DESCRIPTION
TITLE OF THE INVENTION:
TEMPERATURE CONTROL DEVICE, PLASMA ETCHING APPARATUS, AND SEMICONDUCTOR MANUFACTURING SYSTEM

TECHNICAL FIELD

[0001]

The embodiment of the present invention relates to a temperature control device, a plasma etching apparatus, and a semiconductor manufacturing system.

BACKGROUND ART

[0002]

For example, when a three-dimensional NAND flash memory is manufactured, high aspect ratio etching is required.

[0003]

When the high aspect ratio etching is performed, a plasma etching apparatus is generally used. The plasma etching apparatus holds a wafer with, for example, an electrostatic chuck disposed in a chamber, attaches radicals in plasma generated in the chamber to the wafer, and draws ions toward the wafer by applying a voltage. As a result, radicals and ions chemically react on the wafer. As a result, the surface of the wafer is etched.

[0004]

In the plasma etching as described above, ions are drawn toward the wafer with anisotropy by application of voltage. This allows for high aspect ratio etching with suppressed side etching.

[0005]

However, in the plasma etching apparatus, if appropriate temperature control is not performed according to an etching progress status, the finish of high aspect ratio etching will be unsatisfactory. For example, if radicals adhere to an inner peripheral surface of a hole during etching, side etching may progress, but the adhesion of radicals to the inner peripheral surface can be suppressed by temperature control. For this reason, the plasma etching apparatus usually controls a temperature of the wafer. Such temperature control is performed, for example, by passing a heat medium through the electrostatic chuck. In addition, gas may be supplied between the electrostatic chuck and the wafer to adjust thermal conductivity of the heat transferred from the electrostatic chuck to the wafer.

[0006]

Prior documents of such a plasma etching apparatus include JP2023-043845A, JP2023-065471A, JP2023-002461A, and JP2023-137580A.

[0007]

Examples of the temperature control pattern required for the plasma etching apparatus include early switching from a low temperature to a high temperature or vice versa. In this regard, many plasma etching apparatuses use low-temperature and high-temperature refrigerants and switch between temperature zones by switching valves provided in flow paths of each refrigerant. In addition, there are cases where a gradual switching from a low temperature to a high temperature is required. In this regard, as described above, many plasma etching apparatuses use low-temperature and high-temperature refrigerants, and gradually change a mixing ratio of the low-temperature and high-temperature refrigerants by controlling an opening degree of valves in the flow paths of each refrigerant.

[0008]

However, the temperature control described above is performed by switching the valves provided in the flow paths of each refrigerant, and therefore requires a plurality of control inputs. Furthermore, the mechanical characteristics of each valve may differ. As a result, desired temperature control may not always be achieved with good responsiveness and accuracy.

[0009]

When a plurality of valves are used, an occupied range of each valve and an occupied range of a pipe connected to each valve may become large. In addition, in the plasma etching apparatus, many members such as electrodes and their cables that generate a bias for drawing ions toward the wafer, electrodes and their cables that apply a bias to the electrostatic chuck, and a pipe for introducing gas are arranged on the chuck and the periphery thereof. In recent years, there has been a strong demand in the field of semiconductor manufacturing apparatuses for improving manufacturing efficiency by suppressing the footprint. Considering this, it is desirable to minimize a size and an occupied range of components as much as possible.

SUMMARY OF THE INVENTION

[0010]

The present invention has been made in consideration of such points, and an object thereof is to provide a temperature control device, a plasma etching apparatus, and a semiconductor manufacturing system capable of improving responsiveness and accuracy of temperature control while suppressing a size and an occupied range.

[0011]

The embodiment of the present invention relates to the following aspects.

[0012]

Aspect 1. A temperature control device that performs temperature control by a fluid flowing through a supply pipe portion, the device including: a valve device; a first fluid supply device configured to supply a first fluid to the valve device; a second fluid supply device configured to supply a second fluid to the valve device; and the supply pipe portion configured to allow the first fluid, the second fluid, or the first fluid and the second fluid flowing out of the valve device, to flow, in which

the valve device includes a first valve member and a second valve member that are in contact with each other and are relatively rotatable while maintaining a contact state, and

the first fluid, the second fluid, or the first fluid and the second fluid are supplied from the valve device to the supply pipe portion according to the relative rotation between the first valve member and the second valve member.

[0013]

Aspect 2. The temperature control device according to Aspect 1, in which the first valve member includes a first upstream flow path, a first downstream flow path, a second upstream flow path, and a second downstream flow path, each opening on a surface facing the second valve member and a surface different from the surface facing the second valve member, respectively, the first fluid is supplied to the first upstream flow path, the second fluid is supplied to the second upstream flow path, and the supply pipe portion receives the first fluid from the first downstream flow path and the second fluid from the second downstream flow path, and

the second valve member includes:

a first relay flow path that, according to the relative rotation between the first valve member and the second valve member, overlaps with the first upstream flow path and the first downstream flow path, thereby allowing flow of the first fluid from the first upstream flow path to the first downstream flow path, and does not overlap with at least one of the first upstream flow path and the first downstream flow path, thereby blocking the flow of the first fluid from the first upstream flow path to the first downstream flow path; and

a second relay flow path that, according to the relative rotation between the first valve member and the second valve member, overlaps with

the second upstream flow path and the second downstream flow path, thereby allowing flow of the second fluid from the second upstream flow path to the second downstream flow path, and does not overlap with at least one of the second upstream flow path and the second downstream flow path, thereby blocking the flow of the second fluid from the second upstream flow path to the second downstream flow path.

[0014]

Aspect 3. The temperature control device according to Aspect 2, in which in the valve device, the flow of the second fluid from the second upstream flow path to the second downstream flow path is blocked in a state where an area in which an opening end of the first upstream flow path and an opening end of the first downstream flow path, which are open on a surface of the first valve member facing the second valve member, overlap with the first relay flow path is maximized, and the flow of the first fluid from the first upstream flow path to the first downstream flow path is blocked in a state where an area in which an opening end of the second upstream flow path and an opening end of the second downstream flow path, which are open on the surface of the first valve member facing the second valve member, overlap with the second relay flow path is maximized.

[0015]

Aspect 4. The temperature control device according to Aspect 3, in which in the valve device, when the first valve member and the second valve member are relatively rotated from the state in which the area in which the opening end of the first upstream flow path and the opening end of the first downstream flow path, which are open on the surface of the first valve member facing the second valve member, overlap with the first relay flow path is maximized to the state in which the flow of the first fluid from the first upstream flow path to the first downstream flow path is blocked, the area in which the opening end of the first upstream flow path and the opening end of the first downstream flow path overlap with the first relay flow path gradually decreases, and the area in which the opening end of the second upstream flow path and the opening end of the second downstream flow path overlap with the second relay flow path gradually increases.

[0016]

Aspect 5. The temperature control device according to any one of Aspects 2 to 4, in which the first valve member further includes a first bypass flow path and a second bypass flow path, which are open on the surface facing the second valve member and the surface different from the surface facing the second valve member,

the first relay flow path allows the flow of the first fluid from the first upstream flow path to the first bypass flow path when blocking the flow of the first fluid from the first upstream flow path to the first downstream flow path,

the first relay flow path allows the flow of the first fluid from the first upstream flow path to the first downstream flow path and the first bypass flow path when overlapping the first upstream flow path, the first downstream flow path, and the first bypass flow path,

the second relay flow path allows the flow of the second fluid from the second upstream flow path to the second bypass flow path when blocking the flow of the second fluid from the second upstream flow path to the second downstream flow path, and

the second relay flow path allows the flow of the second fluid from the second upstream flow path to the second downstream flow path and the second bypass flow path when overlapping the second upstream flow path, the second downstream flow path, and the second bypass flow path.

[0017]

Aspect 6. The temperature control device according to any one of Aspects 2 to 5, in which the first valve member further includes a return flow path, a first branch flow path, and a second branch flow path, which are open on the surface facing the second valve member and the surface different from the surface facing the second valve member,

the return flow path receives the first fluid, the second fluid, or the first fluid and the second fluid after being temperature-controlled while flowing through the supply pipe portion, the first branch flow path is connected to the first fluid supply device, and the second branch flow path is connected to the second fluid supply device, and

the second valve member further includes a third relay flow path that, according to the relative rotation between the first valve member and the second valve member, overlaps with the return flow path and the first branch flow path, thereby allowing a flow of a fluid from the return flow path to the first branch flow path, and overlaps with the return flow path and the second branch flow path, thereby allowing a flow of a fluid from the return flow path to the second branch flow path.

[0018]

Aspect 7. A plasma etching apparatus including: a chuck configured to hold a wafer; and

the temperature control device according to any one of Aspects 1 to 6.

[0019]

Aspect 8. The plasma etching apparatus according to Aspect 7, in which the first fluid and the second fluid are liquid refrigerants, and

the temperature control device supplies the first fluid, the second fluid, or the first fluid and the second fluid from the supply pipe portion to a flow path formed in the chuck.

[0020]

Aspect 9. The plasma etching apparatus according to Aspect 7, in which the first fluid and the second fluid are gases, and

the temperature control device supplies the first fluid, the second fluid, or the first fluid and the second fluid from the supply pipe portion to a space between the chuck and the wafer.

[0021]

Aspect 10. The plasma etching apparatus according to any one of Aspects 7 to 9, in which the temperature control device cools the first fluid by a refrigeration cycle device of a reverse Brayton cycle.

[0022]

Aspect 11. A semiconductor manufacturing system including:

a semiconductor manufacturing apparatus; and

the temperature control device according to any one of Aspects 1 to 6.

[0023]

Aspect 12. A semiconductor manufacturing system including:

a plurality of semiconductor manufacturing apparatuses; and

the temperature control device according to any one of Aspects 1 to 6, in which

the temperature control device includes a plurality of the valve devices and a plurality of the supply pipe portions,

the first fluid supply device includes a plurality of first branch pipe portions and distributes the first fluid to the plurality of first branch pipe portions, and the second fluid supply device includes a plurality of second branch pipe portions and distributes the second fluid to the plurality of second branch pipe portions, and

the plurality of valve devices are connected to the corresponding first branch pipe portions and second branch pipe portions, respectively, and are connected to the corresponding semiconductor manufacturing apparatuses via the corresponding supply pipe portions.

[0024]

In Aspect 12, the plurality of semiconductor manufacturing apparatuses may include apparatuses that perform different processes.

[0025]

In Aspect 12, the temperature control device may cool the first fluid by a refrigeration cycle device of a reverse Brayton cycle.

[0026]

According to the embodiment of the present invention, it is possible to improve responsiveness and accuracy of temperature control while suppressing a size and an occupied range.

BRIEF DESCRIPTION OF DRAWINGS

[0027]

[Fig. 1] Fig. 1 is a view schematically illustrating a plasma etching apparatus including a temperature control device according to an embodiment.

[Fig. 2] Fig. 2 is an exploded perspective view of a valve device constituting the temperature control device illustrated in Fig. 1.

[Fig. 3A] Fig. 3A is a view illustrating a first valve member constituting the valve device illustrated in Fig. 2.

[Fig. 3B] Fig. 3B is a view illustrating a second valve member constituting the valve device illustrated in Fig. 2.

[Fig. 4A] Fig. 4A is a view for describing an operation of the valve device illustrated in Fig. 2.

[Fig. 4B] Fig. 4B is a view for describing an operation of the valve device illustrated in Fig. 2.

[Fig. 4C] Fig. 4C is a view for describing an operation of the valve device illustrated in Fig. 2.

[Fig. 4D] Fig. 4D is a view for describing an operation of the valve device illustrated in Fig. 2.

[Fig. 4E] Fig. 4E is a view for describing an operation of the valve device illustrated in Fig. 2.

[Fig. 5] Fig. 5 is a view schematically illustrating the temperature control device of Fig. 1 that performs temperature control of a fluid by a refrigeration cycle device of a reverse Brayton cycle and a plasma etching apparatus including the temperature control device.

[Fig. 6] Fig. 6 is a view schematically illustrating another plasma etching apparatus including the temperature control device illustrated in Fig. 1.

[Fig. 7] Fig. 7 is a view schematically illustrating a plasma etching apparatus including a temperature control device according to a modification.

[Fig. 8] Fig. 8 is a view schematically illustrating a semiconductor manufacturing system including the temperature control device illustrated in

Fig. 1.

MODE FOR CARRYING OUT THE INVENTION

[0028]

Hereinafter, an embodiment will be described in detail with reference to the accompanying drawings.

[0029]

Temperature Control Device and Plasma Etching Apparatus

Fig. 1 schematically illustrates a plasma etching apparatus 100 including a temperature control device 1 according to an embodiment.

[0030]

The plasma etching apparatus 100 includes a chuck 102 having a lower electrode 101, an upper electrode 103, and a chamber 104 accommodating the chuck 102 and the upper electrode 103. The chuck 102 holds a wafer W. The chuck 102 is, for example, an electrostatic chuck. The chuck 102 accommodates, for example, the lower electrode 101 therein.

[0031]

In the present embodiment, the temperature control device 1 supplies a temperature-controlled fluid to a flow path (not illustrated) formed in the chuck 102. As a result, the temperature control device 1 controls the temperature of the wafer W via the chuck 102.

[0032]

The temperature control device 1 includes a valve device 2, a first fluid supply device 40 that supplies a first fluid to the valve device 2, a second fluid supply device 50 that supplies a second fluid to the valve device 2, a supply pipe portion 61 that causes the first fluid, the second fluid, or the first fluid and the second fluid, which flow out of the valve device 2, to flow, a discharge pipe portion 62 that returns the first fluid, the second fluid, or the first fluid and the second fluid having passed through the chuck 102 from the supply pipe portion 61 to the valve device 2, and a controller 70. The temperature control device 1 supplies the first fluid, the second fluid, or the first fluid and the second fluid from the valve device 2 to the supply pipe portion 61 according to the operation of the valve device 2.

[0033]

The first fluid supply device 40 includes a first temperature control unit 41, a first upstream pipe portion 42 that connects the first temperature control unit 41 to the valve device 2 and is positioned on the upstream side with respect to the valve device 2, and a first downstream pipe portion 43 that connects the first temperature control unit 41 to the valve device 2 and

is positioned on the downstream side with respect to the valve device 2. The first fluid supply device 40 supplies the first fluid whose temperature has been controlled by the first temperature control unit 41 from the first upstream pipe portion 42 to the valve device 2. The first fluid supplied to the valve device 2 is either supplied to the supply pipe portion 61 or discharged from the valve device 2 without being supplied to the supply pipe portion 61, according to the operation of the valve device 2.

[0034]

When the first fluid is supplied to the supply pipe portion 61, the first fluid returns to the valve device 2 after passing through the chuck 102, and is then discharged from the valve device 2. The first downstream pipe portion 43 receives the first fluid discharged from the valve device 2 after being supplied to the supply pipe portion 61 or without being supplied to the supply pipe portion 61, and sends it to the first temperature control unit 41. The first fluid flowing into the first temperature control unit 41 from the first downstream pipe portion 43 is again temperature-controlled by the first temperature control unit 41 and then flows into the first upstream pipe portion 42.

[0035]

The second fluid supply device 50 includes a second temperature control unit 51, a second upstream pipe portion 52 that connects the second temperature control unit 51 to the valve device 2 and is positioned on the upstream side with respect to the valve device 2, and a second downstream pipe portion 53 that connects the second temperature control unit 51 to the valve device 2 and is positioned on the downstream side with respect to the valve device 2. The second fluid supply device 50 supplies the second fluid whose temperature has been controlled to a temperature different from that of the first fluid by the second temperature control unit 51 from the second upstream pipe portion 52 to the valve device 2. The second fluid supplied to the valve device 2 is either supplied to the supply pipe portion 61 or discharged from the valve device 2 without being supplied to the supply pipe portion 61, according to the operation of the valve device 2.

[0036]

When the second fluid is supplied to the supply pipe portion 61, the second fluid returns to the valve device 2 after passing through the chuck 102, and is then discharged from the valve device 2. The second downstream pipe portion 53 receives the second fluid discharged from the valve device 2 after being supplied to the supply pipe portion 61 or without being supplied to the supply pipe portion 61, and sends it to the second

temperature control unit 51. The second fluid flowing into the second temperature control unit 51 from the second downstream pipe portion 53 is again temperature-controlled by the second temperature control unit 51 and then flows into the second upstream pipe portion 52.

[0037]

In the present embodiment, as described above, the first fluid and the second fluid can be supplied from the valve device 2 to the supply pipe portion 61 according to the operation of the valve device 2. In the present embodiment, the temperature of the first fluid whose temperature is controlled by the first temperature control unit 41 is set to be lower than the temperature of the second fluid whose temperature is controlled by the second temperature control unit 51. As a result, when the first fluid and the second fluid are supplied from the valve device 2 to the supply pipe portion 61, temperature control by the mixed fluid having an intermediate temperature between the temperature of the first fluid and the temperature of the second fluid becomes possible.

[0038]

When the first fluid and the second fluid are supplied from the valve device 2 to the supply pipe portion 61 as described above, the mixed fluid of the first fluid and the second fluid that returns to the valve device 2 after passing through the chuck 102 is distributed and discharged from the valve device 2 to the first fluid supply device 40 and the second fluid supply device 50. In the present specification, the fluid of the mixed fluid discharged to the first fluid supply device 40 side is treated as the first fluid, and the fluid of the mixed fluid discharged to the second fluid supply device 50 side is treated as the second fluid. After the first fluid and the second fluid are supplied from the valve device 2 to the supply pipe portion 61 as described above, the first fluid returning to the first temperature control unit 41 is again temperature-controlled by the first temperature control unit 41 and then flows into the first upstream pipe portion 42. The second fluid returning to the second temperature control unit 51 is again temperature-controlled by the second temperature control unit 51 and then flows into the second upstream pipe portion 52.

[0039]

In the present embodiment, the first fluid and the second fluid are the same liquid. The first fluid and the second fluid may be fluorine-based brine, alcohol-based brine, ether-based brine, water, or the like. The first fluid and the second fluid are not particularly limited.

[0040]

Valve Device

The valve device 2 includes a first valve member 10 and a second valve member 20 that are in contact with each other and are relatively rotatable while maintaining a contact state, and a drive device 30. The drive device 30 applies power for relatively rotating the first valve member 10 and the second valve member 20. The drive device 30 includes, for example, an electric motor, and relatively rotates the first valve member 10 and the second valve member 20. The drive device 30 is controlled by the controller 70.

[0041]

The valve device 2 sets the fluid supplied from the valve device 2 to the supply pipe portion 61 as a first fluid, a second fluid, or a first fluid and a second fluid according to the relative rotation between the first valve member 10 and the second valve member 20. When the first fluid and the second fluid are supplied to the supply pipe portion 61, a mixing ratio of the first fluid and the second fluid can be controlled according to the relative rotation between the first valve member 10 and the second valve member 20.

[0042]

Fig. 2 is an exploded perspective view of the valve device 2, and illustrates the first valve member 10 and the second valve member 20. Fig. 3A is a view illustrating the first valve member 10. Fig. 3B is a view illustrating the second valve member 20. Hereinafter, the first valve member 10 and the second valve member 20 will be described in detail with reference to Figs. 2 to 3B.

[0043]

The first valve member 10 is a disk-shaped member. The first valve member 10 includes a first upstream flow path 11U, a first downstream flow path 11D, a first bypass flow path 11B, a second upstream flow path 12U, a second downstream flow path 12D, a second bypass flow path 12B, a return flow path 13, a first branch flow path 131, and a second branch flow path 132.

[0044]

The first upstream flow path 11U, the first downstream flow path 11D, the first bypass flow path 11B, the second upstream flow path 12U, the second downstream flow path 12D, the second bypass flow path 12B, the return flow path 13, the first branch flow path 131, and the second branch flow path 132 are opened on a first surface S1 of the first valve member 10 facing the second valve member 20 and a second surface S2 different from

the first surface S1. The first surface S1 of the first valve member 10 is a surface on a side in contact with the second valve member 20. In the present embodiment, the second surface S2 is a surface opposite to the first surface S1, and each of the above-described flow paths penetrates in an axial direction of the disk-shaped first valve member 10. However, the mode of forming the flow paths is not limited to the illustrated example, and for example, a part or all of the flow paths may be opened on a side surface of the first valve member 10 while being opened on the first surface S1.

[0045]

The first upstream pipe portion 42 of the first fluid supply device 40 is connected to the first upstream flow path 11U. The first fluid is supplied to the first upstream flow path 11U. The supply pipe portion 61 is connected to the first downstream flow path 11D. The first downstream pipe portion 43 of the first fluid supply device 40 is connected to the first bypass flow path 11B. In Fig. 2, the first upstream pipe portion 42, the supply pipe portion 61, and the first downstream pipe portion 43 are indicated by two-dot chain lines.

[0046]

The second upstream pipe portion 52 of the second fluid supply device 50 is connected to the second upstream flow path 12U. The second fluid is supplied to the second upstream flow path 12U. The supply pipe portion 61 is connected to the second downstream flow path 12D. The second downstream pipe portion 53 of the second fluid supply device 50 is connected to the second bypass flow path 12B. In Fig. 2, the second upstream pipe portion 52, the supply pipe portion 61, and the second downstream pipe portion 53 are indicated by two-dot chain lines.

[0047]

The discharge pipe portion 62 is connected to the return flow path 13. The first downstream pipe portion 43 of the first fluid supply device 40 is connected to the first branch flow path 131. The second downstream pipe portion 53 of the second fluid supply device 50 is connected to the second branch flow path 132.

[0048]

The second valve member 20 is a disk-shaped member. In the present embodiment, the first valve member 10 is fixed, and the second valve member 20 is rotated by the drive device 30 with respect to the first valve member 10. However, the second valve member 20 may be fixed, and the first valve member 10 may be rotated.

[0049]

The second valve member 20 includes a first relay flow path 21, a

second relay flow path 22, and a third relay flow path 23, each having a groove shape recessed from a surface facing the first valve member 10. The second valve member 20 has a shaft connecting hole 24 at the center thereof. The drive device 30 couples, for example, a rotary drive shaft to the shaft connecting hole 24. As a result, the second valve member 20 can be rotated by the drive device 30.

[0050]

The first relay flow path 21 is positioned so as to at least partially face the first upstream flow path 11U, the first downstream flow path 11D, and the first bypass flow path 11B. The second relay flow path 22 is positioned so as to at least partially face the second upstream flow path 12U, the second downstream flow path 12D, and the second bypass flow path 12B. The third relay flow path 23 is positioned so as to at least partially face the return flow path 13, the first branch flow path 131, and the second branch flow path 132. The first relay flow path 21, the second relay flow path 22, and the third relay flow path 23 change the overlapping state with the flow path in the corresponding first valve member 10 according to the rotation of the second valve member 20 with respect to the first valve member 10, thereby switching the state in which the first fluid, the second fluid, or the first fluid and the second fluid flow out of the valve device 2. Hereinafter, the first relay flow path 21, the second relay flow path 22, and the third relay flow path 23 will be described in detail.

[0051]

The first relay flow path 21 overlaps with the first upstream flow path 11U and the first downstream flow path 11D according to the rotation (in other words, the position in the rotation direction) of the second valve member 20 with respect to the first valve member 10, thereby allowing the flow of the first fluid from the first upstream flow path 11U to the first downstream flow path 11D (first fluid supply state). In addition, the first relay flow path 21 does not overlap with at least one of the first upstream flow path 11U and the first downstream flow path 11D according to the rotation of the second valve member 20 with respect to the first valve member 10 to a state different from the first fluid supply state, thereby blocking the flow of the first fluid from the first upstream flow path 11U to the first downstream flow path 11D (first fluid blocking state). In the present embodiment, the first relay flow path 21 does not overlap with the first downstream flow path 11D in the first fluid blocking state. At this time, the flat portion of the second valve member 20 blocks the first downstream flow path 11D, thereby blocking the flow of the first fluid from the first

upstream flow path 11U to the first downstream flow path 11D.

[0052]

The first fluid supply state includes a fully open supply state in which an area in which an opening end of the first upstream flow path 11U and an opening end of the first downstream flow path 11D, which are open on the first surface S1 of the first valve member 10 facing the second valve member 20, overlap with the first relay flow path 21 is maximized, and a supply and bypass state in which the first relay flow path 21 overlaps with the first upstream flow path 11U, the first downstream flow path 11D, and the first bypass flow path 11B. In the supply and bypass state, the first fluid is allowed to flow from the first upstream flow path 11U to the first downstream flow path 11D and the first bypass flow path 11B. The first fluid flowing into the first bypass flow path 11B flows into the first downstream pipe portion 43.

[0053]

When the supply amount of the first fluid to the supply pipe portion 61 is reduced relative to the fully open supply state, the first fluid is supplied in the supply and bypass state. When the state transitions from the fully open supply state to the supply and bypass state and the rotation of the second valve member 20 proceeds in a direction away from the fully open supply state, the overlap between the first relay flow path 21 and the first bypass flow path 11B gradually increases, and the overlap between the first relay flow path 21 and the first upstream flow path 11U gradually decreases. Then, since the first relay flow path 21 and the first upstream flow path 11U do not overlap each other, the state of the first relay flow path 21 enters the first fluid blocking state. In the first fluid blocking state, all of the first fluid flowing into the first upstream flow path 11U flows into the first bypass flow path 11B, thereby flowing into the first downstream pipe portion 43.

[0054]

The second relay flow path 22 rotationally moves along with the first relay flow path 21 according to the rotation (in other words, the position in the rotation direction) of the second valve member 20 with respect to the first valve member 10. The second relay flow path 22 overlaps with the second upstream flow path 12U and the second downstream flow path 12D according to the rotation of the second valve member 20 with respect to the first valve member 10, thereby allowing the flow of the second fluid from the second upstream flow path 12U to the second downstream flow path 12D (second fluid supply state). In addition, the second relay flow path 22 does not overlap with at least one of the second upstream flow path 12U and the

second downstream flow path 12D according to the rotation of the second valve member 20 with respect to the first valve member 10 to a state different from the second fluid supply state, thereby blocking the flow of the second fluid from the second upstream flow path 12U to the second downstream flow path 12D (second fluid blocking state). In the present embodiment, the second relay flow path 22 does not overlap with the second downstream flow path 12D in the second fluid blocking state. At this time, the flat portion of the second valve member 20 blocks the second downstream flow path 12D, thereby blocking the flow of the second fluid from the second upstream flow path 12U to the second downstream flow path 12D.

[0055]

The second fluid supply state includes a fully open supply state in which an area in which an opening end of the second upstream flow path 12U and an opening end of the second downstream flow path 12D, which are open on the first surface S1 of the first valve member 10 facing the second valve member 20, overlap with the second relay flow path 22 is maximized, and a supply and bypass state in which the second relay flow path 22 overlaps with the second upstream flow path 12U, the second downstream flow path 12D, and the second bypass flow path 12B. In the supply and bypass state, the flow of the second fluid from the second upstream flow path 12U to the second downstream flow path 12D and the second bypass flow path 12B is allowed. The second fluid flowing into the second bypass flow path 12B flows into the second downstream pipe portion 53.

[0056]

When the supply amount of the second fluid to the supply pipe portion 61 is reduced relative to the fully open supply state, the second fluid is supplied in the supply and bypass state. When the state transitions from the fully open supply state to the supply and bypass state and the rotation of the second valve member 20 proceeds in a direction away from the fully open supply state, the overlap between the second relay flow path 22 and the second bypass flow path 12B gradually increases, and the overlap between the second relay flow path 22 and the second upstream flow path 12U gradually decreases. Then, since the second relay flow path 22 and the second upstream flow path 12U do not overlap each other, the state of the second relay flow path 22 enters the second fluid blocking state. In the second fluid blocking state, all of the second fluid flowing into the second upstream flow path 12U flows into the second bypass flow path 12B, thereby flowing into the second downstream pipe portion 53.

[0057]

In the present embodiment, the flow of the second fluid from the second upstream flow path 12U to the second downstream flow path 12D is blocked in a state where the area in which the opening end of the first upstream flow path 11U and the opening end of the first downstream flow path 11D, which are open on the first surface S1 of the first valve member 10 facing the second valve member 20, overlap with the first relay flow path 21 is maximized. That is, when the first fluid is in the fully open supply state, the second fluid blocking state is formed. On the other hand, in a state where the area in which the opening end of the second upstream flow path 12U and the opening end of the second downstream flow path 12D, which are open on the first surface S1, overlap with the second relay flow path 22 is maximized, the flow of the first fluid from the first upstream flow path 11U to the first downstream flow path 11D is blocked. That is, when the second fluid is in the fully open supply state, the first fluid blocking state is formed.

[0058]

In addition, when the second valve member 20 is rotated from the state in which the area in which the opening end of the first upstream flow path 11U and the opening end of the first downstream flow path 11D, which are open on the first surface S1, overlap with the first relay flow path 21 is maximized to the state in which the flow of the first fluid from the first upstream flow path 11U to the first downstream flow path 11D is blocked, the area in which the opening end of the first upstream flow path 11U and the opening end of the first downstream flow path 11D overlap with the first relay flow path 21 gradually decreases, and the area in which the opening end of the second upstream flow path 12U and the opening end of the second downstream flow path 12D overlap with the second relay flow path 22 gradually increases. On the other hand, when the second valve member 20 is rotated from the state in which the area in which the opening end of the second upstream flow path 12U and the opening end of the second downstream flow path 12D, which are open on the first surface S1, overlap with the second relay flow path 22 is maximized to the state in which the flow of the second fluid from the second upstream flow path 12U to the second downstream flow path 12D is blocked, the area in which the opening end of the second upstream flow path 12U and the opening end of the second downstream flow path 12D overlap with the second relay flow path 22 gradually decreases, and the area in which the opening end of the first upstream flow path 11U and the opening end of the first downstream flow

path 11D overlap with the first relay flow path 21 gradually increases.

[0059]

That is, in the valve device 2, in a case where the first fluid is in the supply and bypass state and the second fluid is in the supply and bypass state, when the supply amount of the first fluid is increased by the rotation of the second valve member 20, the supply amount of the second fluid is decreased, and when the supply amount of the first fluid is decreased, the supply amount of the second fluid is increased. As a result, the mixing ratio of the first fluid and the second fluid can be changed.

[0060]

The first fluid, the second fluid, or the first fluid and the second fluid supplied from the valve device 2 to the chuck 102 through the supply pipe portion 61 return to the valve device 2 via the discharge pipe portion 62 after passing through the chuck 102. The first fluid, the second fluid, or the first fluid and the second fluid thus returned are returned to the first fluid supply device 40, the second fluid supply device 50, or the first fluid supply device 40 and the second fluid supply device 50. The third relay flow path 23 switches the fluid returned to the first fluid supply device 40 and the second fluid supply device 50.

[0061]

Specifically, the third relay flow path 23 overlaps with the return flow path 13 and the first branch flow path 131 according to the rotation (in other words, the position in the rotation direction) of the second valve member 20 with respect to the first valve member 10, thereby allowing the flow of the fluid from the return flow path 13 to the first branch flow path 131. The third relay flow path 23 overlaps with the return flow path 13 and the second branch flow path 132 according to the rotation of the second valve member 20 with respect to the first valve member 10, thereby allowing the flow of the fluid from the return flow path 13 to the second branch flow path 132. The third relay flow path 23 overlaps with the return flow path 13, the first branch flow path 131, and the second branch flow path 132 according to the rotation of the second valve member 20 with respect to the first valve member 10, thereby allowing the flow of the fluid from the return flow path 13 to the first branch flow path 131 and the second branch flow path 132.

[0062]

More specifically, when only the first fluid is supplied to the supply pipe portion 61, the third relay flow path 23 overlaps only with the return flow path 13 and the first branch flow path 131, thereby allowing the flow of the first fluid from the return flow path 13 to the first branch flow path 131.

When only the second fluid is supplied to the supply pipe portion 61, the third relay flow path 23 overlaps only with the return flow path 13 and the second branch flow path 132, thereby allowing the flow of the second fluid from the return flow path 13 to the second branch flow path 132.

[0063]

When the first fluid and the second fluid are supplied to the supply pipe portion 61, the third relay flow path 23 overlaps with the return flow path 13, the first branch flow path 131, and the second branch flow path 132, thereby allowing the flow of the first fluid from the return flow path 13 to the first branch flow path 131 and the flow of the second fluid from the return flow path 13 to the second branch flow path 132. When the third relay flow path 23 overlaps with the return flow path 13, the first branch flow path 131, and the second branch flow path 132, a flow rate of the first fluid flowing into the first branch flow path 131 and a flow rate of the second fluid flowing into the second branch flow path 132 are determined according to a ratio of an area in which the third relay flow path 23 overlaps with the first branch flow path 131 and an area in which the third relay flow path 23 overlaps with the second branch flow path 132.

[0064]

Figs. 4A to 4E are views for describing the operation of the valve device 2. In Figs. 4A to 4E, the first relay flow path 21, the second relay flow path 22, and the third relay flow path 23 are hatched for convenience of description.

[0065]

Fig. 4A illustrates a fully open supply state of the first fluid. In this state, the area in which the opening end of the first upstream flow path 11U and the opening end of the first downstream flow path 11D, which are open on the first surface S1, overlap with the first relay flow path 21 is maximized. The first relay flow path 21 does not overlap with the first bypass flow path 11B. The second relay flow path 22 overlaps only with the second upstream flow path 12U and the second bypass flow path 12B. The third relay flow path 23 overlaps only with the return flow path 13 and the first branch flow path 131. In the fully open supply state of the first fluid illustrated in Fig. 4A, only the low-temperature first fluid is supplied to the supply pipe portion 61. Fig. 4A is labeled “Cold Loop” to indicate this state.

[0066]

Figs. 4B to 4D illustrate a supply and bypass state of the first fluid and a supply and bypass state of the second fluid. In this state, the first relay flow path 21 overlaps with the first upstream flow path 11U, the first

downstream flow path 11D, and the first bypass flow path 11B. The second relay flow path 22 overlaps with the second upstream flow path 12U, the second downstream flow path 12D, and the second bypass flow path 12B. The third relay flow path 23 overlaps with the return flow path 13, the first branch flow path 131, and the second branch flow path 132. In the supply and bypass state of the first fluid and the supply and bypass state of the second fluid illustrated in Figs. 4B to 4D, the low-temperature first fluid and the high-temperature second fluid are supplied to the supply pipe portion 61. Figs. 4B to 4D are labeled "Mixing Loop" to indicate this state.

[0067]

In Fig. 4B, the supply amount of the first fluid is larger than the supply amount of the second fluid. Fig. 4B illustrates, as an example, a state in which the second valve member 20 is rotated by 11.25° from the state of Fig. 4A. In Fig. 4C, the supply amount of the first fluid and the supply amount of the second fluid are the same. Fig. 4C illustrates, as an example, a state in which the second valve member 20 is rotated by 22.5° from the state of Fig. 4A. In Fig. 4D, the supply amount of the first fluid is smaller than the supply amount of the second fluid. Fig. 4D illustrates, as an example, a state in which the second valve member 20 is rotated by 33.75° from the state of Fig. 4A.

[0068]

Fig. 4E illustrates a fully open supply state of the second fluid. In this state, the area in which the opening end of the second upstream flow path 12U and the opening end of the second downstream flow path 12D, which are open on the first surface S1, overlap with the second relay flow path 22 is maximized. The second relay flow path 22 does not overlap with the second bypass flow path 12B. The first relay flow path 21 overlaps only with the first upstream flow path 11U and the first bypass flow path 11B. The third relay flow path 23 overlaps only with the return flow path 13 and the second branch flow path 132. In the fully open supply state of the second fluid illustrated in Fig. 4E, only the high-temperature second fluid is supplied to the supply pipe portion 61. Fig. 4E is labeled "Hot Loop" to indicate this state.

[0069]

As illustrated in Figs. 2 to 4E, each of the first upstream flow path 11U, the first downstream flow path 11D, the first bypass flow path 11B, the second upstream flow path 12U, the second downstream flow path 12D, the second bypass flow path 12B, the return flow path 13, the first branch flow path 131, and the second branch flow path 132 has a fan shape extending in

an arc shape in the rotation direction of the second valve member 20. The widths of the first upstream flow path 11U, the first downstream flow path 11D, the first bypass flow path 11B, the second upstream flow path 12U, the second downstream flow path 12D, the second bypass flow path 12B, the return flow path 13, the first branch flow path 131, and the second branch flow path 132 in the radial direction orthogonal to the rotation center axis of the second valve member 20 are constant except at both ends in the rotation direction (however, they may be constant throughout the entire region).

[0070]

The first upstream flow path 11U is formed radially inside the first downstream flow path 11D and the first bypass flow path 11B. The first downstream flow path 11D and the first bypass flow path 11B are arranged in the rotation direction. The second upstream flow path 12U is formed radially inside the second downstream flow path 12D and the second bypass flow path 12B. The second downstream flow path 12D and the second bypass flow path 12B are arranged in the rotation direction. The return flow path 13 is formed radially inside the first branch flow path 131 and the second branch flow path 132. The first branch flow path 131 and the second branch flow path 132 are arranged in the rotation direction. With the arrangement as described above, it is possible to secure a large flow path area while securing as many flow paths as possible.

[0071]

The first relay flow path 21 has a shape in which a fan-shaped inner peripheral side portion overlapping with the first upstream flow path 11U and an outer peripheral side portion overlapping with the first downstream flow path 11D and/or the first bypass flow path 11B and formed radially outside the inner peripheral side portion are integrated. The inner peripheral side portion and the outer peripheral side portion extend in an arc shape in the rotation direction of the second valve member 20. A length of the inner peripheral side portion of the first relay flow path 21 in the rotation direction is larger than that of the outer peripheral side portion. The inner peripheral side portion of the first relay flow path 21 always overlaps with the first upstream flow path 11U regardless of the overlapping state between the outer peripheral side portion and the first downstream flow path 11D and/or the first bypass flow path 11B. Since the inner peripheral side portion and the outer peripheral side portion of the first relay flow path 21 have a fan shape extending in an arc shape in the rotation direction of the second valve member 20, and the first upstream flow path 11U, the first downstream flow

path 11D, and the first bypass flow path 11B similarly have a fan shape extending in an arc shape in the rotation direction of the second valve member 20, the rate of change in the flow rate is kept constant when the second valve member 20 is rotated to change the mixing ratio of the first fluid and the second fluid. The relationship between the second relay flow path 22 and the second upstream flow path 12U, the second downstream flow path 12D, and the second bypass flow path 12B, and the relationship between the third relay flow path 23 and the return flow path 13, the first branch flow path 131, and the second branch flow path 132 are similar to the relationship between the first relay flow path 21 and the first upstream flow path 11U, the first downstream flow path 11D, and the first bypass flow path 11B described above, and thus, description thereof is omitted. The configuration of the flow path in the valve device 2 is not limited to the aspect of the embodiment. For example, the first bypass flow path 11B and the second bypass flow path 12B may be omitted.

[0072]

The temperature control device 1 according to the present embodiment described above includes the valve device 2, the first fluid supply device 40 that supplies the first fluid to the valve device 2, the second fluid supply device 50 that supplies the second fluid to the valve device 2, and the supply pipe portion 61 that causes the first fluid, the second fluid, or the first fluid and the second fluid, which flow out of the valve device 2, to flow, and performs temperature control by the fluid caused to flow by the supply pipe portion 61. The valve device 2 includes the first valve member 10 and the second valve member 20 that are in contact with each other and are relatively rotatable while maintaining the contact state. Then, the first fluid, the second fluid, or the first fluid and the second fluid are supplied from the valve device 2 to the supply pipe portion 61 according to the relative rotation between the first valve member 10 and the second valve member 20.

[0073]

According to such a configuration, switching or mixing of the first fluid and the second fluid can be performed by the relative rotation between the first valve member 10 and the second valve member 20. Therefore, the size and the occupied range of the valve device 2 are suppressed by suppressing the number of parts. In addition, the switching or mixing of the first fluid and the second fluid can be performed by a single control input by relatively rotating the first valve member 10 and the second valve member 20, thereby improving the responsiveness during switching or mixing of the first

and second fluids. Furthermore, the control becomes simpler by reducing the number of control inputs. Therefore, it is possible to improve the responsiveness and accuracy of the temperature control while suppressing the size and the occupied range.

[0074]

In the plasma etching apparatus 100, the responsiveness and accuracy of the temperature control can be improved, and the footprint can be suppressed. As a result, it is possible to improve the yield of a device that requires high aspect ratio through-holes.

[0075]

Fig. 5 is a view schematically illustrating the temperature control device 1 of Fig. 1 that performs temperature control of the fluid by a refrigeration cycle device 300 of a reverse Brayton cycle and the plasma etching apparatus 100 including the temperature control device 1. The refrigeration cycle device 300 is a refrigeration cycle device of a reverse Brayton cycle that circulates a natural refrigerant (such as air or nitrogen). The refrigeration cycle device 300 is connected to the first temperature control unit 41 of the first fluid supply device 40. The first temperature control unit 41 is a heat exchanger, and cools the first fluid by exchanging heat between the first fluid and a natural refrigerant circulated by the refrigeration cycle device 300.

[0076]

The refrigeration cycle device 300 connects a compressor 301, a cooler 302, the recovery heat exchanger 303, and an expander 304 by a refrigerant circulation path 305 so that the natural refrigerant circulates in this order. A portion of the refrigerant circulation path 305 on the downstream side of the expander 304 and on the upstream side of the compressor 301 is connected to the first temperature control unit 41. The natural refrigerant, which has expanded in the expander 304 and become low in temperature, flows into the first temperature control unit 41 to cool the first fluid. In this example, the natural refrigerant flowing out of the first temperature control unit 41 passes through the recovery heat exchanger 303 before flowing into the compressor 301. As a result, the natural refrigerant flowing out of the compressor 301 and having passed through the cooler 302 is cooled, before flowing into the expander 304, by the natural refrigerant flowing out of the first temperature control unit 41. With such a configuration, the temperature of the natural refrigerant flowing out of the expander 304 can be efficiently lowered.

[0077]

The compressor 301 and the expander 304 are connected to a drive shaft 307A of a common motor 307. As a result, the compressor 301 and the expander 304 rotate in conjunction with each other by the rotation of the drive shaft 307A.

[0078]

The cooler 302 receives the cooling water from a cooling water flow device 310, and cools the high-temperature natural refrigerant flowing out of the compressor 301 with the cooling water. The cooling water flow device 310 includes a common flow path 311, and a first branch flow path 312 and a second branch flow path 313 which branch from a downstream end of the common flow path 311. The common flow path 311 causes the cooling water to flow and distributes the cooling water to the first branch flow path 312 and the second branch flow path 313.

[0079]

The first branch flow path 312 is connected to the cooler 302. The cooler 302 cools the natural refrigerant by exchanging heat between the cooling water from the first branch flow path 312 and the natural refrigerant. In this example, the second branch flow path 313 is connected to the second temperature control unit 51 of the second fluid supply device 50. The second temperature control unit 51 is a heat exchanger, and cools the second fluid by causing the second fluid to exchange heat with cooling water from the cooling water flow device 310. In such a configuration, an increase in complexity and size of the device can be suppressed by sharing the cooling source for the cooler 302 and the second fluid. The cooling water may be, for example, tap water or well water.

[0080]

In recent years, plasma etching apparatuses tend to require temperature control up to a cryogenic temperature range of, for example, -70°C or lower. The refrigeration cycle device 300 of the reverse Brayton cycle can generally perform cooling in a cryogenic temperature range with high efficiency, in other words, with a high coefficient of performance (COP). At present, in a vapor-compression refrigeration cycle device using a fluorine-based refrigerant, efficiency generally decreases when cooling in a cryogenic temperature range such as -70°C or lower is performed. In addition, there may be an increase in size due to use of three-component refrigeration system and a situation where a special refrigerant is required. Considering such a situation, the temperature control device 1 using the refrigeration cycle device 300 of the reverse Brayton cycle can be regarded as a technology capable of performing temperature control more

advantageously than a vapor-compression refrigeration cycle device in a temperature range expected to be required in the future in, for example, a plasma etching apparatus.

[0081]

Another Plasma Etching Apparatus

Fig. 6 is a view schematically illustrating another plasma etching apparatus 100' including the temperature control device 1 illustrated in Fig. 1. Elements in the configuration illustrated in Fig. 6 similar to those in the above-described embodiment are denoted by the same reference numerals, and redundant description is omitted.

[0082]

The temperature control device 1 illustrated in Fig. 6 supplies a first fluid, a second fluid, or a first fluid and a second fluid from the supply pipe portion 61 to a space between the chuck 102 and the wafer W. The temperature control device 1 illustrated in Fig. 6 uses gas as the first fluid and the second fluid. In these respects, the configuration illustrated in Fig. 6 is different from the configuration of Fig. 1. The thermal conductivity of the first fluid is different from the thermal conductivity of the second fluid. For example, one of the first fluid and the second fluid may be argon, and the other may be helium. In the plasma etching apparatus 100', the temperature of the wafer W is controlled by changing the thermal conductivity of the space between the chuck 102 and the wafer W by supplying the first fluid, the second fluid, or the first fluid and the second fluid.

[0083]

The embodiment illustrated in Fig. 6 may be incorporated in the embodiment illustrated in Fig. 1.

[0084]

Modification of Temperature Control Device

Fig. 7 is a view schematically illustrating a plasma etching apparatus 100'' including a temperature control device 1' according to a modification. Elements in the configuration illustrated in Fig. 7 similar to those in the above-described embodiment are denoted by the same reference numerals, and redundant description is omitted.

[0085]

The temperature control device 1' illustrated in Fig. 7 connects a proportional three-way valve 63 to the downstream end of the supply pipe portion 61. A first distribution pipe 64 is connected to one of the two distribution ports of the proportional three-way valve 63, and a second

distribution pipe 65 is connected to the other of the two distribution ports. A downstream end of the first distribution pipe 64 and a downstream end of the second distribution pipe 65 are connected to different flow paths of the chuck 102.

[0086]

Specifically, the first distribution pipe 64 has a fluid inlet in a portion near the center of the chuck 102, and supplies a temperature-controlled first fluid, a second fluid, or a first fluid and a second fluid into the chuck 102 via the flow path extending from the fluid inlet to the outer peripheral side. The second distribution pipe 65 has a fluid inlet in a portion near the outer periphery of the chuck 102, and supplies the temperature-controlled first fluid, the second fluid, or the first fluid and the second fluid into the chuck 102 via the flow path extending from the fluid inlet to the inner peripheral side. The fluid supplied from the first distribution pipe 64 to the portion near the center of the chuck 102 flows out of the portion near the outer periphery of the chuck 102 and returns to the valve device 2 via a first relay pipe 66. The fluid supplied from the second distribution pipe 65 to the portion near the outer periphery of the chuck 102 flows out of the portion near the center of the chuck 102 and returns to the valve device 2 via a second relay pipe 67.

[0087]

In the configuration illustrated in Fig. 7, variation in temperature control can be increased by using the proportional three-way valve 63. In particular, this example is advantageous in that variation in the temperature in the radial direction of the chuck 102 can be suppressed.

[0088]

Semiconductor Manufacturing System

Fig. 8 is a view schematically illustrating a semiconductor manufacturing system 200 including a plurality of temperature control devices 1 illustrated in Fig. 1.

[0089]

The semiconductor manufacturing system 200 includes a plurality of semiconductor manufacturing apparatuses 100a, 100b, and 100c and the above-described temperature control devices 1. However, the temperature control device 1 includes a plurality of valve devices 2, a plurality of supply pipe portions 61, and a plurality of discharge pipe portions 62.

[0090]

The first fluid supply device 40 includes a plurality of first branch pipe portions 42d functioning as the first upstream pipe portion 42, and causes

the first fluid to flow to the plurality of first branch pipe portions 42d in a branched manner. The second fluid supply device 50 includes a plurality of second branch pipe portions 52d functioning as the second upstream pipe portion 52, and causes the second fluid to flow to the plurality of second branch pipe portions 52d in a branched manner. Each of the plurality of valve devices 2 is connected to the corresponding first branch pipe portion 42d and second branch pipe portion 52d, and is connected to any one of the corresponding semiconductor manufacturing apparatuses 100a, 100b, and 100c via the corresponding supply pipe portion 61 and discharge pipe portion 62. Each of the plurality of valve devices 2 is also connected to a first branch return pipe portion 43d functioning as the first downstream pipe portion 43 and a second branch return pipe portion 53d functioning as the second downstream pipe portion 53, respectively.

[0091]

The plurality of semiconductor manufacturing apparatuses 100a, 100b, and 100c include apparatuses that perform different processes. The plurality of semiconductor manufacturing apparatuses 100a, 100b, and 100c may include, for example, a plasma etching apparatus and an ashing apparatus, or may include an apparatus that performs other processes. The plurality of valve devices 2 corresponding to the plurality of semiconductor manufacturing apparatuses that perform the same process may be synchronously controlled or may be independently controlled. The plurality of valve devices 2 corresponding to the plurality of semiconductor manufacturing apparatuses that perform different processes may be independently controlled.

[0092]

The first fluid supply device 40 controls (cools) the temperature of the first fluid by the refrigeration cycle device 300 of the reverse Brayton cycle illustrated in Fig. 5. The first fluid supply device 40 supplies the first fluid whose temperature has been controlled by the refrigeration cycle device 300 to the plurality of semiconductor manufacturing apparatuses 100a, 100b, and 100c via the plurality of valve devices 2, and uses the first fluid for temperature control of the plurality of semiconductor manufacturing apparatuses 100a, 100b, and 100c. The second fluid supply device 50 supplies the second fluid whose temperature has been controlled by the cooling water from the cooling water flow device 310 illustrated in Fig. 5 to the plurality of semiconductor manufacturing apparatuses 100a, 100b, and 100c via the plurality of valve devices 2, and uses the second fluid for temperature control of the plurality of semiconductor manufacturing

apparatuses 100a, 100b, and 100c. Note that the semiconductor manufacturing system 200 illustrated in Fig. 8 includes the plurality of semiconductor manufacturing apparatuses 100a, 100b, and 100c and the above-described temperature control device 1, but may have a configuration in which one semiconductor manufacturing apparatus and one temperature control device 1 are connected.

[0093]

Although the embodiment of the present invention has been described above, the present invention is not limited to the above-described embodiment.

Claims

[Claim 1]

A temperature control device that performs temperature control by a fluid flowing through a supply pipe portion, the device comprising: a valve device; a first fluid supply device configured to supply a first fluid to the valve device; a second fluid supply device configured to supply a second fluid to the valve device; and the supply pipe portion configured to allow the first fluid, the second fluid, or the first fluid and the second fluid flowing out of the valve device, to flow, wherein

the valve device includes a first valve member and a second valve member that are in contact with each other and are relatively rotatable while maintaining a contact state, and

the first fluid, the second fluid, or the first fluid and the second fluid are supplied from the valve device to the supply pipe portion according to the relative rotation between the first valve member and the second valve member.

[Claim 2]

The temperature control device according to claim 1, wherein

the first valve member includes a first upstream flow path, a first downstream flow path, a second upstream flow path, and a second downstream flow path, each opening on a surface facing the second valve member and a surface different from the surface facing the second valve member, respectively, the first fluid is supplied to the first upstream flow path, the second fluid is supplied to the second upstream flow path, and the supply pipe portion receives the first fluid from the first downstream flow path and the second fluid from the second downstream flow path, and

the second valve member includes:

a first relay flow path that, according to the relative rotation between the first valve member and the second valve member, overlaps with the first upstream flow path and the first downstream flow path, thereby allowing flow of the first fluid from the first upstream flow path to the first downstream flow path, and does not overlap with at least one of the first upstream flow path and the first downstream flow path, thereby blocking the flow of the first fluid from the first upstream flow path to the first downstream flow path; and

a second relay flow path that, according to the relative rotation between the first valve member and the second valve member, overlaps with

the second upstream flow path and the second downstream flow path, thereby allowing flow of the second fluid from the second upstream flow path to the second downstream flow path, and does not overlap with at least one of the second upstream flow path and the second downstream flow path, thereby blocking the flow of the second fluid from the second upstream flow path to the second downstream flow path.

[Claim 3]

A plasma etching apparatus comprising:

a chuck configured to hold a wafer; and

the temperature control device according to claim 1.

[Claim 4]

A semiconductor manufacturing system comprising:

a semiconductor manufacturing apparatus; and

the temperature control device according to claim 1.

[Claim 5]

A semiconductor manufacturing system comprising:

a plurality of semiconductor manufacturing apparatuses; and

the temperature control device according to claim 1, wherein

the temperature control device includes a plurality of the valve devices and a plurality of the supply pipe portions,

the first fluid supply device includes a plurality of first branch pipe portions and distributes the first fluid to the plurality of first branch pipe portions, and the second fluid supply device includes a plurality of second branch pipe portions and distributes the second fluid to the plurality of second branch pipe portions, and

the plurality of valve devices are connected to the corresponding first branch pipe portions and second branch pipe portions, respectively, and are connected to the corresponding semiconductor manufacturing apparatuses via the corresponding supply pipe portions.