line that communicates with the first area and can exhaust air from the first area, a measuring instrument whose measurement value varies based on a flow rate of the first area, and a third line that communicates with a second area different from the first area among the plurality of areas and can depressurize the second area, and the elastic member is provided between the first line and the second line so as to be separated

from the first surface of the elastic film when the second surface of the elastic film does not hold a substrate and be in contact with the first surface of the elastic film when the second surface of the elastic film holds a substrate.

[0010]

According to another embodiment, provided is a manufacturing method of a substrate holding apparatus, the manufacturing method comprising: attaching a new elastic member to the above-mentioned substrate holding apparatus from which the elastic member is removed.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

FIG. 1 is a schematic top view of a substrate processing apparatus including a substrate polishing apparatuses;

[0012]

FIG. 2 is a schematic perspective view of a substrate polishing apparatus;

[0013]

FIG. 3 is a schematic cross-sectional view of the substrate polishing apparatus;

[0014]

FIGS. 4A to 4C are diagrams for explaining in detail transfer of a substrate from a transport mechanism to a top ring;

[0015]

FIG. 5 is a diagram for explaining in detail the transfer of the substrate from the transport mechanism to the top ring;

[0016]

FIG. 6A is a cross-sectional view schematically showing a structure of the top ring and a pressure control apparatus in a first embodiment;

[0017]

FIG. 6B is a modified example of FIG. 6A;

[0018]

FIG. 7 is a cross-sectional view showing details of a top ring main body and a membrane in the top ring;

[0019]

FIG. 8 is an enlarged view around an elastic member in FIG. 7;

[0020]

FIG. 9 is a diagram for explaining an operation of each valve in the top ring;

[0021]

FIG. 10 is a flowchart showing a procedure of substrate adsorption determination;

[0022]

FIG. 11 is a diagram schematically showing a cross-section of the membrane and the top ring main body when adsorption fails;

[0023]

FIG. 12A is a diagram schematically showing a cross-section of a substrate, the membrane, and the top ring main body when adsorption succeeds;

[0024]

FIG. 12B is an enlarged view around the elastic member in FIG. 12A;

[0025]

FIG. 13 is a diagram schematically showing a flow rate measured by a flow rate meter after starting adsorption;

[0026]

FIG. 14A is a cross-sectional view showing details of a top ring main body and a membrane in a top ring that is a first modified example;

[0027]

FIG. 14B is an enlarged view around an elastic member in FIG. 14A;

[0028]

FIG. 14C is an enlarged view around the elastic member in FIG. 14A;

[0029]

FIG. 14D is an enlarged view around the elastic member in FIG. 14A;

[0030]

FIG. 15 is a cross-sectional view showing details of a top ring main body and a membrane in a top ring that is a modified example of FIG. 14A;

[0031]

FIG. 16A is a cross-sectional view showing details of a top ring main body and a membrane in a top ring that is a second modified example;

[0032]

FIG. 16B is an enlarged view around an elastic member in FIG. 16A;

[0033]

FIG. 17A is a cross-sectional view showing details of a top ring main body and a membrane in a top ring that is a third modified example;

[0034]

FIG. 17B is an enlarged view around an elastic member in FIG. 17A;

[0035]

FIG. 17C is an enlarged view around the elastic member in FIG. 17A;

[0036]

FIG. 18 is a cross-sectional view showing details of a top ring main body and a membrane in a top ring that is a fourth modified example;

[0037]

FIG. 19 is a cross-sectional view schematically showing a structure of a top ring in a second embodiment;

[0038]

FIG. 20 is a diagram schematically showing a cross-section of a membrane and a top ring main body when adsorption fails; and

[0039]

FIG. 21 is a diagram schematically showing a cross-section of a substrate, the membrane, and the top ring main body when adsorption succeeds.

DETAILED DESCRIPTION OF NON-LIMITING EXAMPLE EMBODIMENTS

[0040]

Hereinafter, embodiments will be specifically described with reference to the drawings.

[0041]

(First Embodiment)

FIG. 1 is a schematic top view of a substrate processing apparatus including a substrate polishing apparatuses. The substrate processing apparatus processes various substrates in a manufacturing process or the like of a semiconductor wafer having a diameter of 300 mm or 450 mm, a flat panel, an image sensor such as CMOS (Complementary Metal Oxide Semiconductor) or CCD (Charge Coupled Device), and a magnetic film in a MRAM (Magnetoresistive Random Access Memory).

[0042]

The substrate processing apparatus includes a substantially rectangular housing 100, a load port 200 on which a substrate cassette that stores many substrates is mounted, one or a plurality of (four in an aspect shown in FIG. 1) substrate polishing apparatuses 300, one or a plurality of (two in the aspect shown in FIG. 1) substrate cleaning apparatuses 400, a substrate drying apparatus 500, transport mechanisms 600a to 600d, and a controller 700.

[0043]

The load port 200 is arranged adjacent to the housing 100. The load port 200 can be mounted with an open cassette, an SMIF

(Standard Mechanical Interface) pod, or a FOUP (Front Opening Unified Pod). The SMIF pod and the FOUP are airtight containers, each of which can maintain an environment independent from external space by storing a substrate cassette inside thereof and covering the inside by a partition wall.

[0044]

The substrate polishing apparatuses 300 that polish a substrate, the substrate cleaning apparatuses 400 that clean a substrate that has been polished, and the substrate drying apparatus 500 that dries a substrate that has been cleaned are stored in the housing 100. The substrate polishing apparatuses 300 are arranged along the longitudinal direction of the substrate processing apparatus. The substrate cleaning apparatuses 400 and the substrate drying apparatus 500 are also arranged along the longitudinal direction of the substrate processing apparatus.

[0045]

The transport mechanism 600a is arranged in a region surrounded by the load port 200, the substrate polishing apparatus 300 located on the side of the load port 200, and the substrate drying apparatus 500. The transport mechanism 600b is arranged in parallel with the substrate polishing apparatuses 300 and in parallel with the substrate cleaning apparatuses 400 and the substrate drying apparatus 500.

[0046]

The transport mechanism 600a receives a substrate before being polished from the load port 200 and transfers the

substrate to the transport mechanism 600b. Further, the transport mechanism 600a receives the substrate after being dried from the substrate drying apparatus 500.

[0047]

The transport mechanism 600b is, for example, a linear transporter, and transfers a substrate before being polished that is received from the transport mechanism 600a to the substrate polishing apparatuses 300. As described later, a top ring (not shown in the drawings) of the substrate polishing apparatuses 300 receives the substrate from the transport mechanism 600b by vacuum suction. The substrate polishing apparatus 300 releases the substrate after being polished to the transport mechanism 600b and the substrate is transferred to the substrate cleaning apparatus 400.

[0048]

The transport mechanism 600c that transfers the substrate between the two substrate cleaning apparatuses 400 is arranged between the substrate cleaning apparatuses 400. The transport mechanism 600d that transfers the substrate between the substrate cleaning apparatus 400 and the substrate drying apparatus 500 is arranged between the substrate cleaning apparatus 400 and the substrate drying apparatus 500.

[0049]

The controller 700 controls an operation of each device of the substrate processing apparatus. The controller 700 may be arranged inside the housing 100, may be arranged outside the housing 100, or may be provided in each of the substrate

polishing apparatuses 300, the substrate cleaning apparatuses 400, and the substrate drying apparatus 500.

[0050]

FIGS. 2 and 3 are schematic perspective view and a schematic cross-sectional view, respectively, of the substrate polishing apparatus 300. The substrate polishing apparatus 300 has a top ring 1, a top ring shaft 2 whose lower portion is connected to the top ring 1, a polishing table 3 having a polishing pad 3a, a nozzle 4 that supplies a polishing liquid onto the polishing table 3, a top ring head 5, and a support shaft 6.

[0051]

The top ring 1 holds a substrate W. As shown in FIG. 3, the top ring 1 is composed of a top ring main body 11 (also referred to as a carrier or a base plate), an annular retainer ring 12, a flexible membrane 13 (elastic film) provided below the top ring main body 11 and inside the retainer ring 12, an air bag 14 provided between the top ring main body 11 and the retainer ring 12, a pressure control apparatus 7, and the like.

[0052]

The retainer ring 12 is provided to an outer circumferential portion of the top ring main body 11. A circumferential edge of the held substrate W is surrounded by the retainer ring 12, so that substrate W does not jump out from the top ring 1 during polishing. The retainer ring 12 may be composed of one member or may be composed of two rings including an inner ring and an outer ring provided outside the inner ring.

In the latter case, the outer ring may be fixed to the top ring main body 11 and the air bag 14 may be provided between the inner ring and the top ring main body 11.

[0053]

The membrane 13 is provided facing the top ring main body 11. A plurality of concentric areas are formed between an upper surface of the membrane 13 and the top ring main body 11. A lower surface of the membrane 13 can hold an upper surface of the substrate W by depressurizing one or a plurality of the areas.

[0054]

The air bag 14 is provided between the top ring main body 11 and the retainer ring 12. The retainer ring 12 can relatively move with respect to the top ring main body 11 in a vertical direction by the air bag 14.

[0055]

The pressure control apparatus 7 individually adjusts pressure of each area formed between the top ring main body 11 and the membrane 13 by supplying fluid between the top ring main body 11 and the membrane 13, evacuating air from between the top ring main body 11 and the membrane 13, and opening a space between the top ring main body 11 and the membrane 13 to the atmosphere. Further, the pressure control apparatus 7 determines whether or not the substrate W is adsorbed to the membrane 13. The configuration of the pressure control apparatus 7 will be described later in detail.

[0056]

In FIG. 2, a lower end of the top ring shaft 2 is connected to a center of an upper surface of the top ring 1. When a lifting mechanism (not shown in the drawings) lifts and lowers the top ring shaft 2, a lower surface of the substrate W held by the top ring 1 comes in and out of contact with the polishing pad 3a. When a motor (not shown in the drawings) rotates the top ring shaft 2, the top ring 1 rotates, and the substrate W held by the top ring 1 also rotates.

[0057]

The polishing pad 3a is provided on an upper surface of the polishing table 3. A lower surface of the polishing table 3 is connected to a rotating shaft, so that the polishing table 3 can rotate. When the polishing liquid is supplied from the nozzle 4 and the substrate W and the polishing table 3 rotate in a state where the lower surface of the substrate W is in contact with the polishing pad 3a, the substrate W is polished.

[0058]

The top ring shaft 2 is connected to one end of the top ring head 5 in FIG. 3 and the support shaft 6 is connected to the other end. When a motor not shown in the drawings rotates the support shaft 6, the top ring head 5 swings, so that the top ring 1 moves between a position over the polishing pad 3a and a substrate transfer position (not shown in the drawings).

[0059]

Subsequently, an operation of transferring the substrate from the transport mechanism 600b in FIG. 1 to the top ring 1 in FIGS. 2 and 3 will be described.

[0059]

FIGS. 4A to 4C and FIG. 5 are diagrams for explaining in detail the transfer of the substrate from the transport mechanism 600b to the top ring 1. FIGS. 4A to 4C are diagrams where the transport mechanism 600b and the top ring 1 are seen from the side. FIG. 5 is a diagram when they are seen from above.

[0060]

As shown in FIG. 4A, the substrate W is mounted on a hand 601 of the transport mechanism 600b. A retainer ring station 800 is used to transfer the substrate W. The retainer ring station 800 has pushing-up pins 801 that push up the retainer ring 12 of the top ring 1. The retainer ring station 800 may have a release nozzle. However, the release nozzle is not shown in the drawings.

[0061]

As shown in FIG. 5, the hand 601 supports parts of an outer circumference of the lower surface of the substrate W. The pushing-up pins 801 and the hand 601 are arranged so as not to be in contact with each other.

[0062]

In a state shown in FIG. 4A, the top ring 1 lowers and the transport mechanism 600b rises. When the top ring 1 lowers, the pushing-up pins 801 push up the retainer ring 12 and the substrate W approaches the membrane 13. When the transport mechanism 600b rises further, the upper surface of the substrate W comes into contact with the lower surface of the membrane 13 (FIG. 4B).

[0063]

In this state, when an area formed between the membrane 13 and the top ring main body 11 is depressurized, the substrate W is adsorbed to the lower surface of the membrane 13. However, in some cases, the substrate W is not adsorbed to the lower surface of the membrane 13 or the substrate W is once adsorbed to the lower surface of the membrane 13 and thereafter falls. Therefore, in the present embodiment, a determination (substrate adsorption determination) as to whether or not the substrate W is adsorbed to the membrane 13 is performed.

Thereafter, the transport mechanism 600b lowers (FIG. 4C).

[0064]

Subsequently, the top ring 1 will be described.

FIG. 6A is a cross-sectional view schematically showing a structure of the top ring 1 and the pressure control apparatus 7 in the first embodiment. On the membrane 13, circumferential walls 13a to 13e extending upward toward the top ring main body 11 are formed. By the circumferential walls 13a to 13e, concentric areas 131 to 135 separated by the circumferential walls 13a to 13e are formed between the upper surface of the membrane 13 and a lower surface of the top ring main body 11. It is desirable that no hole is formed in the lower surface of the membrane 13.

[0065]

Flow paths 141 to 145 which penetrate the top ring main body 11 and whose one ends communicate with the areas 131 to

135, respectively, are formed. The air bag 14 formed of an elastic film is provided directly on the retainer ring 12, and a flow path 146 whose one end communicates with the air bag 14 is formed in the same manner. The other ends of the flow paths 141 to 146 are connected to the pressure control apparatus 7. A pressure sensor and/or a flow rate sensor may be provided on the flow paths 141 to 146.

[0066]

Further, a flow path 150 which penetrates the top ring main body 11 and whose one end communicates with the area 133 is formed for the substrate adsorption determination. The other end of the flow path 150 is opened to the atmosphere.

[0067]

The pressure control apparatus 7 has valves V1 to V6 provided to the flow paths 141 to 146, respectively, pressure regulators R1 to R6, a controller 71, and a pressure adjustor 72. The pressure control apparatus 7 further has a valve V10 and a flow rate meter FS provided to the flow path 150 and a determiner 73 for the substrate adsorption determination. When the valve V10 is closed, no flow occurs, so that the installation order of the valve V10 and the flow rate meter FS does not matter.

[0068]

The controller 71 controls the valves V1 to V6 and V10, the pressure regulators R1 to R6, and the pressure adjustor 72.

[0069]

The pressure adjustor 72 is connected to one ends of the

flow paths 141 to 146 and adjusts pressure of the areas 131 to 135 and the air bag 14 according to the control of the controller 71. Specifically, the pressure adjustor 72 pressurizes the areas 131 to 135 and the air bag 14 by supplying fluid such as air through the flow paths 141 to 146, depressurizes the areas 131 to 135 and the air bag 14 by evacuating air, and opening the areas 131 to 135 and the air bag 14 to the atmosphere.

[0070]

FIG. 6A shows an example in which the valves V1 to V6 are connected to the flow paths 141 to 146, respectively. FIG. 6B is a modified example of FIG. 6A, and a plurality of valves may be connected to each of the flow paths 141 to 146. As an example, FIG. 6B shows a case in which three valves V3-1, V3-2, and V3-3 are connected to the flow path 143. The valve V3-3 is connected to the pressure regulator R3. The valve V3-2 is connected to an atmosphere open source. The valve V3-3 is connected to a vacuum source. When pressurizing the area 133, the valves V3-2 and V3-3 are closed, the valve V3-1 is opened, and the pressure regulator R3 is operated. When making the area 133 open to the atmosphere, the valves V3-1 and V3-3 are closed and the valve V3-2 is opened. When making the area 133 put in a vacuum state, the valves V3-1 and V3-2 are closed and the valve V3-3 is opened.

[0071]

In FIG. 6A, for example, to pressurize the area 135, the controller 71 opens the valve V5 and controls the pressure adjustor 72 so that air is supplied to the area 135. This is simply represented as "the controller 71 pressurizes the area

135" or the like.

[0072]

The flow rate meter FS measures a flow rate of fluid flowing through the flow path 150, in other words, a flow rate of fluid flowing to the area 133 and notifies the determiner 73 of a measurement result. The flow rate is a volume of fluid (in particular, air) flowing per unit time unless otherwise specified. An arrangement position of the flow rate meter FS is not particularly limited if the flow rate meter FS can measure the flow rate of the flow path 150. For example, the flow rate meter FS may be arranged on the flow path 143 because the flow path 143 is connected to the flow path 150.

[0073]

The determiner 73 performs the substrate adsorption determination based on the flow rate measured by the flow rate meter FS.

[0074]

The top ring 1 includes an elastic member 91 made of a material such as NBR, silicon rubber, EPDM, fluoro rubber, chloroprene, or urethane rubber, and this will be described later in detail.

[0075]

FIG. 7 is a cross-sectional view showing details of the top ring main body 11 and the membrane 13 in the top ring 1 (FIG. 7 shows only left half. The same goes for the drawings described below). As shown in FIG. 7, the membrane 13 has a circular contact portion 130 to be in contact with the substrate W and

five circumferential walls 13a to 13e that are directly or indirectly connected to the contact portion 130. The contact portion 130 holds the substrate W while being in contact with a back surface of the substrate W, that is, a surface opposite to a surface to be polished. Further, the contact portion 130 presses the substrate W against the polishing pad 3a during polishing. The circumferential walls 13a to 13e are concentrically arranged annular circumferential walls.

[0076]

Upper ends of the circumferential walls 13a to 13d are sandwiched between holding rings 21 and 22 and the lower surface of the top ring main body 11 and attached to the top ring main body 11. The holding rings 21 and 22 are detachably fixed to the top ring main body 11 by a holding means (not shown in the drawings). Therefore, when the holding means is released, the holding rings 21 and 22 are separated from the top ring main body 11, and thereby the membrane 13 can be removed from the top ring main body 11. A screw or the like can be used as the holding means.

[0077]

The holding rings 21 and 22 are located in the areas 132 and 134, respectively. The flow paths 142 and 144 penetrate the top ring main body 11 and the holding rings 21 and 22, respectively, and communicate with the areas 132 and 134, respectively. The flow paths 141, 143, and 145 each penetrate the top ring main body 11 and communicate with the areas 131, 133, and 135, respectively. The flow path 150 penetrates the

top ring main body 11 and communicates with the area 133.

[0078]

In a state in which the substrate W is not adsorbed, in the area 133, there is a gap g (described later in FIG. 11 and the like), where fluid (air) can flow from the flow path 143 to the flow path 150, between the lower surface of the top ring main body 11 and the membrane 13. When the substrate W is adsorbed to the lower surface of the membrane 13, the membrane 13 is pulled up toward the top ring main body 11, and thus the gap g substantially disappears. It is desirable to narrow the gap g as much as possible.

[0079]

As one feature of the present embodiment, the top ring 1 includes the elastic member 91 (FIG. 8 shows an enlarged view around the elastic member 91 (a portion inside one-dot broken line in FIG. 7)). In the area 133, the elastic member 91 is fitted into a recessed portion 90 provided between the flow path 143 and the flow path 150 in the top ring main body 11. The elastic member 91 has an annular shape and has a wide portion 91a in its upper portion. The wide portion 91a is caught by shoulder portions 90a of the recessed portion 90, so that the elastic member 91 is difficult to fall from the top ring main body 11. However, it is possible to remove the elastic member 91 from the recessed portion 90 by applying a certain degree of force. When the elastic member 91 is worn out, a new top ring 1 is produced by removing the worn-out elastic member 91 from the recessed portion 90 and fitting a new elastic member

91 into the recessed portion 90.

[0080]

In a state in which the top ring 1 does not hold the substrate W, a lower surface of the elastic member 91 is separated from the upper surface of the membrane 13, and there is the gap g. It is desirable that a convex portion 92 is provided to the upper surface of the membrane 13 in a position facing the elastic member 91. A role of the elastic member 91 will be described later. The elastic member 91 may be a hollow member having a cavity therein or may be a member having no cavity.

[0081]

FIG. 9 is a diagram for explaining an operation of each valve in the top ring 1. When adsorbing the substrate W or polishing the substrate W, pressures of any one or more areas selected from among the areas 131, 132, 134, and 135 may be adjusted. In the description below, a case where the pressure of the area 135 is adjusted will be described. In the other areas 131, 132, and 134, an arbitrary pressure adjustment can be performed.

[0082]

When opening the membrane 13 to the atmosphere during idling or the like, the controller 71 opens the valves V3, V5, and V10 and opens the areas 133 and 135 to the atmosphere.

[0083]

When polishing the substrate W, the controller 71 opens the valves V3 and V5, pressurizes the areas 133 and 135, and

closes the valve V10 in order to pressurize the membrane 13 and press the substrate W against the polishing pad 3a.

[0084]

When transferring the substrate W from the transport mechanism 600b to the top ring 1 and causing the substrate W to adsorb the membrane 13, the controller 71 opens the valve V3 and depressurizes the area 135. Further, to perform the substrate adsorption determination, the controller 71 opens the valve V10 to open the area 133 to the atmosphere while opening the valve V5 to somewhat pressurize the area 133. Then, the determiner 73 determines whether or not the substrate is adsorbed to the membrane 13 based on values measured by the flow rate meter FS in the manner described below.

[0085]

FIG. 10 is a flowchart showing a procedure of the substrate adsorption determination. Hereinafter, the area 133 where the flow rate meter FS is provided is called a "determination area" and the area 135 which is depressurized to adsorb the substrate is called an "adsorption area".

[0086]

First, the controller 71 depressurizes the adsorption area 135 (step S1). Then, the controller 71 opens the valve V3 to pressurize the determination area 133 and opens the valve V10 to open the determination area 133 to the atmosphere (step S2). In other words, the controller 71 opens the determination area 133 to the atmosphere through the flow path 150 while pressurizing the determination area 133 through the flow path

143.

[0087]

While the controller 71 depressurizes the adsorption area 135 to about -500 hPa in step S1, the controller 71 pressurizes the determination area 133 to 200 hPa or less, preferably to about 50 hPa in step S2. This is because when the determination area 133 is overpressurized, a force applied downward to the substrate W increases, and this hinders the substrate adsorption.

[0088]

Next, the determiner 73 waits until a predetermined determination start time T0 elapses (step S3). When the determination start time T0 elapses, the determiner 73 compares a flow rate measured by the flow rate meter FS with a predetermined threshold value and determines whether or not the substrate W is adsorbed to the membrane 13 (step S4).

[0089]

FIG. 11 is a diagram schematically showing a cross-section of the membrane 13 and the top ring main body 11 when the adsorption fails. The membrane 13 has flexibility, so that when the substrate W is not adsorbed, a portion corresponding to the adsorption area 135 in the membrane 13 is pulled up toward the top ring main body 11, however a portion corresponding to the determination area 133 is not pulled up and the gap g remains between the portion and the top ring main body 11. Therefore, the flow rate measured by the flow rate meter FS increases.

[0090]

FIG. 12A is a diagram schematically showing a cross-section of the substrate W, the membrane 13, and the top ring main body 11 when the adsorption succeeds. When the substrate W is adsorbed, the entire membrane 13 including the portion corresponding to the determination area 133 is pulled up and closely comes into contact with the top ring main body 11. Therefore, the gap g substantially disappears, and the flow rate measured by the flow rate meter FS decreases.

[0091]

As evident from the above, a flow rate flowing through the determination area 133 corresponds to the size of the gap g, and the larger the gap g, the larger the flow rate.

[0092]

FIG. 12B is an enlarged view around the elastic member 91 in FIG. 12A. When the substrate W is adsorbed, the upper surface of (the convex portion 92 of) the membrane 13 comes into contact with the lower surface of the elastic member 91. Thereby, the gap g is reliably closed, and the flow rate measured by the flow rate meter FS decreases.

[0093]

Therefore, when the flow rate is less than or equal to the threshold value (that is, when the gap g is small), the determiner 73 determines that the adsorption of the substrate W is successfully performed (or the substrate W is adsorbed) (YES in step S4 in FIG. 10, S5, and FIGS. 12A and 12B). Then, the substrate processing apparatus continues operation such as

transport of the substrate W by the top ring 1 (step S6). Thereafter, when the substrate W should be continuously adsorbed (YES in step S7), the determination in step S4 is repeatedly performed.

[0094]

In a state in which the top ring 1 holds the substrate W, that is, in a state in which the upper surface of the membrane 13 and the lower surface of the elastic member 91 are in contact with each other, the substrate W is polished. As shown in FIG. 9, the areas 133 and 135 are pressurized during polishing.

[0095]

If a rigid member is used instead of the elastic member 91, when a height setting of the top ring 1 is low and the rigid member and the convex portion 92 of the elastic film come into contact with each other even when the area 133 is pressurized, the convex portion 92 pressed against the rigid member presses the substrate W, so that a polishing rate increases.

[0096]

On the other hand, in the present embodiment, the elastic member 91 has elasticity, so that even when the height setting of the top ring 1 is low, the substrate W is not strongly pressed against the polishing pad 3a. Therefore, it is possible to uniform the polishing rate of the entire surface of the substrate W.

[0097]

Let us return to FIG. 10. When the flow rate is greater than the threshold value (that is, when the gap g is large) even

after a predetermined error check time elapses, the determiner 73 determines that the adsorption of the substrate W fails (or the substrate W is not adsorbed) (NO in S4, YES in S8, S9, and FIG. 11). Then, the substrate processing apparatus stops the operation and issues an error if necessary (step S10).

[0098]

In the present embodiment, the determination is continued even after it is once determined that the substrate W is adsorbed to the membrane 13 (YES in step S7, S4). Therefore, in such a case that the substrate W falls while the substrate W is being transported, the flow rate becomes greater than the threshold value, so that it is possible to detect that the substrate W disappears (step S9).

[0099]

FIG. 13 is a diagram schematically showing the flow rate measured by the flow rate meter FS after starting adsorption. A solid line indicates a flow rate measured by the flow rate meter FS when the adsorption succeeds. A dashed line indicates a flow rate measured by the flow rate meter FS when the adsorption fails. A dashed-dotted line indicates a flow rate measured by the flow rate meter FS when the adsorption once succeeds, but thereafter the substrate W falls. A horizontal axis indicates time.

[0100]

As shown in FIG. 13, when the adsorption is started at time t_1 (step S1 in FIG. 10), the flow rate increases. This is because there is the gap g between the upper surface of the

membrane 13 and the lower surface of the top ring main body 11 at a time point when the adsorption is started regardless of success or failure of the adsorption, so that air flows.

[0101]

When the adsorption succeeds (the solid line in FIG. 13), the substrate W is adsorbed to the membrane 13, so that the gap g between the membrane 13 and the top ring main body 11 becomes small. Therefore, after a certain time t_2 , the flow rate starts to decrease. Then, at time t_3 when the flow rate becomes less than or equal to the threshold value, it is determined that the adsorption succeeds (step S5 in FIG. 10). Thereafter, when the substrate W is completely adsorbed to the membrane 13 at time t_4 in FIG. 13, the gap g between the membrane 13 and the top ring main body 11 substantially disappears and the flow rate becomes substantially constant.

[0102]

If the substrate W falls from the top ring 1 at time t_{11} , the flow rate increases again (the dashed-dotted line in FIG. 13). This is because the gap g appears again between the membrane 13 and the top ring main body 11 when the substrate W is separated from the membrane 13. In this case, it is determined that the adsorption fails (step S9 in FIG. 10) after a certain error check time elapses from time t_{12} when the flow rate becomes greater than the threshold value (step S8).

[0103]

On the other hand, when the adsorption fails (the dashed line in FIG. 13), the flow rate continues to increase even after

time t_2 , and becomes constant eventually. Therefore, the flow rate is still greater than the threshold value even after the error check time elapses, so that it is determined that the adsorption fails (step S9 in FIG. 10).

[0104]

The reason why the determination start time T_0 is set is to prevent the substrate from being determined to be adsorbed before the substrate is sufficiently adsorbed to the membrane 13 (before time t_5 in FIG. 13). The error check time is also required in the case described below. After polishing, when the substrate W adsorbed to the top ring 1 is pulled up from the polishing pad 3a, the error check time is also required. This is because, in this case, the flow rate temporarily increases and may exceed the threshold value due to adsorption force between the polishing pad 3a and the substrate W.

[0105]

In this way, in the first embodiment, the determination area 133 is pressurized and opened to the atmosphere, and the flow rate of the area 131 is measured. The flow rate corresponds to the size of the gap g between the membrane 13 and the top ring main body 11. Therefore, by monitoring the flow rate, it is possible to accurately determine whether or not the substrate W is successfully adsorbed, so that the substrate W can be appropriately handled. Further, the determination can be continued even after the substrate W is adsorbed, so that even if the substrate W falls after the substrate W is once successfully adsorbed, it is possible to detect the fall of the

substrate W.

[0106]

In the present embodiment, the elastic member 91 is provided to the top ring 1, and the elastic member 91 and the membrane 13 are in contact with each other. Therefore, the gap g when the substrate W is not adsorbed can be small. This is because when the elastic member 91 is used, the substrate W is not strongly pressed by the elastic member 91 when polishing is performed in a state in which the substrate is adsorbed, so that it is possible to uniform the polishing rate over the entire substrate W. The gap g is small, so that when the substrate W is adsorbed, the gap g is reliably closed. Therefore, the accuracy of the determination is improved.

[0107]

That is, by providing the elastic member 91, the determination accuracy of the substrate adsorption can be improved while suppressing partial unevenness of the polishing rate of the substrate W.

[0108]

In the present embodiment, the flow path 150 is opened to the atmosphere. However, for example, the flow rate may be adjusted to a flow rate range suitable to detect adsorption of the substrate by using a flow rate adjusting valve as the valve V10, or the flow rate may be adjusted and/or air may be exhausted by connecting a pressure regulator to the flow path 150 instead of opening the flow path 150 to the atmosphere. When connecting a pressure regulator to the flow path 150, for example, air is

flowed through the flow path 150 by setting R1 to 100 hPa pressurization and setting an added pressure regulator to 50 hPa pressurization.

[0109]

The substrate adsorption determination by the present embodiment can be applied to a membrane 13 where no hole is formed. Further, when the substrate adsorption determination is performed, the valve V10 is opened, so that the determination area 133 is not closed, so that the pressure of the determination area 133 does not rise so much. Therefore, the determination area 133 in the membrane 13 hardly gives stress to the substrate W.

[0110]

In the present embodiment, the area 133 is used as the determination area and the area 135 is used as the adsorption area. However, other areas may be used as the determination area and adsorption area. Specifically, a configuration corresponding to the valve V10, the flow path 150, and the flow rate meter FS is provided to at least one area and the area can be used as the determination area, and other one or more areas can be used as the adsorption areas.

[0111]

It is desirable that the determination area is not adjacent to the adsorption area and is separated from the adsorption area by one or more areas. This is because, when the determination area is adjacent to the adsorption area, even if the adsorption of the substrate W fails, a portion

corresponding to the determination area is also pulled up when a portion corresponding to the adsorption area in the membrane 13 is pulled up, thereby the flow rate flowing through the determination area decreases, and erroneous determination may be made.

[0112]

Hereinafter, some modified examples of the elastic member 91 in the top ring 1 will be described. The description of the same portions as those of the top ring 1 shown in FIGS. 7 and 8 will be omitted.

[0113]

FIG. 14A is a cross-sectional view showing details of a top ring main body 11 and a membrane 13 in a top ring 1 that is a first modified example. The top ring 1 includes an elastic member 191 (FIG. 14B shows an enlarged view around the elastic member 191). The elastic member 191 has horizontal planes 191a and 191b and a vertical plane 191c.

[0114]

The horizontal plane 191a (third plane) is substantially in parallel with the membrane 13. In a state in which the top ring 1 does not hold the substrate W, a lower surface of the horizontal plane 191a is separated from the upper surface of the membrane 13. When the top ring 1 holds the substrate W, the upper surface of (the convex portion 92 of) the membrane 13 comes into contact with the lower surface of the horizontal plane 191a.

[0115]

The horizontal plane 191b (fourth plane) is substantially in parallel with the membrane 13. The horizontal plane 191b is located above the horizontal plane 191a (opposite to the membrane 13) and separated from the horizontal plane 191a. The vertical plane 191c (fifth plane) connects the horizontal plane 191a and the horizontal plane 191b and preferably connects the horizontal planes 191a and 191b on the flow path 150 side. Thereby, a slit 191d opening toward the flow path 143 is formed in the elastic member 191.

[0116]

According to the elastic member 191 as described above, when the top ring 1 holds the substrate W, the membrane 13 more reliably comes into contact with the elastic member 191 and a path between the flow path 143 and the flow path 150 can be closed. The reason of the above is as follows.

[0117]

As shown in FIG. 14C, it is assumed that there is a slight gap between the convex portion 92 of the membrane 13 and the horizontal plane 191a when the substrate W is held. In this case, when pressure is applied from the flow path 143, a flow velocity of fluid in the gap increases, and a negative pressure is generated in the gap by Bernoulli's theorem. Then, the horizontal plane 191a is deformed downward due to elasticity of the horizontal plane 191a and comes into contact with the convex portion 92 (FIG. 14D). When the horizontal plane 191a once comes into contact with the convex portion 92, the fluid from the flow path 143 flows into the slit 191d, so that the

pressure inside the slit 191d becomes high and a force pressing the horizontal plane 191a downward is generated. Thereby, a contact state between the horizontal plane 191a of the elastic member 191 and the convex portion 92 of the membrane 13 is stabilized.

[0118]

Regarding the top ring 1 shown in FIG. 14A, the flow path 143 from which pressure is applied is located on a center side of the top ring 1 and the flow path 150 opened to the atmosphere is located on an outer side of the top ring 1. Therefore, a side of the slit 191d facing the center of the top ring 1 (the side facing the flow path 143) is opened.

[0119]

On the other hand, when the flow path 143 from which pressure is applied is located on an outer side of the top ring 1 and the flow path 150 opened to the atmosphere is located on a center side of the top ring 1, as shown in FIG. 15, a side of the slit 191d facing the outer side of the top ring 1 (the side facing the flow path 143) may be opened.

[0120]

FIG. 16A is a cross-sectional view showing details of a top ring main body 11 and a membrane 13 in a top ring 1 that is a second modified example. The top ring 1 includes an elastic member 291 (FIG. 16B shows an enlarged view around the elastic member 291). The elastic member 291 has horizontal planes 291a and 291b and an inclined plane 291c.

[0121]

The horizontal plane 291a (third plane) is substantially in parallel with the membrane 13. In a state in which the top ring 1 does not hold the substrate W, a lower surface of the horizontal plane 291a is separated from the upper surface of the membrane 13. When the top ring 1 holds the substrate W, the upper surface of the membrane 13 comes into contact with the lower surface of the horizontal plane 291a.

[0122]

The horizontal plane 291b (fourth plane) is substantially in parallel with the membrane 13. The horizontal plane 291b is located above the horizontal plane 291a (opposite to the membrane 13) and separated from the horizontal plane 291a. The inclined plane 291c connects the horizontal plane 291a and the horizontal plane 291b diagonally (in a direction not perpendicular to the membrane 13) and preferably connects one end side (for example, the flow path 150 side) of the horizontal plane 291a and the other end side (for example, the flow path 143 side) of the horizontal plane 291b.

[0123]

Such an elastic member 291 easily expands and contracts in the vertical direction (in a direction perpendicular to the membrane 13). Therefore, even if the substrate W is polished when the height setting of the top ring 1 is low, it is possible to reduce effect of pressing of the substrate W that is pressed by a lower portion of the horizontal plane 291a, so that the polishing rate of the entire surface of the substrate W is uniformized.

[0124]

FIG. 17A is a cross-sectional view showing details of a top ring main body 11 and a membrane 13 in a top ring 1 that is a third modified example. The top ring 1 includes an elastic member 391 and a flow path 392 (FIG. 17B shows an enlarged view around the elastic member 391). The elastic member 391 forms a fluid containing portion 391a (airbag) opening upward, and the flow path 392 is connected to the opening. The flow path 392 is connected to, for example, the pressure adjustor 72 in FIG. 6A, so that it is possible to pressurize (supply fluid to) the fluid containing portion 391a.

[0125]

When the substrate adsorption determination is performed, fluid is supplied from the flow path 392 to the fluid containing portion 391a. Thereby, the elastic member 391 expands downward (toward the membrane 13) and approaches the membrane 13 (FIG. 17C). Therefore, when the top ring 1 holds the substrate W, a lower surface of the elastic member 391 and the upper surface of the membrane 13 stably come into contact with each other. When the substrate is polished, the fluid containing portion 391a may be depressurized (to be a normal state).

[0126]

FIG. 18 is a cross-sectional view showing details of a top ring main body 11 and a membrane 13 in a top ring 1 that is a fourth modified example. The top ring 1 includes an elastic member 491. A convex portion 491a facing downward is provided to a lower surface of the elastic member 491 instead of the

membrane 13. The convex portion 491a may be provided to the elastic member 491 side in this way. Further, a convex portion may be provided to a lower surface of the elastic member of each modified example.

[0127]

(Second Embodiment)

In the first embodiment described above, the flow rate of the fluid flowing through the determination area 133 is directly measured by the flow rate meter FS. However, other physical values may be measured by using a measuring instrument whose measurement value varies according to the flow rate. Therefore, in the second embodiment described below, an example that uses a pressure gauge instead of the flow rate meter FS will be described.

[0128]

FIG. 19 is a cross-sectional view schematically showing a structure of a top ring 1 in the second embodiment. Differently from FIG. 6A, a pressure gauge PS is provided on the flow path 143 communicating with the determination area 133. The pressure gauge PS measures pressure in the flow path 143 and notifies the determiner 73 of a measurement result. The pressure measured by the pressure gauge PS corresponds to the flow rate of fluid flowing through the determination area 133. Also in the present embodiment, the elastic member described in the first embodiment is provided to the top ring 1. However, the details thereof will be omitted.

[0129]

FIG. 20 is a diagram schematically showing a cross-section of a membrane 13 and a top ring main body 11 when adsorption fails. FIG. 20 corresponds to FIG. 11. As shown in FIG. 20, there is a gap g between the determination area 133 and the membrane 13, and the flow rate of the determination area 133 is large. In this case, the fluid easily flows from the flow path 143 to the determination area 133, so that the pressure of the flow path 143 is low. As a result, a measurement result of the pressure gauge PS becomes low.

[0130]

FIG. 21 is a diagram schematically showing a cross-section of the substrate W, the membrane 13, and the top ring main body 11 when adsorption succeeds. FIG. 21 corresponds to FIG. 12A. As shown in FIG. 21, there is almost no gap g between the determination area 133 and the membrane 13, and the flow rate of the determination area 133 is small. In this case, the fluid hardly flows from the flow path 143 to the determination area 133, so that the pressure of the flow path 143 is high. As a result, a measurement result of the pressure gauge PS becomes high.

[0131]

In this way, the pressure gauge PS corresponds to the flow rate. Therefore, whether or not the pressure exceeds a threshold value may be determined instead of step S4 in FIG. 10 (whether or not the flow rate is less than or equal to the threshold value is determined). The pressure gauge PS may be provided on the flow path 150 communicating with the

determination area 133.

[0132]

In this way, the pressure gauge PS corresponds to the flow rate. Therefore, whether or not the pressure is greater than or equal to a threshold value may be determined instead of step S4 in FIG. 10 (whether or not the flow rate is less than or equal to the threshold value is determined).

[0133]

As described above, in the second embodiment, by measuring the pressure that varies according to the flow rate, it is possible to accurately determine whether or not the substrate W is successfully adsorbed.

[0134]

The above embodiments are described so that a person with an ordinary skill in the technical field to which the invention pertains can implement the invention. The various modified examples of the above embodiments can be naturally made by those skilled in the art, and the technical idea of the invention can be applied to other embodiments. Therefore, the invention is not limited to the described embodiments and should encompass the widest range in accordance with the technical ideas defined by the claims.

[0135]

From the above description, for example, the following aspects can be considered.

[0136]

According to one embodiment, provided is a substrate

holding apparatus comprising: a top ring main body; an elastic film comprising a first surface and a second surface, the first surface forming a plurality of areas between the first surface and the top ring main body, the second surface being located opposite to the first surface and capable of holding a substrate; a first line that communicates with a first area among the plurality of areas and can pressurize the first area; a second line that communicates with the first area and can exhaust air from the first area; a measuring instrument whose measurement value varies based on a flow rate of the first area; a third line that communicates with a second area different from the first area among the plurality of areas and can depressurize the second area; and an elastic member provided between the first line and the second line so as to be separated from the first surface of the elastic film when the second surface of the elastic film does not hold a substrate and be in contact with the first surface of the elastic film when the second surface of the elastic film holds a substrate.

[0137]

Preferably, a convex portion is provided at a position facing the elastic member on the first surface of the elastic film.

[0138]

Preferably, a slit opening toward the first line is formed in the elastic member.

[0139]

Preferably, the elastic member comprises: a third surface

that is substantially in parallel with the elastic film and comes into contact with the first surface of the elastic film when the second surface of the elastic film holds a substrate; a fourth surface that is substantially in parallel with the elastic film, is separated from the first surface, and is located opposite to the elastic film; and a fifth surface that connects a portion of the third surface facing the second line and a portion of the fourth surface facing the second line.

[0140]

Preferably, the elastic member is a hollow member.

[0141]

Preferably, the elastic member comprises: a third surface that is substantially in parallel with the elastic film and comes into contact with a convex portion of the first surface of the elastic film when the second surface of the elastic film holds a substrate; a fourth surface that is substantially in parallel with the elastic film, is separated from the first surface, and is located opposite to the elastic film; and an inclined surface that connects the third surface and the fourth surface in a direction not perpendicular to the third surface.

[0142]

Preferably, the elastic member forms a fluid containing portion, and by supplying fluid to the fluid containing portion, at least a part of the elastic member approaches the elastic film.

[0143]

Preferably, the elastic member is provided with a convex

portion at a position facing the first surface of the elastic film.

[0144]

Preferably, a material of the elastic member is one of NBR, silicon rubber, EPDM, fluoro rubber, chloroprene, and urethane rubber.

[0145]

According to another embodiment, provided is a substrate polishing apparatus comprising: the above-mentioned substrate holding apparatus; and a polishing table configured to polish a substrate held by the substrate holding apparatus.

[0146]

According to another embodiment, provided is an elastic member for a substrate holding apparatus, wherein the substrate holding apparatus comprises: a top ring main body, an elastic film comprising a first surface and a second surface, the first surface forming a plurality of areas between the first surface and the top ring main body, the second surface being located opposite to the first surface and capable of holding a substrate; a first line that communicates with a first area among the plurality of areas and can pressurize the first area, a second line that communicates with the first area and can exhaust air from the first area, a measuring instrument whose measurement value varies based on a flow rate of the first area, and a third line that communicates with a second area different from the first area among the plurality of areas and can depressurize the second area, and the elastic member is provided

between the first line and the second line so as to be separated from the first surface of the elastic film when the second surface of the elastic film does not hold a substrate and be in contact with the first surface of the elastic film when the second surface of the elastic film holds a substrate.

[0147]

According to another embodiment, provided is a manufacturing method of a substrate holding apparatus, the manufacturing method comprising: attaching a new elastic member to the above-mentioned substrate holding apparatus from which the elastic member is removed.

What is claimed is:

1. A substrate holding apparatus comprising:

a top ring main body;

an elastic film comprising a first surface and a second surface, the first surface forming a plurality of areas between the first surface and the top ring main body, the second surface being located opposite to the first surface and capable of holding a substrate;

a first line that communicates with a first area among the plurality of areas and can pressurize the first area;

a second line that communicates with the first area and can exhaust air from the first area;

a measuring instrument whose measurement value varies based on a flow rate of the first area;

a third line that communicates with a second area different from the first area among the plurality of areas and can depressurize the second area; and

an elastic member provided between the first line and the second line so as to be separated from the first surface of the elastic film when the second surface of the elastic film does not hold a substrate and be in contact with the first surface of the elastic film when the second surface of the elastic film holds a substrate.

2. The substrate holding apparatus according to claim 1, wherein a convex portion is provided at a position facing the elastic member on the first surface of the elastic film.

3. The substrate holding apparatus according to claim 1,

wherein a slit opening toward the first line is formed in the elastic member.

4. The substrate holding apparatus according to claim 1, wherein

the elastic member comprises:

a third surface that is substantially in parallel with the elastic film and comes into contact with the first surface of the elastic film when the second surface of the elastic film holds a substrate;

a fourth surface that is substantially in parallel with the elastic film, is separated from the first surface, and is located opposite to the elastic film; and

a fifth surface that connects a portion of the third surface facing the second line and a portion of the fourth surface facing the second line.

5. The substrate holding apparatus according to claim 1, wherein the elastic member is a hollow member.

6. The substrate holding apparatus according to claim 1, wherein

the elastic member comprises:

a third surface that is substantially in parallel with the elastic film and comes into contact with a convex portion of the first surface of the elastic film when the second surface of the elastic film holds a substrate;

a fourth surface that is substantially in parallel with the elastic film, is separated from the first surface, and is located opposite to the elastic film; and

an inclined surface that connects the third surface and the fourth surface in a direction not perpendicular to the third surface.

7. The substrate holding apparatus according to claim 1, wherein

the elastic member forms a fluid containing portion, and by supplying fluid to the fluid containing portion, at least a part of the elastic member approaches the elastic film.

8. The substrate holding apparatus according to claim 1, wherein the elastic member is provided with a convex portion at a position facing the first surface of the elastic film.

9. The substrate holding apparatus according to claim 1, wherein a material of the elastic member is one of NBR, silicon rubber, EPDM, fluoro rubber, chloroprene, and urethane rubber.

10. A substrate polishing apparatus comprising:

the substrate holding apparatus according to claim 1; and a polishing table configured to polish a substrate held by the substrate holding apparatus.

11. An elastic member for a substrate holding apparatus, wherein

the substrate holding apparatus comprises:
a top ring main body,
an elastic film comprising a first surface and a second surface, the first surface forming a plurality of areas between the first surface and the top ring main body, the second surface being located opposite to the first surface and capable of holding a substrate;

a first line that communicates with a first area among the plurality of areas and can pressurize the first area,

a second line that communicates with the first area and can exhaust air from the first area,

a measuring instrument whose measurement value varies based on a flow rate of the first area, and

a third line that communicates with a second area different from the first area among the plurality of areas and can depressurize the second area, and

the elastic member is provided between the first line and the second line so as to be separated from the first surface of the elastic film when the second surface of the elastic film does not hold a substrate and be in contact with the first surface of the elastic film when the second surface of the elastic film holds a substrate.

12. A manufacturing method of a substrate holding apparatus, the manufacturing method comprising:

attaching a new elastic member to the substrate holding apparatus according to claim 1 from which the elastic member is removed.