

DESCRIPTION

Title of Invention

HEAT-MEDIUM SUPPLY APPARATUS

5 Technical Field

[0001] The present invention relates to a heat-medium supply apparatus for supplying a heat medium for regulating a temperature of semiconductor manufacturing module, such as etching module, CVD module, or PVD module.

Background Art

10 [0002] Semiconductor manufacturing module (e.g., etching module, CVD module, PVD module) for manufacturing semiconductor devices is configured to execute a manufacturing process while controlling a processing temperature. For example, in the etching module, a processing temperature of a wafer is regulated by a liquid which is a temperature-controlled heat medium flowing through a flow path formed in a susceptor
15 supporting the wafer.

[0003] FIG. 7 is a schematic diagram showing a conventional example of a heat-medium supply apparatus for supplying a heat medium to semiconductor manufacturing module. A heat-medium supply apparatus 500 includes a heating device 501 that heats a heat medium, and a cooling device 502 that cools the heat medium. The heat medium is stored
20 in a heating-side tank 504 and a cooling-side tank 505. The heat medium heated by the heating device 501 is delivered to the heating-side tank 504, and is further delivered from the heating-side tank 504 into a heat-medium mixer 507. On the other hand, the heat medium stored in the cooling-side tank 505 is delivered to the cooling device 502, and is cooled by the cooling device 502. The cooled heat medium is delivered to the heat-
25 medium mixer 507.

[0004] The heated heat medium and the cooled heat medium are mixed in the heat-medium mixer 507, so that the heat medium is regulated to have a temperature required for semiconductor manufacturing module 510. The heat medium having the regulated

temperature is delivered to the semiconductor manufacturing module 510, so that the semiconductor manufacturing module 510 is maintained at a target temperature. The heat medium that has passed through the semiconductor manufacturing module 510 is returned to the heat-medium mixer 507 and is distributed by the heat-medium mixer 507 to the heating-side tank 504 and the cooling-side tank 505. In this manner, the heat medium circulates between the heat-medium supply apparatus 500 and the semiconductor manufacturing module 510.

[0005] Since the heated heat medium and the cooled heat medium for use in regulating the temperature of the semiconductor manufacturing module 510 are mixed in the heat-medium mixer 507, a flow rate of the heat medium delivered from the heating-side tank 504 to the semiconductor manufacturing module 510 does not match a flow rate of the heat medium returning from the semiconductor manufacturing module 510 to the heating-side tank 504. Similarly, a flow rate of the heat medium delivered from the cooling-side tank 505 to the semiconductor manufacturing module 510 does not match a flow rate of the heat medium returning from the semiconductor manufacturing module 510 to the cooling-side tank 505. As a result, a difference occurs in liquid levels of the heat medium in the heating-side tank 504 and the cooling-side tank 505.

[0006] Therefore, when the difference in the liquid levels of the heat medium in the heating-side tank 504 and the cooling-side tank 505 becomes large, an on-off valve 520 is opened to move the heat medium from the heating-side tank 504 to the cooling-side tank 505, or from the cooling-side tank 505 to the heating-side tank 504. As a result, the amounts of the heat medium in the heating-side tank 504 and the cooling-side tank 505 can be balanced.

[0007] However, when the high-temperature heat medium moves from the heating-side tank 504 to the cooling-side tank 505, the temperature of the heat medium in the cooling-side tank 505 rises, and a load on the cooling device 502 increases. On the other hand, when the low-temperature heat medium moves from the cooling-side tank 505 to the heating-side tank 504, the temperature of the heat medium in the heating-side tank 504

heated by the heating device 501 drops, and heat loss occurs. Furthermore, as a result of the change in the temperature in each tank, the temperature of the heat medium supplied to the semiconductor manufacturing module 510 may change.

[0008] Therefore, in order to reduce the temperature change of the heat medium in the heating-side tank 504 and the cooling-side tank 505, it has been proposed to heat or cool the heat medium moving between the heating-side tank 504 and the cooling-side tank 505 by a heater 522 and a chiller 523 (for example, see Patent Document 1).

Citation List

Patent Literature

10 [0009] Patent document 1: Japanese laid-open patent publication No. 2023-98068

Summary of Invention

Technical Problem

[0010] However, since the heater 522 and the chiller 523 are devices using energy (mainly electricity) supplied from outside, the entire energy consumption of the heat-medium supply apparatus 500 increases. In particular, in a factory where many units of semiconductor manufacturing module 510 are arranged, reduction in energy consumption is required.

[0011] Therefore, the present invention provides a heat-medium supply apparatus capable of lowering a temperature of a heat medium moving from a heating-side tank to a cooling-side tank without using external energy. The present invention further provides a heat-medium supply apparatus capable of raising a temperature of a heat medium moving from a cooling-side tank to a heating-side tank without using external energy.

Solution to Problem

[0012] In an embodiment, there is provided a heat-medium supply apparatus for supplying a heat medium for regulating a temperature of a semiconductor manufacturing module, comprising: a heating device configured to heat the heat medium; a cooling device configured to cool the heat medium; a heating-medium delivery pipe configured to deliver the heated heat medium to the semiconductor manufacturing module; a cooling-medium

delivery pipe configured to deliver the cooled heat medium to the semiconductor manufacturing module; a heating-side tank and a cooling-side tank each configured to hold the heat medium therein; a tank communication pipe that provides fluid communication between the heating-side tank and the cooling-side tank; a heating-side return pipe
5 configured to return the heat medium that has passed through the semiconductor manufacturing module to the heating-side tank; a cooling-side return pipe configured to return the heat medium that has passed through the semiconductor manufacturing module to the cooling-side tank; a precooling heat exchanger coupled to the tank communication pipe and configured to cool the heat medium flowing through the tank communication pipe
10 from the heating-side tank toward the cooling-side tank; a precooling heat-medium supply pipe branching off from the heating-side return pipe and extending to the precooling heat exchanger; and a precooling heat-medium return pipe extending from the precooling heat exchanger and coupled to the heating-side return pipe, wherein the heating device is provided in the heating-side return pipe and is configured to heat the heat medium flowing
15 through the heating-side return pipe, a branching point of the precooling heat-medium supply pipe branching off from the heating-side return pipe is located upstream of the heating device, and the precooling heat-medium supply pipe is configured to supply the heat medium before being heated by the heating device to the precooling heat exchanger, a connection point between the precooling heat-medium return pipe and the heating-side
20 return pipe is located upstream of the heating device, and the precooling heat-medium return pipe is configured to supply the heat medium that has passed through the precooling heat exchanger to the heating device through the heating-side return pipe, and the precooling heat exchanger is configured to perform heat exchange between the heat medium flowing through the tank communication pipe from the heating-side tank toward
25 the cooling-side tank and the heat medium supplied through the precooling heat-medium supply pipe.

[0013] The precooling heat exchanger performs the heat exchange between the heat medium flowing through the tank communication pipe from the heating-side tank toward

the cooling-side tank and the heat medium that has passed through the semiconductor manufacturing module. Heat of the heat medium flowing through the tank communication pipe is recovered by the heat medium that has passed through the semiconductor manufacturing module, so that the temperature of the heat medium flowing from the heating-side tank toward the cooling-side tank can be lowered without using an external energy source. In addition, the heat medium that has recovered heat in the precooling heat exchanger is delivered to the heating device, and is heated by the heating device. Since the temperature of the heat medium that has recovered heat has already risen, a load on the heating device is reduced, and energy saving can be achieved.

10 [0014] In an embodiment, the heat-medium supply apparatus further comprises: a communication valve provided in the tank communication pipe; a precooling supply valve provided in the precooling heat-medium return pipe or the precooling heat-medium supply pipe; and an operation controller configured to control operations of the communication valve and the precooling supply valve, wherein the operation controller is configured to

15 open the precooling supply valve while the communication valve is open.

[0015] While the communication valve is open, the precooling supply valve is opened, so that the heat medium that has passed through the semiconductor manufacturing module is delivered to the precooling heat exchanger. Therefore, the heat medium flowing through the tank communication pipe is cooled in the precooling heat exchanger. As a result, the

20 high-temperature heat medium in the heating-side tank is prevented from moving to the low-temperature side tank as it is.

[0016] In an embodiment, the heat-medium supply apparatus further comprises: a heating-side return-temperature measuring device provided in the heating-side return pipe at a position upstream of the heating device; and a communication-temperature measuring

25 device provided in the tank communication pipe, wherein the operation controller is configured to open the communication valve and the precooling supply valve when a temperature of the heat medium in the heating-side return pipe measured by the heating-side return-temperature measuring device is lower than a temperature of the heat medium

in the tank communication pipe measured by the communication-temperature measuring device.

[0017] In a certain stage within a manufacturing process executed by the semiconductor manufacturing module, the heat medium may be heated by the semiconductor manufacturing module. When the heat medium that has passed through the semiconductor manufacturing module has a high temperature, the heat medium cannot cool the heat medium flowing in the tank communication pipe, and cannot recover heat. Therefore, the operation controller opens the communication valve and the precooling supply valve when the temperature of the heat medium in the heating-side return pipe is lower than the temperature of the heat medium in the tank communication pipe. By such an operation, the heat medium that has passed through the semiconductor manufacturing module can cool the heat medium flowing in the tank communication pipe, and can recover heat.

[0018] In an embodiment, the heat-medium supply apparatus further comprises: a preheating heat exchanger coupled to the tank communication pipe and configured to heat the heat medium flowing through the tank communication pipe from the cooling-side tank toward the heating-side tank; a preheating heat-medium supply pipe branching off from the cooling-side return pipe and extending to the preheating heat exchanger; and a preheating heat-medium return pipe extending from the preheating heat exchanger and coupled to the cooling-side return pipe, wherein the cooling device is provided in the cooling-side return pipe and is configured to cool the heat medium flowing through the cooling-side return pipe, a branching point of the preheating heat-medium supply pipe branching off from the cooling-side return pipe is located upstream of the cooling device, and the preheating heat-medium supply pipe is configured to supply the heat medium before being cooled by the cooling device to the preheating heat exchanger, a connection point between the preheating heat-medium return pipe and the cooling-side return pipe is located upstream of the cooling device, and the preheating heat-medium return pipe is configured to supply the heat medium that has passed through the preheating heat exchanger to the cooling device

through the cooling-side return pipe, and the preheating heat exchanger is configured to perform heat exchange between the heat medium flowing through the tank communication pipe from the cooling-side tank toward the heating-side tank and the heat medium supplied through the preheating heat-medium supply pipe.

5 [0019] The preheating heat exchanger performs the heat exchange between the heat medium flowing through the tank communication pipe from the cooling-side tank toward the heating-side tank and the heat medium that has passed through the semiconductor manufacturing module. Heat of the heat medium that has passed through the semiconductor manufacturing module is recovered by the heat medium flowing through
10 the tank communication pipe, so that the temperature of the heat medium flowing from the cooling-side tank toward the heating-side tank can be raised without using an external energy source. In addition, the heat medium whose heat has been taken in the preheating heat exchanger is delivered to the cooling device, and is cooled by the cooling device. Since the temperature of the heat medium whose heat has been taken has already dropped,
15 a load on the cooling device is reduced, and energy saving can be achieved.

[0020] In an embodiment, the semiconductor manufacturing module comprises a plurality of semiconductor manufacturing modules, and each of the heating-medium delivery pipe, the cooling-medium delivery pipe, the heating-side return pipe, and the cooling-side return pipe is coupled to the plurality of semiconductor manufacturing modules.

20 [0021] In an embodiment, there is provided a heat-medium supply apparatus for supplying a heat medium for regulating a temperature of semiconductor manufacturing module, comprising: a heating device configured to heat the heat medium; a cooling device configured to cool the heat medium; a heating-medium delivery pipe configured to deliver the heated heat medium to the semiconductor manufacturing module; a cooling-medium
25 delivery pipe configured to deliver the cooled heat medium to the semiconductor manufacturing module; a heating-side tank and a cooling-side tank each configured to hold the heat medium therein; a tank communication pipe that provides fluid communication between the heating-side tank and the cooling-side tank; a heating-side return pipe

configured to return the heat medium that has passed through the semiconductor manufacturing module to the heating-side tank; a cooling-side return pipe configured to return the heat medium that has passed through the semiconductor manufacturing module to the cooling-side tank; a preheating heat exchanger coupled to the tank communication
5 pipe and configured to heat the heat medium flowing through the tank communication pipe from the cooling-side tank toward the heating-side tank; a preheating heat-medium supply pipe branching off from the cooling-side return pipe and extending to the preheating heat exchanger; and a preheating heat-medium return pipe extending from the preheating heat exchanger and coupled to the cooling-side return pipe, wherein the cooling device is
10 provided in the cooling-side return pipe and is configured to cool the heat medium flowing through the cooling-side return pipe, a branching point of the preheating heat-medium supply pipe branching off from the cooling-side return pipe is located upstream of the cooling device, and the preheating heat-medium supply pipe is configured to supply the heat medium before being cooled by the cooling device to the preheating heat exchanger,
15 a connection point between the preheating heat-medium return pipe and the cooling-side return pipe is located upstream of the cooling device, and the preheating heat-medium return pipe is configured to supply the heat medium that has passed through the preheating heat exchanger to the cooling device through the cooling-side return pipe, and the preheating heat exchanger is configured to perform heat exchange between the heat
20 medium flowing through the tank communication pipe from the cooling-side tank toward the heating-side tank and the heat medium supplied through the preheating heat-medium supply pipe.

[0022] The preheating heat exchanger performs the heat exchange between the heat medium flowing through the tank communication pipe from the cooling-side tank toward
25 the heating-side tank and the heat medium that has passed through the semiconductor manufacturing module. Heat of the heat medium that has passed through the semiconductor manufacturing module is recovered by the heat medium flowing through the tank communication pipe, so that the temperature of the heat medium flowing from the

cooling-side tank toward the heating-side tank can be raised without using an external energy source. In addition, the heat medium whose heat has been taken in the preheating heat exchanger is delivered to the cooling device, and is cooled by the cooling device. Since the temperature of the heat medium whose heat has been taken has already dropped,
5 a load on the cooling device is reduced, and energy saving can be achieved.

[0023] In an embodiment, the heat-medium supply apparatus further comprises: a communication valve provided in the tank communication pipe; a preheating supply valve provided in the preheating heat-medium return pipe or the preheating heat-medium supply pipe; and an operation controller configured to control operations of the communication
10 valve and the preheating supply valve, wherein the operation controller is configured to open the preheating supply valve while the communication valve is open.

[0024] While the communication valve is open, the preheating supply valve is opened, so that the heat medium that has passed through the semiconductor manufacturing module is delivered to the preheating heat exchanger. Therefore, the heat medium flowing through
15 the tank communication pipe is heated in the preheating heat exchanger. As a result, the low-temperature heat medium in the cooling-side tank is prevented from moving to the high-temperature side tank as it is.

[0025] In an embodiment, the heat-medium supply apparatus further comprises: a cooling-side return-temperature measuring device provided in the cooling-side return pipe
20 at a position upstream of the cooling device; and a communication-temperature measuring device provided in the tank communication pipe, wherein the operation controller is configured to open the communication valve and the preheating supply valve when a temperature of the heat medium in the cooling-side return pipe measured by the cooling-side return-temperature measuring device is higher than a temperature of the heat medium
25 in the tank communication pipe measured by the communication-temperature measuring device.

[0026] In a certain stage within a manufacturing process executed by the semiconductor manufacturing module, the heat medium may be cooled by the semiconductor

manufacturing module. When the heat medium that has passed through the semiconductor manufacturing module has a low temperature, the heat medium cannot heat the heat medium flowing in the tank communication pipe, and the heat medium flowing in the tank communication pipe cannot recover heat from the heat medium that has passed through the semiconductor manufacturing module. Therefore, the operation controller opens the communication valve and the preheating supply valve when the temperature of the heat medium in the cooling-side return pipe is higher than the temperature of the heat medium in the tank communication pipe. By such an operation, the heat medium that has passed through the semiconductor manufacturing module can heat the heat medium flowing in the tank communication pipe, so that the heat medium flowing in the tank communication pipe can recover heat from the heat medium that has passed through the semiconductor manufacturing module.

[0027] In an embodiment, the heat-medium supply apparatus further comprises: a precooling heat exchanger coupled to the tank communication pipe and configured to cool the heat medium flowing through the tank communication pipe from the heating-side tank toward the cooling-side tank; a precooling heat-medium supply pipe branching off from the heating-side return pipe and extending to the precooling heat exchanger; and a precooling heat-medium return pipe extending from the precooling heat exchanger and coupled to the heating-side return pipe, wherein the heating device is provided in the heating-side return pipe and is configured to heat the heat medium flowing through the heating-side return pipe, a branching point of the precooling heat-medium supply pipe branching off from the heating-side return pipe is located upstream of the heating device, and the precooling heat-medium supply pipe is configured to supply the heat medium before being heated by the heating device to the precooling heat exchanger, a connection point between the precooling heat-medium return pipe and the heating-side return pipe is located upstream of the heating device, and the precooling heat-medium return pipe is configured to supply the heat medium that has passed through the precooling heat exchanger to the heating device through the heating-side return pipe, and the precooling heat exchanger is configured to

perform heat exchange between the heat medium flowing through the tank communication pipe from the heating-side tank toward the cooling-side tank and the heat medium supplied through the precooling heat-medium supply pipe.

[0028] The precooling heat exchanger performs the heat exchange between the heat medium flowing through the tank communication pipe from the heating-side tank toward the cooling-side tank and the heat medium that has passed through the semiconductor manufacturing module. Heat of the heat medium flowing through the tank communication pipe is recovered by the heat medium that has passed through the semiconductor manufacturing module, so that the temperature of the heat medium flowing from the heating-side tank toward the cooling-side tank can be lowered without using an external energy source. In addition, the heat medium that has recovered heat in the precooling heat exchanger is delivered to the heating device, and is heated by the heating device. Since the temperature of the heat medium that has recovered heat has already risen, a load on the heating device is reduced, and energy saving can be achieved.

[0029] In an embodiment, the semiconductor manufacturing module comprises a plurality of semiconductor manufacturing modules, and each of the heating-medium delivery pipe, the cooling-medium delivery pipe, the heating-side return pipe, and the cooling-side return pipe is coupled to the plurality of semiconductor manufacturing modules.

Advantageous Effects of Invention

[0030] The heat-medium supply apparatus performs the heat exchange between the heat medium flowing through the tank communication pipe and the heat medium that has passed through the semiconductor manufacturing module. Since the heat medium that has passed through the semiconductor manufacturing module is used for energy for temperature control, the heat-medium supply apparatus can lower the temperature of the heat medium moving from the heating-side tank to the cooling-side tank, or raise the temperature of the heat medium moving from the cooling-side tank to the heating-side tank, without using external energy.

Brief Description of Drawings

[0031]

[FIG. 1] FIG. 1 is a schematic diagram showing an embodiment of a semiconductor manufacturing system including a heat-medium supply apparatus and semiconductor manufacturing module.

[FIG. 2] FIG. 2 is a schematic diagram showing another embodiment of the heat-medium supply apparatus.

[FIG. 3] FIG. 3 is a schematic diagram showing still another embodiment of the heat-medium supply apparatus.

10 [FIG. 4] FIG. 4 is a schematic diagram showing still another embodiment of the heat-medium supply apparatus.

[FIG. 5] FIG. 5 is a schematic diagram showing still another embodiment of the heat-medium supply apparatus.

15 [FIG. 6] FIG. 6 is a schematic diagram showing an embodiment of a semiconductor manufacturing system including a heat-medium supply apparatus and a plurality of semiconductor manufacturing modules.

[FIG. 7] FIG. 7 is a schematic diagram showing a conventional example of a heat-medium supply apparatus supplying a heat medium to semiconductor manufacturing module.

20 **Description of Embodiments**

[0032] Hereinafter, embodiments of the present invention will be described with reference to the drawings. FIG. 1 is a schematic diagram showing an embodiment of a semiconductor manufacturing system including a heat-medium supply apparatus 1 and semiconductor manufacturing module 2. The heat-medium supply apparatus 1 is configured to supply a heat medium for regulating a temperature of the semiconductor manufacturing module 2 (for example, etching module, CVD module, PVD module, etc.) to the semiconductor manufacturing module 2.

[0033] As shown in FIG. 1, the semiconductor manufacturing system includes the heat-

medium supply apparatus 1, a heat-medium mixer 5 coupled to the heat-medium supply apparatus 1, and the semiconductor manufacturing module 2 coupled to the heat-medium mixer 5. The heat-medium supply apparatus 1 is coupled to the semiconductor manufacturing module 2 via the heat-medium mixer 5. In the embodiment shown in FIG. 1, etching module for performing a dry etching process on a wafer is used as the semiconductor manufacturing module 2, but the semiconductor manufacturing module 2 is not limited to this embodiment.

[0034] The heat-medium supply apparatus 1 includes a heating device 7 configured to heat the heat medium, a cooling device 8 configured to cool the heat medium, a heating-medium delivery pipe 11 configured to deliver the heated heat medium to the semiconductor manufacturing module 2, and a cooling-medium delivery pipe 12 configured to deliver the cooled heat medium to the semiconductor manufacturing module 2. The heating-medium delivery pipe 11 and the cooling-medium delivery pipe 12 are coupled to the heat-medium mixer 5, and communicate with the semiconductor manufacturing module 2 via the heat-medium mixer 5. The heat-medium mixer 5 includes a plurality of flow-rate regulating valves (not shown) communicating with the heating-medium delivery pipe 11 and the cooling-medium delivery pipe 12, respectively. The heat-medium mixer 5 is configured to regulate the temperature of the heat medium required for the semiconductor manufacturing module 2 by mixing the heated heat medium and the cooled heat medium while regulating a flow rate of the heated heat medium and a flow rate of the cooled heat medium.

[0035] In an embodiment, a fluorine-based inert liquid is used as the heat medium. An example of the heating device 7 includes an electric heater. Examples of the cooling device 8 include a vapor compression refrigeration machine, an absorption refrigeration machine, and the like. The vapor compression refrigeration machine includes a turbo refrigeration machine, a screw refrigeration machine, a rotary refrigeration machine, a scroll refrigeration machine, and the like, and these can be used. The configurations of the heating device 7 and the cooling device 8 are not particularly limited as long as the

heating device 7 and the cooling device 8 can heat and cool the heat medium.

[0036] The heat-medium supply apparatus 1 further includes a heating-side tank 15 and a cooling-side tank 16 each configured to hold the heat medium therein, a tank communication pipe 20 that establishes fluid communication between the heating-side tank 15 and the cooling-side tank 16, a communication valve 21 provided in the tank communication pipe 20, a heating-side return pipe 25 configured to return the heat medium that has passed through the semiconductor manufacturing module 2 to the heating-side tank 15, and a cooling-side return pipe 26 configured to return the heat medium that has passed through the semiconductor manufacturing module 2 to the cooling-side tank 16. The heating-side return pipe 25 extends from the heat-medium mixer 5 to the heating-side tank 15. The cooling-side return pipe 26 extends from the heat-medium mixer 5 to the cooling-side tank 16. The heating-medium delivery pipe 11 extends from the heating-side tank 15 to the heat-medium mixer 5. The cooling-medium delivery pipe 12 extends from the cooling-side tank 16 to the heat-medium mixer 5. A gas layer in the heating-side tank 15 and a gas layer in the cooling-side tank 16 communicate with each other through a gas-layer communication pipe 17. The gas-layer communication pipe 17 is located at a position higher than liquid levels of the heat medium in the heating-side tank 15 and the cooling-side tank 16.

[0037] The heating device 7 is provided in the heating-side return pipe 25, and is configured to heat the heat medium flowing through the heating-side return pipe 25. The heating device 7 is arranged upstream of the heating-side tank 15. The heat medium heated by the heating device 7 is delivered to the heating-side tank 15 through the heating-side return pipe 25, and is stored in the heating-side tank 15. The heat-medium supply apparatus 1 includes a heating-side liquid level detector 31 configured to detect the liquid level of the heat medium in the heating-side tank 15.

[0038] The heat-medium supply apparatus 1 includes a heating-side pump 33 coupled to the heating-medium delivery pipe 11. When the heating-side pump 33 is in operation, the heat medium (heated heat medium) in the heating-side tank 15 is delivered to the heat-

medium mixer 5 through the heating-medium delivery pipe 11, and is further delivered from the heat-medium mixer 5 to the semiconductor manufacturing module 2.

[0039] The cooling device 8 is provided in the cooling-medium delivery pipe 12, and is configured to cool the heat medium flowing through the cooling-medium delivery pipe 12.

5 The cooling device 8 is arranged downstream of the cooling-side tank 16. The heat-medium supply apparatus 1 includes a cooling-side pump 34 coupled to the cooling-medium delivery pipe 12. When the cooling-side pump 34 is in operation, the heat medium is cooled by the cooling device 8 while flowing from the cooling-side tank 16 through the cooling-medium delivery pipe 12. The cooled heat medium is delivered to
10 the heat-medium mixer 5 through the cooling-medium delivery pipe 12, and is further delivered from the heat-medium mixer 5 to the semiconductor manufacturing module 2. The heat-medium supply apparatus 1 includes a cooling-side liquid level detector 32 configured to detect the liquid level of the heat medium in the cooling-side tank 16.

[0040] The heated heat medium and the cooled heat medium are mixed by the heat-
15 medium mixer 5, so that a heat medium having a preset temperature is generated. The heat medium having the preset temperature is delivered from the heat-medium mixer 5 to the semiconductor manufacturing module 2, and heats or cools the wafer (not shown) in the semiconductor manufacturing module 2 while passing through the semiconductor manufacturing module 2. The heat medium that has passed through the semiconductor
20 manufacturing module 2 is returned to the heat-medium mixer 5, and is divided into two flows. One of the two flows flows into the heating-side return pipe 25, and the other flows into the cooling-side return pipe 26. The heat medium that has flowed into the heating-side return pipe 25 is heated by the heating device 7, and then flows into the heating-side tank 15. The heat medium that has flowed into the cooling-side return pipe 26 passes
25 through the cooling-side return pipe 26 and flows into the cooling-side tank 16.

[0041] In this manner, the heat medium circulates between the heating-side tank 15 and the semiconductor manufacturing module 2 through the heating-medium delivery pipe 11 and the heating-side return pipe 25, and simultaneously circulates between the cooling-side

tank 16 and the semiconductor manufacturing module 2 through the cooling-medium delivery pipe 12 and the cooling-side return pipe 26. As the heat medium circulates between the heat-medium supply apparatus 1 and the semiconductor manufacturing module 2, a difference occurs between the liquid level of the heat medium in the heating-side tank 15 and the liquid level of the heat medium in the cooling-side tank 16.

[0042] The heat-medium supply apparatus 1 of the present embodiment is configured to move the heat medium from the heating-side tank 15 to the cooling-side tank 16 in the following manner when the liquid level of the heat medium in the heating-side tank 15 is too high, or when the liquid level of the heat medium in the cooling-side tank 16 is too low.

[0043] The heat-medium supply apparatus 1 includes an operation controller 35 configured to control operation of the communication valve 21 provided in the tank communication pipe 20. The operation controller 35 is configured to open the communication valve 21 to allow the heat medium to move from the heating-side tank 15 to the cooling-side tank 16 through the tank communication pipe 20 when the liquid level of the heat medium in the heating-side tank 15, detected by the heating-side liquid level detector 31, exceeds a preset upper limit level, or when the liquid level of the heat medium in the cooling-side tank 16, detected by the cooling-side liquid level detector 32, falls below a preset lower limit level. Driving force for the movement of the heat medium is a difference in liquid heads between the heating-side tank 15 and the cooling-side tank 16.

[0044] The operation controller 35 includes at least one computer. The operation controller 35 includes a memory 35a in which a program is stored, and an arithmetic device 35b configured to execute arithmetic operations according to instructions included in the program. The memory 35a includes a main memory, such as a random access memory (RAM), and an auxiliary memory, such as a hard disk drive (HDD) or a solid state drive (SSD). Examples of the arithmetic device 35b include a CPU (Central Processing Unit) and a GPU (Graphic Processing Unit). However, the specific configuration of the operation controller 35 is not limited to these examples.

[0045] The operation controller 35 is configured to close the communication valve 21

when the liquid level of the heat medium in the heating-side tank 15 is lowered to a predetermined level, or when the liquid level of the heat medium in the cooling-side tank 16 rises to a predetermined level, as a result of the movement of the heat medium. The communication valve 21 is an actuator-driven valve, such as a motor-operated valve.

5 [0046] The heat-medium supply apparatus 1 is configured to cool the heat medium moving from the heating-side tank 15 to the cooling-side tank 16 through the tank communication pipe 20 when the communication valve 21 is open. More specifically, the heat-medium supply apparatus 1 includes a precooling heat exchanger 40 coupled to the tank communication pipe 20 and configured to cool the heat medium flowing through the
10 tank communication pipe 20 from the heating-side tank 15 toward the cooling-side tank 16, a precooling heat-medium supply pipe 41 branching off from the heating-side return pipe 25 and extending to the precooling heat exchanger 40, and a precooling heat-medium return pipe 42 extending from the precooling heat exchanger 40 and coupled to the heating-side return pipe 25.

15 [0047] The heat-medium supply apparatus 1 further includes a precooling supply valve 45 provided in the precooling heat-medium return pipe 42. In the present embodiment, the precooling supply valve 45 is a three-way valve, and is arranged at a connection point C1 between the precooling heat-medium return pipe 42 and the heating-side return pipe 25. The precooling supply valve 45 is an actuator-driven valve, such as a motor-operated valve.

20 In one embodiment, the precooling supply valve 45 may be a two-way valve (on-off valve). The precooling supply valve 45 is electrically coupled to the operation controller 35, and the operation of the precooling supply valve 45 is controlled by the operation controller 35.

[0048] When the operation controller 35 opens the precooling supply valve 45, the precooling heat-medium return pipe 42 communicates with the heating-side return pipe 25,
25 and as a result, at least a part of the heat medium flowing through the heating-side return pipe 25 flows into the precooling heat-medium supply pipe 41. The heat medium is delivered to the precooling heat exchanger 40 through the precooling heat-medium supply pipe 41. When the operation controller 35 closes the precooling supply valve 45, the

communication between the precooling heat-medium return pipe 42 and the heating-side return pipe 25 is shut off. As a result, the supply of the heat medium to the precooling heat exchanger 40 through the precooling heat-medium supply pipe 41 is stopped.

[0049] The precooling heat exchanger 40 is configured to perform heat exchange between the heat medium supplied through the precooling heat-medium supply pipe 41 and the heat medium flowing through the tank communication pipe 20 from the heating-side tank 15 toward the cooling-side tank 16. The heat medium flowing through the tank communication pipe 20 is the heat medium heated by the heating device 7, and has a high temperature. On the other hand, the heat medium flowing through the precooling heat-medium supply pipe 41 is a mixture of the heated heat medium and the cooled heat medium. Therefore, the temperature of the heat medium flowing through the precooling heat-medium supply pipe 41 is lower than the temperature of the heat medium flowing through the tank communication pipe 20. In the precooling heat exchanger 40, heat of the heat medium flowing through the tank communication pipe 20 is recovered by the heat medium delivered through the precooling heat-medium supply pipe 41. As a result, the temperature of the heat medium flowing through the tank communication pipe 20 drops, and thereafter, the heat medium whose temperature has dropped flows into the cooling-side tank 16.

[0050] In this manner, the precooling heat exchanger 40 can lower the temperature of the heat medium flowing from the heating-side tank 15 toward the cooling-side tank 16 without using external energy. Since an excessive temperature rise of the heat medium in the cooling-side tank 16 is prevented, a load on the cooling device 8 can be reduced, and the heat-medium supply apparatus 1 can control the temperature of the heat medium to be supplied to the semiconductor manufacturing module 2 with high accuracy.

[0051] A branching point B1 of the precooling heat-medium supply pipe 41 from the heating-side return pipe 25 is located upstream of the heating device 7, so that the precooling heat-medium supply pipe 41 supplies the heat medium before being heated by the heating device 7 to the precooling heat exchanger 40. A connection point C1 between

the precooling heat-medium return pipe 42 and the heating-side return pipe 25 is also located upstream of the heating device 7, so that the heat medium that has passed through the precooling heat exchanger 40 is supplied to the heating device 7 through the precooling heat-medium return pipe 42 and the heating-side return pipe 25. The branching point B1
5 is located upstream of the connection point C1.

[0052] The heat medium flowing through the precooling heat-medium return pipe 42 has already been heated by the heat recovery in the precooling heat exchanger 40. Therefore, the heat medium that has passed through the precooling heat-medium return pipe 42 is delivered to the heating device 7 in a state where its temperature has risen, and is further
10 heated by the heating device 7. Since the temperature of the heat medium that has recovered heat has already risen, the load on the heating device 7 is reduced, and energy saving can be achieved.

[0053] The operation controller 35 is configured to open the precooling supply valve 45 while the communication valve 21 is open. While the communication valve 21 is open,
15 the precooling supply valve 45 is opened, so that the heat medium that has passed through the semiconductor manufacturing module 2 is delivered to the precooling heat exchanger 40. Therefore, the heat medium flowing through the tank communication pipe 20 is cooled in the precooling heat exchanger 40. As a result, the high-temperature heat medium in the heating-side tank 15 is prevented from moving to the low-temperature side
20 tank as it is.

[0054] The heat-medium supply apparatus 1 further includes a heating-side return-temperature measuring device 47 provided in the heating-side return pipe 25 at a position upstream of the heating device 7, and a communication-temperature measuring device 51 provided in the tank communication pipe 20. The communication-temperature measuring
25 device 51 is arranged between the heating-side tank 15 and the communication valve 21. The heating-side return-temperature measuring device 47 and the communication-temperature measuring device 51 are electrically coupled to the operation controller 35. A measured value of the temperature of the heat medium in the heating-side return pipe 25

measured by the heating-side return-temperature measuring device 47, and a measured value of the temperature of the heat medium in the tank communication pipe 20 measured by the communication-temperature measuring device 51 are transmitted to the operation controller 35. The operation controller 35 is configured to open the communication valve 21 and the precooling supply valve 45 when the temperature of the heat medium in the heating-side return pipe 25 is lower than the temperature of the heat medium in the tank communication pipe 20.

[0055] In a certain stage within a manufacturing process performed by the semiconductor manufacturing module 2, the heat medium may be heated by the semiconductor manufacturing module 2. When the heat medium that has passed through the semiconductor manufacturing module 2 has a high temperature, the heat medium cannot cool the heat medium flowing in the tank communication pipe 20, and cannot recover heat. Therefore, the operation controller 35 opens the communication valve 21 and the precooling supply valve 45 when the temperature of the heat medium in the heating-side return pipe 25 is lower than the temperature of the heat medium in the tank communication pipe 20. By such an operation, the heat medium that has passed through the semiconductor manufacturing module 2 can cool the heat medium flowing in the tank communication pipe 20, and can recover heat.

[0056] In the embodiment shown in FIG. 1, the precooling supply valve 45 is provided in the precooling heat-medium return pipe 42, while in an embodiment, the precooling supply valve 45 may be provided in the precooling heat-medium supply pipe 41. For example, the precooling supply valve 45 may be provided at the branching point B1 of the precooling heat-medium supply pipe 41 branching off from the heating-side return pipe 25. In this configuration, when the precooling supply valve 45 is opened, the precooling heat-medium supply pipe 41 communicates with the heating-side return pipe 25, and as a result, at least a part of the heat medium flowing through the heating-side return pipe 25 flows into the precooling heat-medium supply pipe 41. When the precooling supply valve 45 is closed, the communication between the precooling heat-medium supply pipe 41 and the heating-

side return pipe 25 is shut off. As a result, the supply of the heat medium to the precooling heat exchanger 40 through the precooling heat-medium supply pipe 41 is stopped.

[0057] FIG. 2 is a schematic diagram showing another embodiment of the heat-medium supply apparatus 1. Configurations and operations of the present embodiment that are not particularly described are the same as those of the embodiment described with reference to FIG. 1, and overlapping descriptions thereof will be omitted. In the embodiment shown in FIG. 2, the precooling supply valve 45 provided in the precooling heat-medium return pipe 42 is a two-way valve (on-off valve). The precooling supply valve 45 is an actuator-driven valve, such as a motor-operated valve.

[0058] The heat-medium supply apparatus 1 includes a heating-side flow-rate restricting device 55 provided in the heating-side return pipe 25. The heating-side flow-rate restricting device 55 is arranged upstream of the heating device 7. More specifically, the heating-side flow-rate restricting device 55 is located downstream of the branching point B1 of the precooling heat-medium supply pipe 41 branching off from the heating-side return pipe 25, and located upstream of the connection point C1 between the precooling heat-medium return pipe 42 and the heating-side return pipe 25.

[0059] The heating-side flow-rate restricting device 55 is configured to restrict the flow rate of the heat medium flowing through the heating-side return pipe 25. Specific examples of the heating-side flow-rate restricting device 55 include an orifice, a flow-rate regulating valve, and the like. A part of the heat medium flowing through the heating-side return pipe 25 is delivered to the precooling heat exchanger 40 through the precooling heat-medium supply pipe 41, and the other part of the heat medium flowing through the heating-side return pipe 25 passes through the heating-side flow-rate restricting device 55 and is delivered to the heating device 7.

[0060] In this embodiment as well, the precooling heat exchanger 40 can lower the temperature of the heat medium flowing from the heating-side tank 15 toward the cooling-side tank 16 without using external energy. In addition, the heat medium that has recovered heat in the precooling heat exchanger 40 is delivered to the heating device 7, and

is heated by the heating device 7. Since the temperature of the heat medium that has recovered heat has already risen, the load on the heating device 7 is reduced, and energy saving can be achieved.

[0061] In the embodiment shown in FIG. 2, the precooling supply valve 45 is provided in the precooling heat-medium return pipe 42, while in an embodiment, the precooling supply valve 45 may be provided in the precooling heat-medium supply pipe 41. In this configuration, when the precooling supply valve 45 is opened, the precooling heat-medium supply pipe 41 communicates with the heating-side return pipe 25, and as a result, a part of the heat medium flowing through the heating-side return pipe 25 flows into the precooling heat-medium supply pipe 41. When the precooling supply valve 45 is closed, the communication between the precooling heat-medium supply pipe 41 and the heating-side return pipe 25 is shut off. As a result, the supply of the heat medium to the precooling heat exchanger 40 through the precooling heat-medium supply pipe 41 is stopped.

[0062] FIG. 3 is a schematic diagram showing another embodiment of the heat-medium supply apparatus 1. Configurations and operations of the present embodiment that are not particularly described are the same as those of the embodiment described with reference to FIG. 1, and overlapping descriptions thereof will be omitted. The heat-medium supply apparatus 1 of the embodiment shown in FIG. 3 includes, instead of the precooling heat exchanger 40, a preheating heat exchanger 60 heating the heat medium flowing through the tank communication pipe 20 from the cooling-side tank 16 toward the heating-side tank 15.

[0063] As shown in FIG. 3, the heat-medium supply apparatus 1 includes the preheating heat exchanger 60 coupled to the tank communication pipe 20, a preheating heat-medium supply pipe 61 branching off from the cooling-side return pipe 26 and extending to the preheating heat exchanger 60, and a preheating heat-medium return pipe 62 extending from the preheating heat exchanger 60 and coupled to the cooling-side return pipe 26. The cooling device 8 is provided in the cooling-side return pipe 26, and is configured to cool the heat medium flowing through the cooling-side return pipe 26. The heat medium cooled by the cooling device 8 is delivered to the cooling-side tank 16 through the cooling-

side return pipe 26, and is stored in the cooling-side tank 16.

[0064] The heat-medium supply apparatus 1 of the present embodiment is configured to allow the heat medium to move from the cooling-side tank 16 to the heating-side tank 15 in the following manner when the liquid level of the heat medium in the cooling-side tank 16 is too high, or when the liquid level of the heat medium in the heating-side tank 15 is too low.

[0065] The operation controller 35 is configured to open the communication valve 21 to allow the heat medium to move from the cooling-side tank 16 to the heating-side tank 15 through the tank communication pipe 20 when the liquid level of the heat medium in the cooling-side tank 16, detected by the cooling-side liquid level detector 32, exceeds a preset upper limit level, or when the liquid level of the heat medium in the heating-side tank 15, detected by the heating-side liquid level detector 31, falls below a preset lower limit level. Driving force for the movement of the heat medium is a difference in liquid heads between the heating-side tank 15 and the cooling-side tank 16.

[0066] The preheating heat exchanger 60 is configured to heat the heat medium moving from the cooling-side tank 16 to the heating-side tank 15 through the tank communication pipe 20 when the communication valve 21 is open. The operation controller 35 is configured to close the communication valve 21 when the liquid level of the heat medium in the cooling-side tank 16 is lowered to a predetermined level, or when the liquid level of the heat medium in the heating-side tank 15 rises to a predetermined level, as a result of the movement of the heat medium.

[0067] The heat-medium supply apparatus 1 further includes a preheating supply valve 65 provided in the preheating heat-medium return pipe 62. In the present embodiment, the preheating supply valve 65 is a three-way valve, and is arranged at a connection point C2 between the preheating heat-medium return pipe 62 and the cooling-side return pipe 26. The preheating supply valve 65 is an actuator-driven valve, such as a motor-operated valve. In an embodiment, the preheating supply valve 65 may be a two-way valve (on-off valve). The preheating supply valve 65 is electrically coupled to the operation controller 35, and

the operation of the preheating supply valve 65 is controlled by the operation controller 35.

[0068] When the operation controller 35 opens the preheating supply valve 65, the preheating heat-medium return pipe 62 communicates with the cooling-side return pipe 26, and as a result, at least a part of the heat medium flowing through the cooling-side return pipe 26 flows into the preheating heat-medium supply pipe 61. The heat medium is delivered to the preheating heat exchanger 60 through the preheating heat-medium supply pipe 61. When the operation controller 35 closes the preheating supply valve 65, the communication between the preheating heat-medium return pipe 62 and the cooling-side return pipe 26 is shut off. As a result, the supply of the heat medium to the preheating heat exchanger 60 through the preheating heat-medium supply pipe 61 is stopped.

[0069] The preheating heat exchanger 60 is configured to perform heat exchange between the heat medium supplied through the preheating heat-medium supply pipe 61 and the heat medium flowing through the tank communication pipe 20 from the cooling-side tank 16 toward the heating-side tank 15. The heat medium flowing through the tank communication pipe 20 is the heat medium that has been cooled by the cooling device 8, and has a low temperature. On the other hand, the heat medium flowing through the preheating heat-medium supply pipe 61 is the mixture of the heated heat medium and the cooled heat medium. Therefore, the temperature of the heat medium flowing through the preheating heat-medium supply pipe 61 is higher than the temperature of the heat medium flowing through the tank communication pipe 20. In the preheating heat exchanger 60, heat of the heat medium delivered through the preheating heat-medium supply pipe 61 is recovered by the heat medium flowing through the tank communication pipe 20. As a result, the temperature of the heat medium flowing through the tank communication pipe 20 rises. Thereafter, the heat medium whose temperature has risen flows into the heating-side tank 15.

[0070] In this manner, the preheating heat exchanger 60 can raise the temperature of the heat medium flowing from the cooling-side tank 16 toward the heating-side tank 15 without using external energy. Since an excessive temperature drop of the heat medium in the

heating-side tank 15 is prevented, a load on the heating device 7 can be reduced, and the heat-medium supply apparatus 1 can control the temperature of the heat medium to be supplied to the semiconductor manufacturing module 2 with high accuracy.

[0071] A branching point B2 of the preheating heat-medium supply pipe 61 branching off
5 from the cooling-side return pipe 26 is located upstream of the cooling device 8, so that the preheating heat-medium supply pipe 61 supplies the heat medium before being cooled by the cooling device 8 to the preheating heat exchanger 60. The connection point C2 between the preheating heat-medium return pipe 62 and the cooling-side return pipe 26 is also located upstream of the cooling device 8, so that the heat medium that has passed
10 through the preheating heat exchanger 60 is supplied to the cooling device 8 through the preheating heat-medium return pipe 62 and the cooling-side return pipe 26. The branching point B2 is located upstream of the connection point C2.

[0072] The heat medium flowing through the preheating heat-medium return pipe 62 has already been cooled by having its heat taken in the preheating heat exchanger 60.
15 Therefore, the heat medium that has passed through the preheating heat-medium return pipe 62 is delivered to the cooling device 8 in a state where its temperature has dropped, and is further cooled by the cooling device 8. Since the temperature of the heat medium whose heat has been taken has already dropped, the load on the cooling device 8 is reduced, and energy saving can be achieved.

[0073] The operation controller 35 is configured to open the preheating supply valve 65 while the communication valve 21 is open. While the communication valve 21 is open, the preheating supply valve 65 is opened, so that the heat medium that has passed through the semiconductor manufacturing module 2 is delivered to the preheating heat exchanger 60. Therefore, the heat medium flowing through the tank communication pipe 20 is
20 heated in the preheating heat exchanger 60. As a result, the low-temperature heat medium in the cooling-side tank 16 is prevented from moving to the high-temperature side tank as it is.

[0074] The heat-medium supply apparatus 1 further includes a cooling-side return-

temperature measuring device 67 provided in the cooling-side return pipe 26 at a position upstream of the cooling device 8, and a communication-temperature measuring device 52 provided in the tank communication pipe 20. The communication-temperature measuring device 52 is arranged between the cooling-side tank 16 and the communication valve 21.

5 The cooling-side return-temperature measuring device 67 and the communication-temperature measuring device 52 are electrically coupled to the operation controller 35. A measured value of the temperature of the heat medium in the cooling-side return pipe 26 measured by the cooling-side return-temperature measuring device 67, and a measured value of the temperature of the heat medium in the tank communication pipe 20 measured

10 by the communication-temperature measuring device 52 are transmitted to the operation controller 35. The operation controller 35 is configured to open the communication valve 21 and the preheating supply valve 65 when the temperature of the heat medium in the cooling-side return pipe 26 is higher than the temperature of the heat medium in the tank communication pipe 20.

15 [0075] In a certain stage within a manufacturing process performed by the semiconductor manufacturing module 2, the heat medium may be cooled by the semiconductor manufacturing module 2. When the heat medium that has passed through the semiconductor manufacturing module 2 has a low temperature, the heat medium cannot heat the heat medium flowing in the tank communication pipe 20, and the heat medium

20 flowing in the tank communication pipe 20 cannot recover heat from the heat medium that has passed through the semiconductor manufacturing module 2. Therefore, the operation controller 35 opens the communication valve 21 and the preheating supply valve 65 when the temperature of the heat medium in the cooling-side return pipe 26 is higher than the temperature of the heat medium in the tank communication pipe 20. By such an operation,

25 the heat medium that has passed through the semiconductor manufacturing module 2 can heat the heat medium flowing in the tank communication pipe 20, and the heat medium flowing in the tank communication pipe 20 can recover heat from the heat medium that has passed through the semiconductor manufacturing module 2.

[0076] In the embodiment shown in FIG. 3, the preheating supply valve 65 is provided in the preheating heat-medium return pipe 62, while in an embodiment, the preheating supply valve 65 may be provided in the preheating heat-medium supply pipe 61. For example, the preheating supply valve 65 may be provided at the branching point B2 of the preheating heat-medium supply pipe 61 branching off from the cooling-side return pipe 26. In this configuration, when the preheating supply valve 65 is opened, the preheating heat-medium supply pipe 61 communicates with the cooling-side return pipe 26, and as a result, at least a part of the heat medium flowing through the cooling-side return pipe 26 flows into the preheating heat-medium supply pipe 61. When the preheating supply valve 65 is closed, the communication between the preheating heat-medium supply pipe 61 and the cooling-side return pipe 26 is shut off. As a result, the supply of the heat medium to the preheating heat exchanger 60 through the preheating heat-medium supply pipe 61 is stopped.

[0077] FIG. 4 is a schematic diagram showing another embodiment of the heat-medium supply apparatus 1. Configurations and operations of the present embodiment that are not particularly described are the same as those of the embodiment described with reference to FIG. 3, and overlapping descriptions thereof will be omitted. In the embodiment shown in FIG. 4, the preheating supply valve 65 provided in the preheating heat-medium return pipe 62 is a two-way valve (on-off valve). The preheating supply valve 65 is an actuator-driven valve, such as a motor-operated valve.

[0078] The heat-medium supply apparatus 1 includes a cooling-side flow-rate restricting device 75 provided in the cooling-side return pipe 26. The cooling-side flow-rate restricting device 75 is arranged upstream of the cooling device 8. More specifically, the cooling-side flow-rate restricting device 75 is located downstream of the branching point B2 of the preheating heat-medium supply pipe 61 branching off from the cooling-side return pipe 26, and located upstream of the connection point C2 between the preheating heat-medium return pipe 62 and the cooling-side return pipe 26.

[0079] The cooling-side flow-rate restricting device 75 is configured to restrict the flow rate of the heat medium flowing through the cooling-side return pipe 26. Specific

examples of the cooling-side flow-rate restricting device 75 include an orifice, a flow-rate regulating valve, and the like. A part of the heat medium flowing through the cooling-side return pipe 26 is delivered to the preheating heat exchanger 60 through the preheating heat-medium supply pipe 61, and the other part of the heat medium flowing through the cooling-side return pipe 26 passes through the cooling-side flow-rate restricting device 75 and is delivered to the cooling device 8.

[0080] Also in the present embodiment, the preheating heat exchanger 60 can raise the temperature of the heat medium flowing from the cooling-side tank 16 toward the heating-side tank 15 without using external energy. In addition, the heat medium whose heat has been taken in the preheating heat exchanger 60 is delivered to the cooling device 8, and is cooled by the cooling device 8. Since the temperature of the heat medium whose heat has been taken has already dropped, the load on the cooling device 8 is reduced, and energy saving can be achieved.

[0081] In the embodiment shown in FIG. 4, the preheating supply valve 65 is provided in the preheating heat-medium return pipe 62, while in an embodiment, the preheating supply valve 65 may be provided in the preheating heat-medium supply pipe 61. In this configuration, when the preheating supply valve 65 is opened, the preheating heat-medium supply pipe 61 communicates with the cooling-side return pipe 26, and as a result, at least a part of the heat medium flowing through the cooling-side return pipe 26 flows into the preheating heat-medium supply pipe 61. When the preheating supply valve 65 is closed, the communication between the preheating heat-medium supply pipe 61 and the cooling-side return pipe 26 is shut off. As a result, the supply of the heat medium to the preheating heat exchanger 60 through the preheating heat-medium supply pipe 61 is stopped.

[0082] FIG. 5 is a schematic diagram showing an embodiment of the heat-medium supply apparatus 1 in which the embodiment shown in FIG. 1 and the embodiment shown in FIG. 3 are combined. The heat-medium supply apparatus 1 of the embodiment shown in FIG. 5 includes both the precooling heat exchanger 40 configured to cool the heat medium flowing through the tank communication pipe 20 from the heating-side tank 15 toward the

cooling-side tank 16, and the preheating heat exchanger 60 configured to heat the heat medium flowing through the tank communication pipe 20 from the cooling-side tank 16 toward the heating-side tank 15. Other configurations of the present embodiment that are not particularly described are the same as those of the embodiments shown in FIG. 1 and FIG. 3, and overlapping descriptions thereof will be omitted.

[0083] The present embodiment including the precooling heat exchanger 40 and the preheating heat exchanger 60 can reduce thermal fluctuations in the heating-side tank 15 and the cooling-side tank 16 accompanying the movement of the heat medium, and can reduce loads on both the heating device 7 and the cooling device 8.

[0084] The heating-side flow-rate restricting device 55 described with reference to FIG. 2, and the cooling-side flow-rate restricting device 75 described with reference to FIG. 4 can be applied to the embodiment shown in FIG. 5. The precooling supply valve 45 may be provided in the precooling heat-medium supply pipe 41. The preheating supply valve 65 may be provided in the preheating heat-medium supply pipe 61.

[0085] FIG. 6 is a schematic diagram showing another embodiment of a semiconductor manufacturing system including the heat-medium supply apparatus 1 and a plurality of semiconductor manufacturing modules 2. The heat-medium supply apparatus 1 is the heat-medium supply apparatus 1 of any one of the embodiments described with reference to FIGS. 1 to 5. As shown in FIG. 6, the heat-medium supply apparatus 1 is coupled to the plurality of semiconductor manufacturing modules 2 via a plurality of heat-medium mixers 5. More specifically, each of the heating-medium delivery pipe 11, the cooling-medium delivery pipe 12, the heating-side return pipe 25, and the cooling-side return pipe 26 of the heat-medium supply apparatus 1 is coupled to the plurality of semiconductor manufacturing modules 2 via the plurality of heat-medium mixers 5. The heat-medium supply apparatus 1 of the present embodiment can regulate processing temperatures of the plurality of semiconductor manufacturing modules 2.

[0086] The previous description of embodiments is provided to enable a person skilled in the art to make and use the present invention. Moreover, various modifications to these

embodiments will be readily apparent to those skilled in the art, and the generic principles and specific examples defined herein may be applied to other embodiments. Therefore, the present invention is not intended to be limited to the embodiments described herein but is to be accorded the widest scope as defined by limitation of the claims.

5 **Industrial Applicability**

[0087] The present invention is applicable to a heat-medium supply apparatus for supplying a heat medium for regulating a temperature of a semiconductor manufacturing module, such as etching module, CVD module, or PVD module, to the semiconductor manufacturing module.

10 **Reference Signs List**

[0088]

- | | |
|----|---------------------------------------|
| 1 | Heat-medium supply apparatus |
| 2 | Semiconductor manufacturing module |
| 5 | Heat-medium mixer |
| 15 | 7 Heating device |
| | 8 Cooling device |
| | 11 Heating-medium delivery pipe |
| | 12 Cooling-medium delivery pipe |
| | 15 Heating-side tank |
| 20 | 16 Cooling-side tank |
| | 20 Tank communication pipe |
| | 21 Communication valve |
| | 25 Heating-side return pipe |
| | 26 Cooling-side return pipe |
| 25 | 17 Gas-layer communication pipe |
| | 31 Heating-side liquid level detector |
| | 32 Cooling-side liquid level detector |
| | 33 Heating-side pump |

	34	Cooling-side pump
	35	Operation controller
	40	Precooling heat exchanger
	41	Precooling heat-medium supply pipe
5	42	Precooling heat-medium return pipe
	45	Precooling supply valve
	47	Heating-side return-temperature measuring device
	51, 52	Communication-temperature measuring device
	55	Heating-side flow-rate restricting device
10	60	Preheating heat exchanger
	61	Preheating heat-medium supply pipe
	62	Preheating heat-medium return pipe
	65	Preheating supply valve
	67	Cooling-side return-temperature measuring device
15	75	Cooling-side flow-rate restricting device
	B1, B2	Branching point
	C1, C2	Connection point

CLAIMS

[Claim 1] A heat-medium supply apparatus for supplying a heat medium for regulating a temperature of a semiconductor manufacturing module, comprising:

a heating device configured to heat the heat medium;

5 a cooling device configured to cool the heat medium;

a heating-medium delivery pipe configured to deliver the heated heat medium to the semiconductor manufacturing module;

a cooling-medium delivery pipe configured to deliver the cooled heat medium to the semiconductor manufacturing module;

10 a heating-side tank and a cooling-side tank each configured to hold the heat medium therein;

a tank communication pipe that provides fluid communication between the heating-side tank and the cooling-side tank;

a heating-side return pipe configured to return the heat medium that has passed
15 through the semiconductor manufacturing module to the heating-side tank;

a cooling-side return pipe configured to return the heat medium that has passed through the semiconductor manufacturing module to the cooling-side tank;

a precooling heat exchanger coupled to the tank communication pipe and configured to cool the heat medium flowing through the tank communication pipe from the
20 heating-side tank toward the cooling-side tank;

a precooling heat-medium supply pipe branching off from the heating-side return pipe and extending to the precooling heat exchanger; and

a precooling heat-medium return pipe extending from the precooling heat exchanger and coupled to the heating-side return pipe,

25 wherein the heating device is provided in the heating-side return pipe and is configured to heat the heat medium flowing through the heating-side return pipe,

a branching point of the precooling heat-medium supply pipe branching off from the heating-side return pipe is located upstream of the heating device, and the precooling

heat-medium supply pipe is configured to supply the heat medium before being heated by the heating device to the precooling heat exchanger,

a connection point between the precooling heat-medium return pipe and the heating-side return pipe is located upstream of the heating device, and the precooling heat-medium return pipe is configured to supply the heat medium that has passed through the precooling heat exchanger to the heating device through the heating-side return pipe, and

the precooling heat exchanger is configured to perform heat exchange between the heat medium flowing through the tank communication pipe from the heating-side tank toward the cooling-side tank and the heat medium supplied through the precooling heat-medium supply pipe.

[Claim 2] The heat-medium supply apparatus according to claim 1, further comprising:

a communication valve provided in the tank communication pipe;
a precooling supply valve provided in the precooling heat-medium return pipe or the precooling heat-medium supply pipe; and

an operation controller configured to control operations of the communication valve and the precooling supply valve,

wherein the operation controller is configured to open the precooling supply valve while the communication valve is open.

[Claim 3] The heat-medium supply apparatus according to claim 2, further comprising:

a heating-side return-temperature measuring device provided in the heating-side return pipe at a position upstream of the heating device; and

a communication-temperature measuring device provided in the tank communication pipe,

wherein the operation controller is configured to open the communication valve

and the precooling supply valve when a temperature of the heat medium in the heating-side return pipe measured by the heating-side return-temperature measuring device is lower than a temperature of the heat medium in the tank communication pipe measured by the communication-temperature measuring device.

5

[Claim 4] The heat-medium supply apparatus according to claim 1, further comprising:

a preheating heat exchanger coupled to the tank communication pipe and configured to heat the heat medium flowing through the tank communication pipe from the cooling-side tank toward the heating-side tank;

a preheating heat-medium supply pipe branching off from the cooling-side return pipe and extending to the preheating heat exchanger; and

a preheating heat-medium return pipe extending from the preheating heat exchanger and coupled to the cooling-side return pipe,

wherein the cooling device is provided in the cooling-side return pipe and is configured to cool the heat medium flowing through the cooling-side return pipe,

a branching point of the preheating heat-medium supply pipe branching off from the cooling-side return pipe is located upstream of the cooling device, and the preheating heat-medium supply pipe is configured to supply the heat medium before being cooled by the cooling device to the preheating heat exchanger,

a connection point between the preheating heat-medium return pipe and the cooling-side return pipe is located upstream of the cooling device, and the preheating heat-medium return pipe is configured to supply the heat medium that has passed through the preheating heat exchanger to the cooling device through the cooling-side return pipe, and

the preheating heat exchanger is configured to perform heat exchange between the heat medium flowing through the tank communication pipe from the cooling-side tank toward the heating-side tank and the heat medium supplied through the preheating heat-medium supply pipe.

[Claim 5] The heat-medium supply apparatus according to claim 1, wherein the semiconductor manufacturing module comprises a plurality of semiconductor manufacturing modules, and

5 each of the heating-medium delivery pipe, the cooling-medium delivery pipe, the heating-side return pipe, and the cooling-side return pipe is coupled to the plurality of semiconductor manufacturing modules.

[Claim 6] A heat-medium supply apparatus for supplying a heat medium for
10 regulating a temperature of semiconductor manufacturing module, comprising:

 a heating device configured to heat the heat medium;

 a cooling device configured to cool the heat medium;

 a heating-medium delivery pipe configured to deliver the heated heat medium to the semiconductor manufacturing module;

15 a cooling-medium delivery pipe configured to deliver the cooled heat medium to the semiconductor manufacturing module;

 a heating-side tank and a cooling-side tank each configured to hold the heat medium therein;

20 a tank communication pipe that provides fluid communication between the heating-side tank and the cooling-side tank;

 a heating-side return pipe configured to return the heat medium that has passed through the semiconductor manufacturing module to the heating-side tank;

 a cooling-side return pipe configured to return the heat medium that has passed through the semiconductor manufacturing module to the cooling-side tank;

25 a preheating heat exchanger coupled to the tank communication pipe and configured to heat the heat medium flowing through the tank communication pipe from the cooling-side tank toward the heating-side tank;

 a preheating heat-medium supply pipe branching off from the cooling-side return

pipe and extending to the preheating heat exchanger; and

a preheating heat-medium return pipe extending from the preheating heat exchanger and coupled to the cooling-side return pipe,

wherein the cooling device is provided in the cooling-side return pipe and is
5 configured to cool the heat medium flowing through the cooling-side return pipe,

a branching point of the preheating heat-medium supply pipe branching off from the cooling-side return pipe is located upstream of the cooling device, and the preheating heat-medium supply pipe is configured to supply the heat medium before being cooled by the cooling device to the preheating heat exchanger,

10 a connection point between the preheating heat-medium return pipe and the cooling-side return pipe is located upstream of the cooling device, and the preheating heat-medium return pipe is configured to supply the heat medium that has passed through the preheating heat exchanger to the cooling device through the cooling-side return pipe, and

the preheating heat exchanger is configured to perform heat exchange between the
15 heat medium flowing through the tank communication pipe from the cooling-side tank toward the heating-side tank and the heat medium supplied through the preheating heat-medium supply pipe.

[Claim 7] The heat-medium supply apparatus according to claim 6, further
20 comprising:

a communication valve provided in the tank communication pipe;

a preheating supply valve provided in the preheating heat-medium return pipe or the preheating heat-medium supply pipe; and

an operation controller configured to control operations of the communication
25 valve and the preheating supply valve,

wherein the operation controller is configured to open the preheating supply valve while the communication valve is open.

[Claim 8] The heat-medium supply apparatus according to claim 7, further comprising:

 a cooling-side return-temperature measuring device provided in the cooling-side return pipe at a position upstream of the cooling device; and

5 a communication-temperature measuring device provided in the tank communication pipe,

 wherein the operation controller is configured to open the communication valve and the preheating supply valve when a temperature of the heat medium in the cooling-side return pipe measured by the cooling-side return-temperature measuring device is higher
10 than a temperature of the heat medium in the tank communication pipe measured by the communication-temperature measuring device.

[Claim 9] The heat-medium supply apparatus according to claim 6, further comprising:

15 a precooling heat exchanger coupled to the tank communication pipe and configured to cool the heat medium flowing through the tank communication pipe from the heating-side tank toward the cooling-side tank;

 a precooling heat-medium supply pipe branching off from the heating-side return pipe and extending to the precooling heat exchanger; and

20 a precooling heat-medium return pipe extending from the precooling heat exchanger and coupled to the heating-side return pipe,

 wherein the heating device is provided in the heating-side return pipe and is configured to heat the heat medium flowing through the heating-side return pipe,

 a branching point of the precooling heat-medium supply pipe branching off from
25 the heating-side return pipe is located upstream of the heating device, and the precooling heat-medium supply pipe is configured to supply the heat medium before being heated by the heating device to the precooling heat exchanger,

 a connection point between the precooling heat-medium return pipe and the

heating-side return pipe is located upstream of the heating device, and the precooling heat-medium return pipe is configured to supply the heat medium that has passed through the precooling heat exchanger to the heating device through the heating-side return pipe, and

the precooling heat exchanger is configured to perform heat exchange between the
5 heat medium flowing through the tank communication pipe from the heating-side tank toward the cooling-side tank and the heat medium supplied through the precooling heat-medium supply pipe.

[Claim 10] The heat-medium supply apparatus according to claim 6, wherein the
10 semiconductor manufacturing module comprises a plurality of semiconductor manufacturing modules, and

each of the heating-medium delivery pipe, the cooling-medium delivery pipe, the heating-side return pipe, and the cooling-side return pipe is coupled to the plurality of semiconductor manufacturing modules.

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