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PROCESSING LIQUID SUPPLY SYSTEM, PROCESSING LIQUID SUPPLY METHOD, AND RECORDING MEDIUM

Abstract

A processing liquid supply system includes a processing liquid supply for supplying a processing liquid into a processing tub in which a substrate is immersed to be processed; a circulation path for allowing the processing liquid to flow out from the processing tub and return back into the processing tub; a pump and a flowmeter provided in the circulation path; and a controller. The controller performs: storing the processing liquid in the processing tub; filling the circulation path with the processing liquid; circulating the processing liquid through the circulation path by operating, after the filling of the circulation path, the pump such that the processing liquid reaches a predetermined initial set flow rate; and operating, after a timepoint when a measurement value of the flowmeter has reached the initial set flow rate, the pump to achieve a predetermined processing set flow rate at which the substrate is processed.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Japanese Patent Application No. 2024-021321 filed on Feb. 15, 2024, the entire disclosure of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The various aspects and embodiments described herein pertain generally to a processing liquid supply system, a processing liquid supply method, and a recording medium.

BACKGROUND

[0003] Conventionally, there is known a substrate processing apparatus configured to circulate a processing liquid through a processing tub for processing a substrate to perform various types of processes on the substrate immersed in the processing tub (see Patent Document 1).

[0004] Patent Document 1: Japanese Patent Laid-open Publication No. 2021-022707.

SUMMARY

[0005] In one or more embodiments, a processing liquid supply system includes a processing liquid supply, a circulation path, a pump, a flowmeter, and a controller. The processing liquid supply is configured to supply a processing liquid into a processing tub in which a substrate is immersed to be processed. The circulation path is configured to allow the processing liquid to flow out from the processing tub and return back into the processing tub. The pump and the flowmeter are provided in the circulation path. The controller is configured to control each component. The controller performs: storing the processing liquid in the processing tub by supplying the processing liquid from the processing liquid supply; filling the circulation path with the processing liquid by operating the pump to allow the processing liquid to flow through the circulation path; circulating the processing liquid through the circulation path by operating, after the filling of the circulation path, the pump such that the processing liquid flowing through the circulation path reaches a predetermined initial set flow rate; and operating, after a timepoint when a measurement value of the flowmeter has reached the initial set flow rate, the pump to achieve a predetermined processing set flow rate at which the substrate is processed.

[0006] The foregoing summary is illustrative only and is not intended to be any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] In the detailed description that follows, embodiments are described as illustrations only since various changes and modifications will become apparent to those skilled in the art from the following detailed description. The use of the same reference numbers in different figures indicates similar or identical items.

[0008] FIG. **1** is a block diagram illustrating a configuration example of a substrate processing apparatus according to one or more embodiments.

[0009] FIG. **2** is a diagram illustrating a configuration example of a liquid processing device according to one or more embodiments.

[0010] FIG. **3** is a diagram illustrating a configuration example of a processing liquid supply system according to one or more embodiments.

[0011] FIG. **4** is a timing chart illustrating an example sequence of a startup processing performed by the substrate processing apparatus according to one or more embodiments.

[0012] FIG. **5** is a timing chart illustrating an example sequence of a circulation processing and a temperature control processing performed by the processing liquid supply system according to one or more embodiments.

[0013] FIG. **6** is a timing chart illustrating an example sequence of the circulation processing and the temperature control processing performed by the processing liquid supply system according to one or more embodiments.

[0014] FIG. **7** is a diagram illustrating a configuration example of a processing liquid supply system according to a first modification example of one or more embodiments.

[0015] FIG. **8** is a diagram illustrating a configuration example of a processing liquid supply system according to a second modification example of one or more embodiments.

[0016] FIG. **9** is a diagram illustrating an example sequence of a control processing performed by the processing liquid supply system according to one or more embodiments.

[0017] FIG. **10** is a diagram illustrating another example sequence of the control processing performed by the processing liquid supply system according to one or more embodiments.

[0018] FIG. **11** is a diagram illustrating still another example sequence of the control processing performed by the processing liquid supply system according to one or more embodiments.

DETAILED DESCRIPTION

[0019] In the following detailed description, reference is made to the accompanying drawings, which form a part of the description. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. Furthermore, unless otherwise noted, the description of each successive drawing may reference features from one or more of the previous drawings to provide clearer context and a more substantive explanation of the current exemplary embodiment. Still, the one or more embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein and illustrated in the drawings, may be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0020] Hereinafter, exemplary embodiments of a processing liquid supply system, a processing liquid supply method, and a recording medium according to the present disclosure will be described in detail with reference to the accompanying drawings. However, the present disclosure is not limited by the exemplary embodiments to be described below. Also, it should be noted that the drawings are schematic and relations in sizes of individual components and ratios of the individual components may sometimes be different from actual values. Even between the drawings, there may exist parts having different dimensional relationships or different ratios.

[0021] Conventionally, there is known a substrate processing apparatus in which a processing liquid is circulated through a processing tub for processing a substrate to perform various types of processes on the substrate immersed in the processing tub. In this conventional technique, however, if an output of a pump alone is increased to increase a flow rate of the processing liquid sent from a circulation path back into the processing tub, there is a risk of malfunctioning of the pump.

[0022] In this regard, to overcome the aforementioned problem, there is a demand for a technique capable of increasing the flow rate of the processing liquid sent from the circulation path back into the processing tub without causing any problem in the operation of the pump.

Configuration of Substrate Processing Apparatus

[0023] First, a configuration of a substrate processing apparatus **1** including a processing liquid supply system **3** according to the present disclosure will be explained with reference to FIG. **1**.

FIG. **1** is a block diagram illustrating a configuration example of the substrate processing apparatus **1** according to one or more embodiments.
[0024] As shown in FIG. **1**, the substrate processing apparatus **1** according to the exemplary embodiment is equipped with a liquid processing device **2**, a processing liquid supply system **3**, and a control device **4**.
[0025] The liquid processing device **2** is configured to process a substrate (hereinafter, also referred to as “wafer”) such as a semiconductor wafer by using a processing liquid L (see FIG. **2**).
[0026] The processing liquid L according to the exemplary embodiment contains, by way of example, a phosphoric acid (H3PO4) aqueous solution. In the present disclosure, the phosphoric acid aqueous solution is also simply referred to as “phosphoric acid”. Further, the processing liquid L according to the exemplary embodiment may also include a silicic acid compound. This silicic acid compound can be added to the phosphoric acid aqueous solution, for example, with a solution in which colloidal silicon is dispersed.
[0027] In addition, in the present disclosure, the processing liquid L is not limited to the one containing the phosphoric acid, and any of various types of processing liquids for liquid-processing the wafer W may be employed.
[0028] The processing liquid supply system **3** is configured to supply the above-described processing liquid L to the liquid processing device **2**. A configuration example of the processing liquid supply system **3** will be described later.
[0029] The control device **4** controls the liquid processing device **2** and the processing liquid supply system **3**. The control device **4** is, for example, a computer, and includes a controller **5** and a storage **6**. The storage **6** stores therein programs for controlling various types of processes performed in the substrate processing apparatus **1**. The controller **5** controls operations of the liquid processing device **2** and the processing liquid supply system **3** by reading and executing the programs stored in the storage **6**. The functionality of the elements disclosed herein may be implemented using circuitry or processing circuitry which includes general purpose processors, special purpose processors, integrated circuits, ASICs (“Application Specific Integrated Circuits”), FPGAs (“Field-Programmable Gate Arrays”), conventional circuitry and/or combinations thereof which are programmed, using one or more programs stored in one or more memories, or otherwise configured to perform the disclosed functionality. Processors and controllers are considered processing circuitry or circuitry as they include transistors and other circuitry therein. In the disclosure, the circuitry, units, or means are hardware that carry out or are programmed to perform the recited functionality. The hardware may be any hardware disclosed herein which is programmed or configured to carry out the recited functionality. There is a memory that stores a computer program which includes computer instructions. These computer instructions provide the logic and routines that enable the hardware (e.g., processing circuitry or circuitry) to perform the method disclosed herein. This computer program can be implemented in known formats as a computer-readable storage medium, a computer program product, a memory device, a record medium such as a CD-ROM or DVD, and/or the memory of a FPGA or ASICT.
[0030] Further, these programs may be recorded on a computer-readable recording medium and installed from the recording medium into the storage **6** of the control device **4**. The computer-readable recording medium may be, by way of non-limiting example, a hard disk (HD), a flexible disk (FD), a compact disk (CD), a magnet optical disk (MO), a memory card, or the like.
[0031] The substrate processing apparatus **1** may be equipped with a plurality of liquid processing devices **2**. In this case, the substrate processing apparatus **1** may include a plurality of processing liquid supply systems **3** respectively corresponding to the plurality of liquid processing devices **2**, or may include one processing liquid supply system **3** corresponding to all the plurality of liquid processing devices **2**.
Configuration of Liquid Processing Device
[0032] Now, a configuration example of the liquid processing device **2** will be described with

reference to FIG. **2**. FIG. **2** is a diagram illustrating an example of the configuration of the liquid processing device **2** according to the exemplary embodiment.
[0033] The liquid processing device **2** shown in FIG. **2** is a batch type processing device configured to process a multiple number of wafers W (only one is shown in FIG. **2**) all at once. As depicted in FIG. **2**, the liquid processing device **2** is equipped with a processing tub **21**, a holder **22**, and a plurality of (here, four) dischargers **23**. Here, the number of the dischargers **23** included in the liquid processing device **2** is not limited to four.
[0034] The processing tub **21** includes an inner tub **21***a* and an outer tub **21***b*. The inner tub **21***a* is a box-shaped tub with an open top, and stores the processing liquid L therein. A lot composed of a plurality of wafers W is immersed in the inner tub **21***a*. The outer tub **21***b* is disposed around the inner tub **21***a*. The outer tub **21***b* also has an open top. The processing liquid L that has overflown from the inner tub **21***a* is introduced into the outer tub **21***b*.
[0035] The holder **22** is configured to hold the multiple number of wafers W forming the lot in a vertical posture. The holder **22** has an elevating mechanism (not shown) configured to move the wafers W held thereby up and down, and serves to lower the lot from above the inner tub **21***a* in the processing tub **21** to immerse it in the inner tub **21***a*, or raise the lot immersed in the inner tub **21***a* to take it out from the processing tub **21**.
[0036] The plurality of dischargers **23** are disposed inside the inner tub **21***a*, specifically, in the vicinity of a bottom of the inner tub **21***a*. The dischargers **23** are connected to the processing liquid supply system **3**, and discharge the processing liquid L supplied from the processing liquid supply system **3** into the inner tub **21***a*.
[0037] The liquid processing device **2** holds the lot with the holder **22**, and immerses the lot held thereby in the processing liquid L stored in the inner tub **21***a*. As a result, the multiple number of wafers W are processed by the processing liquid L.
[0038] For example, in the exemplary embodiment, among a silicon nitride film and a silicon oxide film formed on the wafer W, the silicon nitride film is selectively etched by the phosphoric acid aqueous solution, which is the processing liquid L.
<Configuration of processing liquid supply system>
[0039] Now, a configuration example of the processing liquid supply system **3** will be described with reference to FIG. **3**. FIG. **3** is a diagram illustrating a configuration example of the processing liquid supply system **3** according to one or more embodiments.
[0040] As depicted in FIG. **3**, the processing liquid supply system **3** includes a processing liquid supply **31** and a circulation path **32**. The processing liquid supply **31** supplies the processing liquid L to the processing tub **21**. The processing liquid supply **31** supplies unused processing liquid L to the inner tub **21***a* of the processing tub **21**, for example.
[0041] The processing liquid supply **31** has a source **31***a*, a supply path **31***b*, and a flow rate controller **31***c*. The source **31***a* is, for example, a tank that stores the processing liquid L therein. The supply path **31***b* connects the source **31***a* to the inner tub **21***a*, allowing the processing liquid L to be supplied from the source **31***a* to the inner tub **21***a*. Also, the supply path **31***b* may be connected to the outer tub **21***b*.
[0042] The flow rate controller **31***c* is provided in the supply path **31***b*, and serves to adjust the amount of the processing liquid L supplied to the processing tub **21**. The flow rate controller **31***c* is composed of, by way of example, an opening/closing valve, a flow control valve, a flowmeter, and so forth.
[0043] The circulation path **32** is connected to the liquid processing device **2** to supply the processing liquid L to the liquid processing device **2**. The circulation path **32** is a circulation line through which the processing liquid L flowing out from the processing tub **21** is returned back into the processing tub **21**.
[0044] Specifically, one end of the circulation path **32** is connected to multiple positions (two positions in FIG. **3**) at a bottom of the outer tub **21***b*, and the other end of the circulation path **32** is

connected to the plurality of dischargers **23** located inside the inner tub **21***a*. In the processing liquid supply system **3**, the processing liquid L sent from the outer tub **21***b* into the circulation path **32** passes through the circulation path **32** and is then supplied from the dischargers **23** into the inner tub **21***a*.

[0045] Furthermore, the processing liquid L supplied from the dischargers **23** into the inner tub **21***a* overflows from the inner tub **21***a* into the outer tub **21***b*. In this way, the circulation path **32** allows the processing liquid L to be circulated between the inner tub **21***a* and the outer tub **21***b*.

[0046] The circulation path **32** is provided with a pump **33**, a pressure gauge **34**, a check valve **35**, a heater **36**, a filter **37**, a branching portion **38**, and a flowmeter **39** in this order from the upstream side with respect to the processing tub **21**.

[0047] The pump **33** forms a circulating flow of the processing liquid L that comes out from the processing tub **21**, passes through the circulation path **32**, and returns back into the processing tub **21**. The pump **33** is, by way of non-limiting example, a magnetic levitation pump configured to force-feed the processing liquid L as a rotator thereof is rotated in the processing liquid L while being magnetically levitated. However, the pump **33** of the present disclosure is not limited to the magnetic levitation pump, and may be, by way of example, a diaphragm pump or the like.

[0048] Meanwhile, since the magnetic levitation pump, which has higher liquid feeding capacity than other types of pumps, is used for the pump **33**, the feed flow rate of the processing liquid L returned from the circulation path **32** into the processing tub **21** can be increased.

[0049] The pressure gauge **34** measures the pressure of the processing liquid L flowing through the circulation path **32**. A measurement value of the pressure of the processing liquid L measured by the pressure gauge **34** is outputted to the controller **5** (see FIG. **1**). The check valve **35** suppresses a backflow of the processing liquid L flowing through the circulation path **32**. The check valve **35** is, by way of non-limiting example, an air-operated valve.

[0050] The heater **36** heats the processing liquid L flowing through the circulation path **32**. In this exemplary embodiment, by heating the processing liquid L with this heater **36**, the processing liquid L stored in the processing tub **21** is heated up to a processing set temperature AS (see FIG. **5**) (for example, about 160° C. to 170° C.) required for processing the wafer W.

[0051] The filter **37** is configured to remove contaminants such as particles contained in the processing liquid L flowing through the circulation path **32**. The filter **37** may include a plurality of filter modules arranged in parallel.

[0052] The number of the filter modules belonging to the single filter **37** may be decided in consideration of filtration ability required for the filter **37**, a pressure drop allowed in the filter **37**, and so forth. In the present disclosure, the filter **37** is composed of two filter modules arranged in parallel, as illustrated in FIG. **3**.

[0053] A branch path **41** leading to the outer tub **21***b* of the processing tub **21** is branched off from the branching portion **38**. The flowmeter **39** measures the flow rate of the processing liquid L flowing through the circulation path **32**. A measurement value of the flow rate of the processing liquid L measured by the flowmeter **39** is outputted to the controller **5**.

[0054] The branch path **41** is a flow path for sampling the concentration of the processing liquid L flowing through the circulation path **32**. A flowmeter **42**, a concentration meter **43**, and a valve **44** are provided in this branch path **41** in this order from the upstream side with respect to the branching portion **38**.

[0055] The flowmeter **42** measures the flow rate of the processing liquid L flowing through the branch path **41**. A measurement value of the flow rate of the processing liquid L measured by the flowmeter **42** is outputted to the controller **5**.

[0056] The concentration meter **43** measures the concentration of the processing liquid L flowing through the branch path **41**, which reflects the concentration of the processing liquid L flowing through the circulation path **32**. The concentration meter **43** measures, for example, a phosphoric acid concentration of the processing liquid L flowing through the branch path **41**. A measurement value of the concentration of the processing liquid L measured by the concentration meter **43** is outputted to the controller **5**. The valve **44** controls whether or not the processing liquid L is to be supplied from the branching portion **38** to the outer tub **21***b*.

[0057] The processing liquid supply system **3** is also equipped with a thermometer **45**. The thermometer **45** measures the temperature of the processing liquid L flowing through the circulation path **32** by measuring the temperature of the processing liquid L stored in the processing tub **21**. The thermometer **45** measures the temperature of the processing liquid L stored in the inner tub **21***a*, for example. A measurement value of the temperature of the processing liquid L measured by the thermometer **45** is outputted to the controller **5**.

[0058] Furthermore, the thermometer **45** of the present disclosure is not limited to measuring the temperature of the processing liquid L stored in the inner tub **21***a*, but may be configured to measure the temperature of the processing liquid L stored in the outer tub **21***b* or to measure the temperature of the processing liquid L flowing through the circulation path **32**.

Details of Startup Processing

[0059] Now, details of a startup processing of the substrate processing apparatus **1** according to one or more embodiments will be described with reference to FIG. **4** to FIG. **6**. FIG. **4** is a timing chart showing an example sequence of the startup processing performed by the substrate processing apparatus **1** according to the embodiment.

[0060] First, the controller **5** (see FIG. **1**) performs a draining processing of draining all the processing liquid L used (see FIG. **3**) from the inner tub **21***a* (see FIG. **3**) and the outer tub **21***b* (see FIG. **3**) of the processing tub **21** (see FIG. **3**) from time T**01**.

[0061] Next, from time T**02** when the draining processing is completed, the controller **5** performs a storage processing of replenishing the inner tub **21***a* and the outer tub **21***b* of the processing tub **21** with the processing liquid L unused. Specifically, the controller **5** first supplies the processing liquid L from the processing liquid supply **31** (see FIG. **3**) to the inner tub **21***a*, filling the inner tub **21***a* with the processing liquid L.

[0062] Next, the controller **5** further supplies the processing liquid L from the processing liquid supply **31** into the inner tub **21***a*, thus allowing the processing liquid L overflowing from the inner tub **21***a* to be supplied into the outer tub **21***b*. Then, at time T**04** when the liquid level of the processing liquid L supplied to the outer tub **21***b* reaches a predetermined second height, the controller **5** ends the storage processing.

[0063] The controller **5** performs a circulation processing of circulating the processing liquid L through the circulation path **32** (see FIG. **3**) from time T**03** when the liquid level of the processing liquid L supplied into the outer tub **21***b* reaches a preset first height, which is lower than the second height. During this circulation processing, from time T**05** when the processing liquid L meets a condition to be described below, the controller **5** performs a temperature control processing of adjusting the temperature of the processing liquid L to a preset processing set temperature AS (see FIG. **5**).

[0064] Details of these circulation processing and temperature control processing will be discussed with reference to FIG. **5** and FIG. **6**. FIG. **5** and FIG. **6** are timing charts illustrating example sequences of the circulation processing and the temperature control processing performed by the processing liquid supply system **3** according to one or more embodiments.

[0065] As shown in FIG. **5**, as an initial process in the circulation processing, the controller **5** (see FIG. **1**) operates the pump **33** (see FIG. **3**) from the aforementioned time T**03** to allow the processing liquid L (see FIG. **3**) to flow through the circulation path **32** (see FIG. **3**), thereby performing a charging processing of filling the circulation path **32** with the processing liquid L.

[0066] In addition, when a magnetic levitation pump is used for the pump **33**, there are two types of operation modes for the pump **33**: a flow rate feedback control (referred to as “flow rate FB control” in the accompanying drawings) and a rotation speed control.

[0067] In flow rate feedback control, the rotation speed of the rotator inside the pump **33** is

automatically controlled so that a flow rate measurement value of the processing liquid L measured by the flowmeter **39** (see FIG. **3**) reaches a designated flow rate.
[0068] By way of example, in the flow rate feedback control, if the flow rate measurement value of the processing liquid L is lower than the designated flow rate, the pump **33** increases the rotation speed of the rotator. On the other hand, in the flow rate feedback control, if the flow rate measurement value of the processing liquid L is higher than the designated flow rate, the pump **33** reduces the rotation speed of the rotator.
[0069] In the rotation speed control, the rotation speed of the rotator of the pump **33** is controlled to a specified rotation speed.
[0070] In the charging processing according to one or more embodiments, the controller **5** operates the pump **33** under the rotation speed control, as shown in FIG. **5**. Furthermore, in the charging processing, the controller **5** operates the pump **33** at a specified rotation speed RS.
[0071] In this way, by operating the pump **33** under the rotation speed control during the charging processing, the pump **33** can be operated stably even when the circulation path **32** is not filled with the processing liquid L, the measurement value of the flowmeter **39** is unstable, and the flow rate feedback control is difficult to perform. Therefore, according to one or more embodiments, the circulation path **32** can be stably filled with the processing liquid L.
[0072] In addition, in one or more embodiments, during the charging processing, the pump **33** needs to be operated at the rotation speed RS at which the measurement value of the flowmeter **39** becomes equal to or greater than a minimum circulation flow rate FL and cavitation does not occur inside the pump **33**. This allows the circulation path **32** to be stably filled with the processing liquid L.
[0073] Furthermore, as shown in FIG. **5**, the charging processing according to one or more embodiments needs to be carried out for a predetermined period P**1** from the time T**03** as long as the circulation path **32** can be sufficiently filled with processing liquid L. This allows the circulation path **32** to be filled with processing liquid L more reliably.
[0074] Also, in one or more embodiments, a concentration measurement value of the processing liquid L measured by the concentration meter **43** (see FIG. **3**) before and after the start of the charging processing is stabilized at an initial concentration C**0** supplied from the processing liquid supply **31** (see FIG. **3**), as shown in FIG. **5**.
[0075] Likewise, a temperature measurement value of the processing liquid L measured by the thermometer **45** (see FIG. **3**) before and after the start of the charging processing is stabilized at an initial temperature A**0** supplied from the processing liquid supply **31**.
[0076] Following the charging processing described so far, the controller **5** performs a stop processing of stopping the pump **33** (that is, setting the rotation speed of the rotator to zero) from time T**11** to stop the circulation of the processing liquid L in the circulation path **32** in the circulation processing according to one or more embodiments. The time T**11** is the time upon the lapse of the predetermined period P**1** from the time T**03**. As a result, the measurement value of the flowmeter **39** becomes zero, as shown in FIG. **5**.
[0077] Thereafter, in the circulation processing according to one or more embodiments, the controller **5** performs, from time T**12**, a first circulation processing of circulating the processing liquid L so that the processing liquid L (see FIG. **3**) flowing through the circulation path **32** (see FIG. **3**) reaches a predetermined initial set flow rate F**1**, as shown in FIG. **6**. Here, the time T**12** is the time upon the lapse of a predetermined period from the time T**11** (see FIG. **5**). Further, the initial set flow rate F**1** is a value larger than the minimum circulation flow rate FL.
[0078] To perform this first circulation processing, the controller **5** (see FIG. **1**) switches the operation mode of the pump **33** (see FIG. **3**) from the rotation speed control to the flow rate feedback control.
[0079] In the first circulation processing, the controller **5** operates the pump **33**, while setting the set flow rate of the processing liquid L in the circulation path **32** to the initial set flow rate F**1**. As a

result, the measurement value of the flowmeter **39** gradually increases from zero, as shown in FIG. **6**.
[0080] Furthermore, in the present exemplary embodiment, from the time T**05** after the start of the first circulation processing, the controller **5** operates the heater **36** (see FIG. **3**) to perform the temperature control processing for the processing liquid L. This time T**05** is the time upon the lapse of a predetermined period P**2** from time T**13** when the measurement value of the flowmeter **39** reaches the minimum circulation flow rate FL.
[0081] In this way, instead of operating the heater **36** immediately after the minimum circulation flow rate FL is reached, by allowing a margin of the period P**2** before operating the heater **36**, it is possible to operate the heater **36** after securing a sufficient circulation flow rate in the circulation path **32**.
[0082] Therefore, according to one or more embodiments, it is possible to suppress a problem that might be caused by operating the heater **36** when the flow rate in the circulation path **32** is not sufficient.
[0083] In one or more embodiments, the measurement value of the thermometer **45** gradually rises from the temperature A**0** from the time T**05** when the temperature control processing is begun. Further, in one or more embodiments, as the processing liquid L overflows from the inner tub **21***a* into the outer tub **21***b* and the temperature of the processing liquid L increases, the moisture in the processing liquid L evaporates from the processing tub **21**, so that the measurement value of the concentration meter **43** gradually rises from the concentration C**0**.
[0084] Then, in the present exemplary embodiment, after a timepoint (time T**14** in the example of FIG. **6**) when the measurement value of the flowmeter **39** reaches the initial set flow rate F**1**, the controller **5** performs a second circulation processing in which the pump **33** is operated so that the flow rate in the circulation path **32** reaches a preset processing set flow rate F**2** for processing the wafer W. This processing set flow rate F**2** is a value larger than the initial set flow rate F**1**.
[0085] That is, in the circulation processing according to one or more embodiments, the pump **33** is operated so that the flow rate in the circulation path **32** reaches the processing set flow rate F**2** after the flow rate in the circulation path **32** is first stabilized to the initial set flow rate F**1**.
[0086] As a result, as compared to a case where the pump **33** is operated so that the flow rate in the circulation path **32** increases from zero to the processing set flow rate F**2** at once, it is possible to suppress cavitation from occurring in the pump **33** even if the flow rate of the processing liquid L is increased.
[0087] Therefore, according to one or more embodiments, the flow rate of the processing liquid L sent from the circulation path **32** back into the processing tub **21** can be increased.
[0088] Furthermore, in the present exemplary embodiment, the controller **5** may start the second circulation processing when the measurement value of the flowmeter **39** becomes the initial set flow rate F**1** and the measurement value of the concentration meter **43** reaches a predetermined concentration range.
[0089] By way of example, in one or more embodiments, the second circulation processing may be started when the measurement value of the concentration meter **43** falls between a preset lower limit concentration CTL, which is lower than a processing set concentration CS for processing the wafer W, and a preset upper limit concentration CTH, which is higher than the processing set concentration CS.
[0090] This allows the pump **33** to be operated to achieve the processing set flow rate F**2** after the viscosity of the processing liquid L is brought close to a viscosity level for processing of the wafer W. Thus, even if the flow rate of the processing liquid L is increased, occurrence of cavitation inside the pump **33** can be further suppressed.
[0091] Therefore, according to the present exemplary embodiment, the flow rate of the processing liquid L sent from the circulation path **32** back into the processing tub **21** can be stably increased.
[0092] In addition, in the present exemplary embodiment, the controller **5** may start the second

circulation processing when the measurement value of the flowmeter **39** reaches the initial set flow rate F**1** and the measurement value of the thermometer **45** falls within a predetermined temperature range.
[0093] By way of example, in one or more embodiments, the second circulation processing may be started when the measurement value of the thermometer **45** falls between a preset lower limit temperature ATL, which is lower than the processing set temperature AS for processing the wafer W, and a preset upper limit temperature ATH, which is higher than the processing set temperature AS.
[0094] This allows the pump **33** to be operated to achieve the processing set flow rate F**2** after the viscosity of the processing liquid L is made closer to the viscosity level for processing the wafer W. Thus, even if the flow rate of the processing liquid L is increased, occurrence of cavitation inside the pump **33** can be further suppressed.
[0095] Therefore, according to the present exemplary embodiment, the flow rate of the processing liquid L sent from the circulation path **32** back into the processing tub **21** can be stably increased.
[0096] Furthermore, in one or more embodiments, the second circulation processing may be started from time T**15** when the measurement value of the flowmeter **39** has reached the initial set flow rate F**1**, the measurement value of the concentration meter **43** has reached the predetermined concentration range, and the measurement value of the thermometer **45** has reached the predetermined temperature range.
[0097] This allows the pump **33** to be operated to achieve the processing set flow rate F**2** after the viscosity of the processing liquid L is made further closer to the viscosity level for processing the wafer W. Thus, even if the flow rate of the processing liquid L is increased, occurrence of cavitation inside the pump **33** can be further suppressed.
[0098] Therefore, according to the present exemplary embodiment, the flow rate of the processing liquid L sent from the circulation path **32** back into the processing tub **21** can be stably increased.
[0099] In the example of FIG. **6**, the controller **5** starts the second circulation processing from the aforementioned time T**15**, and gradually increases the set flow rate of the pump **33** from the time T**15** to time T**16**. The time T**16** is the time upon the lapse of a predetermined period P**3** from the time T**15**.
[0100] Then, the controller **5** sets the set flow rate of the pump **33** to the processing set flow rate F**2** for processing the wafer W at the time T**16**. As a result, the measurement value of the flowmeter **39** becomes the processing set flow rate F**2** for processing the wafer W, the measurement value of the concentration meter **43** becomes the processing set concentration CS for processing the wafer W, and the measurement value of the thermometer **45** becomes the processing set temperature AS for processing the wafer W. Then, the series of processes of the startup processing are completed.
[0101] In the present exemplary embodiment, by gradually increasing the set flow rate of the pump **33** from the time T**15** to the time T**16**, a rapid change in the flow rate in the circulation path **32** can be suppressed. Thus, according to the present exemplary embodiment, it is possible to suppress occurrence of cavitation inside the pump **33**.
First Modification Example
[0102] Now, the processing liquid supply system **3** according to a first modification example of one or more embodiments and a startup processing using this processing liquid supply system **3** will be explained with reference to FIG. **7** in addition to FIG. **5** and FIG. **6** described above. FIG. **7** is a diagram illustrating a configuration example of the processing liquid supply system **3** according to the first modification example of one or more embodiments.
[0103] The first modification example shown in FIG. **7** is different from the above-described exemplary embodiment in the configuration of the circulation path **32**. Specifically, in this first modification example, multiple circulation paths **32** (two in the example of FIG. **7**) are provided for the single processing tub **21**. With this configuration, it is possible to increase the flow rate of the processing liquid L returned back into the processing tub **21** from the circulation path **32**, as

compared to the case where only one circulation path **32** is provided for the single processing tub **21**.

[0104] The circulation path **32** according to the first modification example includes circulation paths **32**A and **32**B. Each of the circulation paths **32**A and **32**B is connected to the liquid processing device **2** to supply the processing liquid L to the liquid processing device **2**. Each of the circulation paths **32**A and **32**B is a circulation line through which the processing liquid L flows out from the processing tub **21** and returns back into the processing tub **21**.

[0105] To elaborate, one end of each of the circulation paths **32**A and **32**B is connected to the bottom of the outer tub **21***b*, and the other end of each of the circulation paths **32**A and **32**B is connected to the plurality of dischargers **23** located inside the inner tub **21***a*.

[0106] In the processing liquid supply system **3**, the processing liquid L sent from the outer tub **21***b* to the circulation paths **32**A and **32**B passes through the circulation paths **32**A and **32**B and is then supplied into the inner tub **21***a* from the dischargers **23**.

[0107] Furthermore, the processing liquid L supplied from the dischargers **23** to the inner tub **21***a* overflows from the inner tub **21***a* into the outer tub **21***b*. In this way, the circulation paths **32**A and **32**B circulate the processing liquid L between the inner tub **21***a* and the outer tub **21***b*.

[0108] The circulation path **32**A is provided with a pump **33**A, a pressure gauge **34**A, a check valve **35**A, a heater **36**A, a filter **37**A, and a flowmeter **39**A in this order from the upstream side with respect to the processing tub **21**.

[0109] The pump **33**A forms a circulation flow of the processing liquid L that comes out from the processing tub **21**, passes through the circulation path **32**A, and then returns back into the processing tub **21**. The pump **33**A is, for example, a magnetic levitation pump. However, it should be noted that the pump **33**A of the present disclosure is not limited to the magnetic levitation pump, and may be a diaphragm pump, or the like.

[0110] The pressure gauge **34**A measures the pressure of the processing liquid L flowing through the circulation path **32**A. A measurement value of the pressure of the processing liquid L measured by the pressure gauge **34**A is outputted to the controller **5** (see FIG. **1**). The check valve **35**A suppresses a backflow of the processing liquid L flowing through the circulation path **32**A. The check valve **35**A is, by way of non-limiting example, an air-operated valve.

[0111] The heater **36**A heats the processing liquid L flowing through the circulation path **32**A. In the first modification example, by heating the processing liquid L with the heater **36**A, the processing liquid L stored in the processing tub **21** is heated up to the processing set temperature AS (see FIG. **5**) required for processing the wafer W.

[0112] The filter **37**A removes contaminants such as particles contained in the processing liquid L flowing through the circulation path **32**A. The filter **37**A may include multiple filter modules arranged in parallel.

[0113] The flowmeter **39**A measures the flow rate of the processing liquid L flowing through the circulation path **32**A. A measurement value of the flow rate of the processing liquid L measured by the flowmeter **39**A is outputted to the controller **5**.

[0114] The circulation path **32**B is provided with a pump **33**B, a pressure gauge **34**B, a check valve **35**B, a heater **36**B, a filter **37**B, the branching portion **38**, and a flowmeter **39**B in this order from the upstream side with respect to the processing tub **21**.

[0115] The pump **33**B forms a circulation flow of the processing liquid L that flows out from the processing tub **21**, passes through the circulation path **32**B, and then returns back into the processing tub **21**. The pump **33**B is, for example, a magnetic levitation pump configured to force-feed the processing liquid L as a rotator thereof is rotated in the processing liquid L while being magnetically levitated. However, the pump **33**B of the present disclosure is not limited to the magnetic levitation pump, and may be a diaphragm pump or the like.

[0116] The pressure gauge **34**B measures the pressure of the processing liquid L flowing through the circulation path **32**B. A measurement value of the pressure of the processing liquid L measured by the pressure gauge **34**B is outputted to the controller **5**. The check valve **35**B suppresses a backflow of the processing liquid L flowing through the circulation path **32**B. The check valve **35**B is, by way of non-limiting example, an air-operated valve.

[0117] The heater **36**B heats the processing liquid L flowing through the circulation path **32**B. In the first modification example, by heating the processing liquid L with this heater **36**B, the processing liquid L stored in the processing tub **21** is heated up to the processing set temperature AS required for processing the wafer W.

[0118] The filter **37**B removes contaminants such as particles contained in the processing liquid L flowing through the circulation path **32**B. The filter **37**B may include multiple filter modules arranged in parallel.

[0119] The branch path **41** that leads to the outer tub **21***b* of the processing tub **21** is branched off from the branching portion **38**. The flowmeter **39**B measures the flow rate of the processing liquid L flowing through the circulation path **32**B. A measurement value of the flow rate of the processing liquid L measured by the flowmeter **39**B is outputted to the controller **5**.

[0120] The branch path **41** is a flow path for sampling the concentration of the processing liquid L flowing through the circulation path **32**B. This branch path **41** is provided with the flowmeter **42**, the concentration meter **43**, and the valve **44** in this order from the upstream side with respect to the branching portion **38**.

[0121] The flowmeter **42** measures the flow rate of the processing liquid L flowing through the branch path **41**. A measurement value of the flow rate of the processing liquid L measured by the flowmeter **42** is outputted to the controller **5**.

[0122] The concentration meter **43** measures the concentration of the processing liquid L flowing through the branch path **41** to measure the concentration of the processing liquid L flowing through the circulation path **32**. The concentration meter **43** measures, for example, a phosphoric acid concentration of the processing liquid L flowing through the branch path **41**. A measurement value of the concentration of the processing liquid L measured by the concentration meter **43** is outputted to the controller **5**. The valve **44** controls whether or not the processing liquid L is to be supplied from the branching portion **38** to the outer tub **21***b*.

[0123] Now, details of the startup processing of the substrate processing apparatus **1** using the processing liquid supply system **3** according to the first modification example will be explained with reference to FIG. **5** and FIG. **6**.

[0124] As shown in FIG. **5**, the controller **5** (see FIG. **1**) operates the pumps **33**A and **33**B (see FIG. **7**) as a circulation processing from the time T**03**, which is the same as in the above-described exemplary embodiment. Thus, the controller **5** allows the processing liquid L (see FIG. **7**) to flow through the circulation paths **32**A and **32**B (see FIG. **7**), thereby performing a charging processing of filling the circulation paths **32**A and **32**B with the processing liquid L.

[0125] In the charging processing according to the first modification example, the controller operates the pumps **33**A and **33**B, which are magnetic levitation pumps, under a rotation speed control, as shown in FIG. **5**. Also, the controller **5** operates the pumps **33**A and **33**B at the predetermined rotation speed Rs in the charging processing.

[0126] In this way, by operating the pumps **33**A and **33**B under the rotation speed control in the charging processing, the pumps **33**A and **33**B can be stably operated even when the circulation paths **32**A and **32**B are not filled with the processing liquid L and thus a flow rate feedback control is difficult to perform. Therefore, according to the first modification example, the circulation paths **32**A and **32**B can be stably filled with the processing liquid L.

[0127] Further, in the first modification example, the pumps **33**A and **33**B need to be operated at the rotation speed Rs at which the measurement values of the flowmeters **39**A and **39**B (see FIG. **7**) become equal to or greater than the minimum circulation flow rate FL and cavitation does not occur inside the pumps **33**A and **33**B in the charging processing. This allows the circulation paths **32**A and **32**B to be stably filled with the processing liquid L.

[0128] Furthermore, the charging processing according to the first modification example needs to be carried out from the time T**03** for the period P**1**, which is confirmed in advance as being sufficient to fill both of the circulation paths **32**A and **32**B with the processing liquid L, as shown in FIG. **5**. This allows the circulation paths **32**A and **32**B to be filled with the processing liquid L more reliably.
[0129] Following the charging processing described so far, the controller **5** performs a stop processing of stopping the pumps **33**A and **33**B from the time T**11**, which is the same as in the above-described exemplary embodiment, thereby stopping the circulation of the processing liquid L in the circulation paths **32**A and **32**B in the circulation processing according to the first modification example. As a result, measurement values obtained by the flowmeters **39**A and **39**B become zero, as shown in FIG. **5**.
[0130] In this way, in the circulation processing according to the first modification example, by performing the stop processing of stopping the circulation of the processing liquid L after the charging processing, both of the circulation paths **32**A and **32**B can be brought into a state in which a circulation flow rate therein is zero. Therefore, according to the first modification example, the circulation flow can be started up in the state that the flow rates in the circulation paths **32**A and **32**B are the same.
[0131] Next, in the circulation processing according to the first modification example, the controller **5** performs, from the time T**12**, which is the same as in the above-described exemplary embodiment, a first circulation processing of circulating the processing liquid L such that the processing liquid L (see FIG. **7**) flowing through both the circulation paths **32**A and **32**B (see FIG. **7**) reaches the initial set flow rate F**1**, as shown in FIG. **6**.
[0132] To carry out this first circulation processing, the controller **5** (see FIG. **1**) switches the operation mode of the pumps **33**A and **33**B (see FIG. **7**) from a rotation speed control to a flow rate feedback control.
[0133] Then, in the first circulation processing, the controller **5** operates the pumps **33**A and **33**B, while setting the set flow rates of the processing liquid L in the circulation paths **32**A and **32**B to the initial set flow rate F**1**. As a result, as shown in FIG. **6**, the measurement values of the flowmeters **39**A and **39**B (see FIG. **7**) gradually rise from zero.
[0134] Further, in the first modification example, from the time T**05** after the start of the first circulation processing, the controller **5** operates the heaters **36**A and **36**B (see FIG. **7**) to perform a temperature control processing for the processing liquid L.
[0135] In this way, in the first modification example, the heaters **36**A and **36**B are not operated immediately after the minimum circulation flow rate FL is reached, but are operated after a margin of the period P**2**.
[0136] This allows the heaters **36**A and **36**B to be operated after sufficient circulation flow rates are secured in the circulation paths **32**A and **32**B, which makes it possible to suppress a problem that might be caused by operating the heaters **36**A and **36**B when the flow rates in the circulation paths **32**A and **32**B are not sufficient.
[0137] In the first modification example, the measurement value of the thermometer **45** gradually rises from the temperature A**0** from the time T**05** when the temperature control processing is begun. Further, in the first modification example, as the processing liquid L overflows from the inner tub **21***a* into the outer tub **21***b* and the temperature of the processing liquid L increases, the moisture in the processing liquid L evaporates from the processing tub **21**, so that the measurement value of the concentration meter **43** gradually rises from the concentration C**0**.
[0138] Then, in the first modification example, after a timepoint when the measurement values of both the flowmeters **39**A and **39**B reach the initial set flow rate F**1**, the controller **5** performs a second circulation processing in which the pumps **33**A and **33**B are operated so that the flow rates in the circulation paths **32**A and **32**B reach the preset processing set flow rate F**2**.
[0139] That is, in the circulation processing according to the first modification example, the pumps

33A and **33**B are operated so that the flow rates in the circulation paths **32**A and **32**B reach the processing set flow rate F**2** after the flow rates in the circulation paths **32**A and **32**B are first stabilized to the initial set flow rate F**1**.

[0140] Thus, the controller **5** can stably perform a feedback control to secure the processing set flow rate F**2** in both of the circulation paths **32**A and **32**B. Therefore, according to the first modification example, the flow rates of the processing liquid L discharged from the multiple dischargers **23** via the circulation paths **32**A and **32**B can be made the same, so that non-uniformity in the temperature of the processing liquid L in the inner tub **21***a* can be reduced.

[0141] Furthermore, as compared to a case where the pumps **33**A and **33**B are operated so that the flow rates in the circulation paths **32**A and **32**B increase from zero to the processing set flow rate F**2** at once, it is possible to suppress cavitation from occurring inside the pumps **33**A and **33**B even if the flow rate of the processing liquid L is increased.

[0142] Therefore, according to the first modification example, the flow rate of the processing liquid L sent from the circulation paths **32**A and **32**B back into the processing tub **21** can be increased.

[0143] Furthermore, in the first modification example, the controller **5** may start a second circulation processing when the measurement values of the flowmeters **39**A and **39**B all reach the initial set flow rate F**1** and the measurement value of the concentration meter **43** falls within a predetermined concentration range (between the lower limit concentration CTL and the upper limit concentration CTH).

[0144] Accordingly, since the pumps **33**A and **33**B can be operated to achieve the processing set flow rate F**2** after the viscosity of the processing liquid L is brought close to a viscosity level required for processing the wafer W, occurrence of cavitation inside the pumps **33**A and **33**B can be further suppressed even if the flow rate of the processing liquid L is increased.

[0145] Therefore, according to the first modification example, the flow rate of the processing liquid L sent from the circulation paths **32**A and **32**B back to the processing tub **21** can be stably increased.

[0146] In addition, in the first modification example, the controller **5** may start the second circulation processing when the measurement values of the flowmeters **39**A and **39**B all reach the initial set flow rate F**1** and the measurement value of the thermometer **45** falls within a predetermined temperature range (between the lower limit temperature ATL and the upper limit temperature ATH).

[0147] This allows the pumps **33**A and **33**B to be operated to achieve the processing set flow rate F**2** after the viscosity of the processing liquid L is brought close to the viscosity level for processing the wafer W, occurrence of cavitation inside the pumps **33**A and **33**B can be further suppressed even if the flow rate of the processing liquid L is increased.

[0148] Therefore, according to the first modification example, the flow rate of the processing liquid L sent from the circulation paths **32**A and **32**B back to the processing tub **21** can be stably increased.

[0149] Furthermore, in the first modification example, the controller **5** may start the second circulation processing from the time T**15** when the measurement values of the flowmeters **39**A and **39**B have reached the initial set flow rate F**1**, the measurement value of the concentration meter **43** has reached the predetermined concentration range, and the measurement value of the thermometer **45** has reached the predetermined temperature range.

[0150] This allows the pumps **33**A and **33**B to be operated to achieve the processing set flow rate F**2** after the viscosity of the processing liquid L is brought further close to the viscosity level for processing the wafer W. Thus, even if the flow rate of the processing liquid L is increased, occurrence of cavitation inside the pumps **33**A and **33**B can be further suppressed.

[0151] Therefore, according to the first modification example, the flow rate of the processing liquid L sent from the circulation paths **32**A and **32**B back into the processing tub **21** can be stably increased.

[0152] The controller **5** starts the second circulation processing from the time T**15**, and gradually increases the set flow rates of the pumps **33**A and **33**B from the time T**15** to the time T**16**. Then, the controller **5** sets the set flow rates of the pumps **33**A and **33**B to the processing set flow rate F**2** for processing the wafer W at the time T**16**.

[0153] As a result, the measurement values of the flowmeters **39**A and **39**B become the processing set flow rate F**2** for processing the wafer W, the measurement value of the concentration meter **43** becomes the processing set concentration CS for processing the wafer W, and the measurement value of the thermometer **45** becomes the processing set temperature AS for processing the wafer W. Then, the series of processes of the startup processing according to the first modification example are completed.

[0154] In the first modification example, by gradually increasing the set flow rates of the pumps **33**A and **33**B from the time T**15** to the time T**16**, a rapid change in the flow rates in the circulation paths **32**A and **32**B can be suppressed. Thus, according to the first modification example, it is possible to suppress occurrence of cavitation inside the pumps **33**A and **33**B.

[0155] In the example of FIG. **7** described so far, the circulation path **32** includes the two circulation paths **32**A and **32**B. However, the present disclosure is not limited thereto, and the circulation path **32** may include three or more circulation paths.

Second Modification Example

[0156] Now, the processing liquid supply system **3** according to a second modification example and a startup processing using this processing liquid supply system **3** will be explained with reference to FIG. **8** in addition to FIG. **5** and FIG. **6**. FIG. **8** is a diagram illustrating a configuration example of the processing liquid supply system **3** according to the second modification example.

[0157] The second modification example shown in FIG. **8** is different from one or more embodiments and the first modification example described above in the configuration of the circulation path **32**. Specifically, in the second modification example, the single circulation path **32** is branched at a branching portion **50** on its way into multiple (two in the shown example) branch circulation paths **32***a* and **32***b*.

[0158] With this configuration, the feed flow rate of the processing liquid L returned from the circulation path **32** back into the processing tub **21** can be increased, as compared to the case where the single circulation path **32** is provided from the uppermost stream to the downmost stream for the single processing tub **21**.

[0159] The circulation path **32** is provided with the pump **33**, the pressure gauge **34**, the check valve **35**, and the branching portion **50** in this order from the upstream side with respect to the processing tub **21**. Also, the circulation path **32** is branched into the branch circulation paths **32***a* and **32***b* at the branching portion **50**.

[0160] The pump **33** forms a circulation flow of the processing liquid L that flows out from the processing tub **21**, passes through the circulation path **32** and the branch circulation paths **32***a* and **32***b*, and returns back into the processing tub **21**. The pump **33** is, by way of non-limiting example, a magnetic levitation pump. However, the pump **33** of the present disclosure is not limited to the magnetic levitation pump, and may be a diaphragm pump or the like.

[0161] The pressure gauge **34** measures the pressure of the processing liquid L flowing through the circulation path **32**. A measurement value of the pressure of the processing liquid L measured by the pressure gauge **34** is outputted to the controller **5** (see FIG. **1**). The check valve **35** suppresses a backflow of the processing liquid L flowing through the circulation path **32**. The check valve **35** is, for example, an air-operated valve.

[0162] In this way, by disposing the pump **33** upstream of the branching portion **50**, the processing liquid L can be sent to the multiple branch circulation paths **32***a* and **32***b* without needing to increase the number of the pump **33**. Therefore, according to the second modification example, the manufacturing cost of the processing liquid supply system **3** can be reduced.

[0163] The branch circulation path **32***a* is provided with a heater **36**A, a filter **37**A, and a flowmeter

39A in this order from the upstream side with respect to the branching portion **50**.

[0164] The heater **36**A heats the processing liquid L flowing through the branch circulation path **32***a*. In the second modification example, by heating the processing liquid L with this heater **36**A, the processing liquid L stored in the processing tub **21** is heated up to the processing set temperature AS (see FIG. **5**) required for processing the wafer W.

[0165] The filter **37**A removes contaminants such as particles contained in the processing liquid L flowing through the branch circulation path **32***a*. The filter **37**A may include multiple filter modules arranged in parallel.

[0166] The flowmeter **39**A measures the flow rate of the processing liquid L flowing through the branch circulation path **32***a*. A measurement value of the flow rate of the processing liquid L measured by the flowmeter **39**A is outputted to the controller **5**.

[0167] The branch circulation path **32***b* is provided with a heater **36**B, a filter **37**B, a branching portion **38**, and a flowmeter **39**B in this order from the upstream side with respect to the branching portion **50**.

[0168] The heater **36**B heats the processing liquid L flowing through the branch circulation path **32***b*. In the second modification example, by heating the processing liquid L with this heater **36**B, the processing liquid L stored in the processing tub **21** is heated up to the processing set temperature AS required for processing the wafer W.

[0169] The filter **37**B removes contaminants such as particles contained in the processing liquid L flowing through the branch circulation path **32***b*. The filter **37**B may include multiple filter modules arranged in parallel.

[0170] The branch path **41** leading to the outer tub **21***b* of the processing tub **21** is branched from the branching portion **38**. The flowmeter **39**B measures the flow rate of the processing liquid L flowing through the branch circulation path **32***b*. A measurement value of the flow rate of the processing liquid L measured by the flowmeter **39**B is outputted to the controller **5**.

[0171] The branch path **41** is a flow path for sampling the concentration of the processing liquid L flowing through the branch circulation path **32***b*. This branch path **41** is provided with the flowmeter **42**, the concentration meter **43**, and the valve **44***a* in this order from the upstream side with respect to the branching portion **38**.

[0172] The flowmeter **42** measures the flow rate of the processing liquid L flowing through the branch path **41**. A measurement value of the flow rate of the processing liquid L measured by the flowmeter **42** is outputted to the controller **5**.

[0173] The concentration meter **43** measures the concentration of the processing liquid L flowing through the branch path **41** to measure the concentration of the processing liquid L flowing through the circulation path **32**. The concentration meter **43** measures, for example, a phosphoric acid concentration of the processing liquid L flowing through the branch path **41**. A measurement value of the concentration of the processing liquid L measured by the concentration meter **43** is outputted to the controller **5**. The valve **44** controls whether or not the processing liquid L is to be supplied from the branching portion **38** to the outer tub **21***b*.

[0174] Now, details of the startup processing of the substrate processing apparatus **1** using the processing liquid supply system **3** according to the second modification example will be explained with reference to FIG. **5** and FIG. **6**.

[0175] As shown in FIG. **5**, the controller **5** (see FIG. **1**) operates the pumps **33** (see FIG. **8**) as a circulation processing from the time T**03**, which is the same as in the above-described exemplary embodiment. Thus, the controller **5** allows the processing liquid L (see FIG. **8**) to flow through the circulation path **32** (see FIG. **8**) and the branch circulation paths **32***a* and **32***b* (see FIG. **8**), thereby performing a charging processing of filling the circulation path **32** and the branch circulation paths **32***a* and **32***b* with the processing liquid L.

[0176] In the charging processing according to the second modification example, the controller **5** operates the pump **33**, which is a magnetic levitation pump, under a rotation speed control, as shown in FIG. **5**. Also, the controller **5** operates the pump **33** at the predetermined rotation speed Rs in the charging processing.

[0177] In this way, by operating the pump **33** under the rotation speed control in the charging processing, the pump **33** can be stably operated even when the circulation path **32** and the branch circulation paths **32***a* and **32***b* are not filled with the processing liquid L and thus a flow rate feedback control is difficult to perform. Therefore, according to the second modification example, the circulation path **32** and the branch circulation paths **32***a* and **32***b* can be stably filled with the processing liquid L.

[0178] Further, in the second modification example, the pump **33** needs to be operated at the rotation speed Rs at which the measurement values of the flowmeters **39**A and **39**B (see FIG. **8**) become equal to or greater than the minimum circulation flow rate FL and cavitation does not occur inside the pump **33** in the charging processing. This allows the circulation path **32** and the branch circulation paths **32***a* and **32***b* to be stably filled with the processing liquid L.

[0179] Furthermore, the charging processing according to the second modification example needs to be carried out from the time T**03** for the period P**1**, which is confirmed in advance as being sufficient to fill all of the circulation path **32** and the branch circulation paths **32***a* and **32***b* with the processing liquid L, as shown in FIG. **5**. This allows the circulation path **32** and the branch circulation paths **32***a* and **32***b* to be filled with the processing liquid L more reliably.

[0180] Following the charging processing described so far, the controller **5** performs a stop processing of stopping the pump **33** from the time T**11**, which is the same as in the above-described exemplary embodiment, thereby stopping the circulation of the processing liquid L in the circulation path **32** and the branch circulation paths **32***a* and **32***b* in the circulation processing according to the second modification example. As a result, the measurement values of the flowmeters **39**A and **39**B become zero, as shown in FIG. **5**.

[0181] In this way, in the circulation processing according to the second modification example, by performing the stop processing of stopping the circulation of the processing liquid L after the charging processing, both of the branch circulation paths **32***a* and **32***b* can be brought into a state in which a circulation flow rate therein is zero. Therefore, according to the second modification example, the circulation flow can be started up in the state that the flow rates in the branch circulation paths **32***a* and **32***b* are the same.

[0182] Next, in the circulation processing according to the second modification example, the controller **5** performs, from the time T**12**, which is the same as in the above-described exemplary embodiment, a first circulation processing of circulating the processing liquid L such that the processing liquid L (see FIG. **8**) flowing through the branch circulation paths **32***a* and **32***b* (see FIG. **8**) reaches the initial set flow rate F**1**, as shown in FIG. **6**.

[0183] To carry out this first circulation processing, the controller **5** (see FIG. **1**) switches the operation mode of the pump **33** (see FIG. **8**) from a rotation speed control to a flow rate feedback control.

[0184] Then, in the first circulation processing, the controller **5** operates the pump **33**, while setting the set flow rates of the processing liquid L in the branch circulation paths **32***a* and **32***b* to the initial set flow rate F**1**. As a result, as shown in FIG. **6**, the measurement values of the flowmeters **39**A and **39**B (see FIG. **8**) gradually rise from zero.

[0185] Further, in the second modification example, from the time T**05** after the start of the first circulation processing, the controller **5** operates the heaters **36**A and **36**B (see FIG. **8**) to perform a temperature control processing for the processing liquid L.

[0186] In this way, in the second modification example, the heaters **36**A and **36**B are not operated immediately after the minimum circulation flow rate FL is reached, but are operated after a margin of the period P**2**.

[0187] This allows the heaters **36**A and **36**B to be operated after sufficient circulation flow rates are achieved in the branch circulation paths **32***a* and **32***b*, which makes it possible to suppress a problem that might be caused by operating the heaters **36**A and **36**B when the flow rates in the branch circulation paths **32***a* and **32***b* are not sufficient.

[0188] In the second modification example, the measurement value of the thermometer **45** gradually rises from the temperature A**0** from the time T**05** when the temperature control processing is begun. Further, in the second modification example, as the processing liquid L overflows from the inner tub **21***a* into the outer tub **21***b* and the temperature of the processing liquid L increases, the moisture in the processing liquid L evaporates from the processing tub **21**, so that the measurement value of the concentration meter **43** gradually rises from the concentration C**0**.

[0189] Then, in the second modification example, after a timepoint when the measurement values of both the flowmeters **39**A and **39**B reach the initial set flow rate F**1**, the controller **5** performs a second circulation processing in which the pump **33** is operated so that the flow rates in the branch circulation paths **32***a* and **32***b* reach the preset processing set flow rate F**2**.

[0190] That is, in the circulation processing according to the second modification example, the pump **33** is operated so that the flow rates in the branch circulation paths **32***a* and **32***b* reach the processing set flow rate F**2** after the flow rates in the branch circulation paths **32***a* and **32***b* are first stabilized to the initial set flow rate F**1**.

[0191] Thus, the controller **5** can stably perform a feedback control to secure the processing set flow rate F**2** in both of the branch circulation paths **32***a* and **32***b*. Therefore, according to the second modification example, the flow rates of the processing liquid L discharged from the multiple dischargers **23** via the branch circulation paths **32***a* and **32***b* can be made the same, so that non-uniformity in the temperature of the processing liquid L in the inner tub **21***a* can be reduced.

[0192] Besides, as compared to a case where the pump **33** is operated so that the flow rates in the branch circulation paths **32***a* and **32***b* increase from zero to the processing set flow rate F**2** at once, it is possible to suppress cavitation from occurring inside the pump **33** even if the flow rate of the processing liquid L is increased.

[0193] Therefore, according to the second modification example, the flow rate of the processing liquid L sent from the circulation path **32** and the branch circulation paths **32***a* and **32***b* back to the processing tub **21** can be increased.

[0194] Furthermore, in the second modification example, the controller **5** may start a second circulation processing when the measurement values of the flowmeters **39**A and **39**B all reach the initial set flow rate F**1** and the measurement value of the concentration meter **43** falls within a predetermined concentration range (between the lower limit concentration CTL and the upper limit concentration CTH).

[0195] Accordingly, since the pump **33** can be operated to achieve the processing set flow rate F**2** after the viscosity of the processing liquid L is brought close to a viscosity level for processing the wafer W, occurrence of cavitation inside the pump **33** can be further suppressed even if the flow rate of the processing liquid L is increased.

[0196] Therefore, according to the second modification example, the flow rate of the processing liquid L sent from the circulation path **32** and the branch circulation paths **32***a* and **32***b* back to the processing tub **21** can be stably increased.

[0197] In addition, in the second modification example, the controller **5** may start the second circulation processing when the measurement values of the flowmeters **39**A and **39**B all reach the initial set flow rate F**1** and the measurement value of the thermometer **45** falls within a predetermined temperature range (between the lower limit temperature ATL and the upper limit temperature ATH).

[0198] This allows the pump **33** to be operated to achieve the processing set flow rate F**2** after the viscosity of the processing liquid L is brought close to the viscosity level for processing the wafer W, so that occurrence of cavitation inside the pump **33** can be further suppressed even if the flow rate of the processing liquid L is increased.

[0199] Therefore, according to the second modification example, the flow rate of the processing liquid L sent from the circulation path **32** and the branch circulation paths **32**_a_ and **32**_b_ back to the processing tub **21** can be stably increased.
[0200] Furthermore, in the second modification example, the controller **5** may start the second circulation processing from the time T**15** when the measurement values of the flowmeters **39**A and **39**B have reached the initial set flow rate F**1**, the measurement value of the concentration meter **43** has reached the predetermined concentration range, and the measurement value of the thermometer **45** has reached the predetermined temperature range.
[0201] This allows the pump **33** to be operated to achieve the processing set flow rate F**2** after the viscosity of the processing liquid L is brought further close to the viscosity level for processing the wafer W. Thus, even if the flow rate of the processing liquid L is increased, occurrence of cavitation inside the pumps **33** can be further suppressed.
[0202] Therefore, according to the second modification example, the flow rate of the processing liquid L sent from the circulation path **32** and the branch circulation paths **32**_a_ and **32**_b_ back into the processing tub **21** can be stably increased.
[0203] The controller **5** starts the second circulation processing from the time T**15**, and gradually increases the set flow rate of the pump **33** from the time T**15** to the time T**16**. Then, the controller **5** sets the set flow rate of the pump **33** to the processing set flow rate F**2** for processing the wafer W at the time T**16**.
[0204] As a result, the measurement values of the flowmeters **39**A and **39**B become the processing set flow rate F**2** for processing the wafer W, the measurement value of the concentration meter **43** becomes the processing set concentration CS for processing the wafer W, and the measurement value of the thermometer **45** becomes the processing set temperature AS for processing the wafer W. Then, the series of processes of the startup processing according to the second modification example are completed.
[0205] In the second modification example, by gradually increasing the set flow rate of the pump **33** from the time T**15** to the time T**16**, a rapid change in the flow rates in the circulation path **32** and the branch circulation paths **32**_a_ and **32**_b_ can be suppressed. Thus, according to the second modification example, it is possible to suppress occurrence of cavitation inside the pump **33**.
[0206] In the example of FIG. **8** described so far, the circulation path **32** is branched into the two branch circulation paths **32**_a_ and **32**_b_ on its way. However, the present disclosure is not limited thereto, and the circulation path **32** may be branched into three or more branch circulation paths.
[0207] The processing liquid supply system **3** according to one or more embodiments includes the processing liquid supply **31**, the circulation path **32** (**32**A and **32**B), the pump **33** (**33**A and **33**B), the flowmeter **39** (**39**A and **39**B), and the controller **5**. The processing liquid supply **31** supplies the processing liquid L to the processing tub **21** in which the substrate (wafer W) is to be immersed and processed. The circulation path **32** (**32**A and **32**B) allows the processing liquid L to flow out from the processing tub **21** and return back into the processing tub **21**. The pump **33** (**33**A and **33**B) and the flowmeter **39** (**39**A and **39**B) are provided in the circulation path **32** (**32**A and **32**B). The controller **5** controls the individual components. Also, the controller **5** performs storage processing, a charging processing, a first circulation processing, and a second circulation processing. In the storage processing, the processing liquid L is supplied from the processing liquid supply **31** and stored in the processing tub **21**. In the charging processing, the pump **33** (**33**A and **33**B) is operated to allow the processing liquid L to flow through the circulation path **32** (**32**A and **32**B), thus filling the circulation path **32** (**32**A and **32**B) with the processing liquid L. In the first circulation processing, the pump **33** (**33**A and **33**B) is operated after the charging processing so that the processing liquid L passing through the circulation path **32** (**32**A and **32**B) reaches the initial set flow rate F**1**, thus allowing the processing liquid L to be circulated through the circulation path **32** (**32**A and **32**B). In the second circulation processing, the pump **33** (**33**A and **33**B) is operated to achieve the processing set flow rate F**2** for processing the substrate (wafer W) after the

measurement value of the flowmeter **39** (**39**A and **39**B) becomes the initial set flow rate F**1**. This makes it possible to increase the flow rate of the processing liquid L sent from the circulation path **32** back into the processing tub **21**.

[0208] Further, the processing liquid supply system **3** according to one or more embodiments further includes the heater **36** (**36**A and **36**B) provided in the circulation path **32** (**32**A and **32**B) and the thermometer **45** configured to measure the temperature of the processing liquid L flowing through the circulation path **32** (**32**A and **32**B). In the first circulation processing, the controller **5** operates the heater **36** (**36**A and **36**B) to heat the processing liquid L, and starts the second circulation processing when the measurement value of the flowmeter **39** (**39**A and **39**B) has reached the initial set flow rate F**1** and the measurement value of the thermometer **45** has reached within a predetermined temperature range. This makes it possible to stably increase the flow rate of the processing liquid L sent from the circulation path **32** (**32**A and **32**B) back into the processing tub **21**.

[0209] Moreover, the processing liquid supply system **3** according to one or more embodiments further includes the concentration meter **43** configured to measure the concentration of the processing liquid L flowing through the circulation path **32** (**32**A and **32**B). In the first circulation processing, the controller **5** operates the heater **36** (**36**A and **36**B) to heat the processing liquid L. Then, the controller **5** starts the second circulation processing when the measurement value of the flowmeter **39** (**39**A and **39**B) has reached the initial set flow rate F**1**, the measurement value of the thermometer **45** has reached within a predetermined temperature range, and the measurement value of the concentration meter **43** has reached within a predetermined concentration range. This makes it possible to stably increase the flow rate of the processing liquid L sent from the circulation path **32** (**32**A and **32**B) back to the processing tub **21**.

[0210] Also, the processing liquid supply system **3** according to one or more embodiments further includes the heater **36** (**36**A and **36**B) provided in the circulation path **32** (**32**A and **32**B) and the concentration meter **43** configured to measure the concentration of the processing liquid L flowing through the circulation path **32** (**32**A and **32**B). In the first circulation processing, the controller **5** operates the heater **36** (**36**A and **36**B) to heat the processing liquid L. Then, the controller **5** starts the second circulation processing when the measurement value of the flowmeter **39** (**39**A and **39**B) has reached the initial set flow rate F**1** and the measurement value of the concentration meter **43** has reached within a predetermined concentration range. This makes it possible to stably increase the flow rate of the processing liquid L sent from the circulation path **32** (**32**A and **32**B) back into the processing tub **21**.

[0211] Besides, in the processing liquid supply system **3** according to one or more embodiments, the circulation paths **32**A and **32**B are provided in plural numbers. The pumps **33**A and **33**B and the flowmeters **39**A and **39**B are provided in the circulation paths **32**A and **32**B, respectively. In the charging processing, the controller **5** operates the pumps **33**A and **33**B respectively provided in the circulation paths **32**A and **32**B to fill all the circulation paths **32**A and **32**B with the processing liquid L. Further, between the charging processing and the first circulation processing, the controller **5** stops the operation of all the pumps **33**A and **33**B to perform a stop processing of stopping the circulation in all of the circulation paths **32**A and **32**B. This makes it possible to start up a circulation flow in the state where all the circulation paths **32**A and **32**B have the same flow rate.

[0212] In addition, in the processing liquid supply system **3** according to one or more embodiments, the controller **5** starts the second circulation processing when the measurement values of all the flowmeters **39**A and **39**B have reached the initial set flow rate F**1** in the first circulation processing. This makes it possible to reduce non-uniformity in the temperature of the processing liquid L in the inner tub **21***a*.

[0213] Further, in the processing liquid supply system **3** according to one or more embodiments, the circulation path **32** is branched downstream of the pump **33** into the multiple branch circulation paths **32***a* and **32***b*. The flowmeters **39**A and **39**B are provided in the branch circulation paths **32***a* and **32***b*, respectively. In the charging processing, the controller **5** operates the pump **33** to fill all the branch circulation paths **32***a* and **32***b* with the processing liquid L. Further, between the charging processing and the first circulation processing, the controller **5** stops the operation of the pump **33** to perform a stop processing of stopping the circulation in all of the branch circulation paths **32***a* and **32***b*. This makes it possible to start up a circulation flow in the state where all the branch circulation paths **32***a* and **32***b* have the same flow rate.

[0214] Moreover, in the processing liquid supply system **3** according to one or more embodiments, the pump **33** (**33**A and **33**B) is a magnetic levitation pump configured to force-feed the processing liquid L as its rotator is rotated in the processing liquid L while being magnetically levitated. The controller **5** performs the force-feeding of the processing liquid L while controlling the rotation speed of the rotator based on the measurement value of the flowmeter **39** (**39**A and **39**B). This makes it possible to increase the flow rate of the processing liquid L sent from the circulation path **32** back into the processing tub **21**.

[0215] Additionally, in the processing liquid supply system **3** according to one or more embodiments, the controller **5** operates the pump **33** (**33**A and **33**B) while fixing the rotation speed of the rotator to a preset rotation speed in the charging processing. This makes it possible to stably fill the circulation path **32** with the processing liquid L.

Sequence of Control Processing

[0216] Now, a sequence of a control processing according to one or more embodiments will be explained with reference to FIG. **9** to FIG. **11**. FIG. **9** is a flowchart showing an example sequence of a control processing performed by the processing liquid supply system **3** according to one or more embodiments.

[0217] In the control processing according to one or more embodiments, the controller **5** first performs a charging processing of operating the pump **33** to allow the processing liquid L to flow through the circulation path **32**, thereby filling the circulation path **32** with the processing liquid L (process S**101**).

[0218] Next, the controller **5** determines whether the circulation path **32** is filled with the processing liquid L (process S**102**). For example, if the charging processing (process S**101**) is performed for the predetermined period P**1** or more, the controller **5** may make a determination that the circulation path **32** is filled with the processing liquid L.

[0219] If it is determined that the circulation path **32** is filled with the processing liquid L (process S**102**, Yes), the controller **5** performs a stop processing of stopping the pump **33** to stop the circulation of the processing liquid L in the circulation path **32** (process S**103**). If, on the other hand, it is determined that the circulation path **32** is not filled with the processing liquid L (process S**102**, No), the processing returns back to the process S**101**.

[0220] Following the stop processing (process S**103**), the controller **5** determines whether or not the circulation of the processing liquid L is stopped in the circulation path **32** (process S**104**). For example, if the stop processing (process S**103**) is performed for a preset period or more, the controller **5** may make a determination that the circulation of the processing liquid L is stopped in the circulation path **32**.

[0221] Then, when it is determined that the circulation of the processing liquid L is stopped in the circulation path **32** (process S**104**, Yes), the controller **5** performs a first circulation processing of circulating the processing liquid L so that the processing liquid L flowing through the circulation path **32** reaches the predetermined initial set flow rate F**1** (process S**105**). On the other hand, when it is determined that the circulation of the processing liquid L is not stopped in the circulation path **32** (process S**104**, No), the processing returns back to the process S**103**.

[0222] Following the first circulation processing (process S**105**), the controller **5** determines whether the flow rate of the processing liquid L in the circulation path **32** has reached the initial set flow rate F**1** (process S**106**). Then, if it is determined that the flow rate of the processing liquid L in the circulation path **32** has reached the initial set flow rate F**1** (process S**106**, Yes), the controller **5** determines whether the temperature of the processing liquid L is within a predetermined temperature range (between the lower limit temperature ATL and the upper limit temperature ATH) (process S**107**).

[0223] If it is determined that the temperature of the processing liquid L is within the predetermined temperature range (process S**107**, Yes), the controller **5** determines whether the concentration of the processing liquid L is within the predetermined concentration range (between the lower limit concentration CTL and the upper limit concentration CTH) (process S**108**).

[0224] When it is determined that the concentration of the processing liquid L is within the predetermined concentration range (process S**108**, Yes), the controller **5** performs a second circulation processing of operating the pump **33** so that the predetermined processing set flow rate F**2** for processing the wafer W is achieved in the circulation path **32** (process S**109**). Then, the series of processes of the start-up processing are completed.

[0225] In the process S**106**, if it is determined that the flow rate of the processing liquid L in the circulation path **32** has not reached the initial set flow rate F**1** (process S**106**, No), the processing returns back to the process S**105**.

[0226] Also, in the process S**107**, if it is determined that the temperature of the processing liquid L is not within the predetermined temperature range (process S**107**, No), the processing returns back to the process S**105**.

[0227] Also, in the process S**108**, if it is determined that the concentration of the processing liquid L is not within the predetermined concentration range (process S**108**, No), the processing returns back to the process S**105**.

[0228] FIG. **10** is a flowchart showing another example sequence of the control processing performed by the processing liquid supply system **3** according to one or more embodiments.

[0229] In the control processing shown in FIG. **10**, the controller **5** first performs a charging processing of operating the pump **33** to allow the processing liquid L to flow through the circulation path **32**, thereby filling the circulation path **32** with the processing liquid L (process S**201**).

[0230] Next, the controller **5** determines whether the circulation path **32** is filled with the processing liquid L (process S**202**). Then, if it is determined that the circulation path **32** is filled with the processing liquid L (process S**202**, Yes), the controller **5** performs a stop processing of stopping the pump **33** to stop the circulation of the processing liquid L in the circulation path **32** (process S**203**).

[0231] On the other hand, if it is determined that the circulation path **32** is not filled with the processing liquid L (process S**202**, No), the processing returns back to the process S**201**.

[0232] Following the stop processing (process S**203**), the controller **5** determines whether or not the circulation of the processing liquid L is stopped in the circulation path **32** (process S**204**). If it is determined that the circulation of the processing liquid L is stopped in the circulation path **32** (process S**204**, Yes), the controller **5** performs a first circulation processing of circulating the processing liquid L so that the processing liquid L flowing through the circulation path **32** reaches the initial set flow rate F**1** (process S**205**).

[0233] On the other hand, if it is determined that the circulation of the processing liquid L in the circulation path **32** is not stopped (process S**204**, No), the processing returns back to the process S**203**.

[0234] Following the first circulation processing (process S**205**), the controller **5** determines whether the flow rate of the processing liquid L in the circulation path **32** has reached the initial set flow rate F**1** (process S**206**). If it is determined that the flow rate of the processing liquid L in the circulation path **32** has reached the initial set flow rate F**1** (process S**206**, Yes), the controller **5** determines whether the temperature of the processing liquid L is within a predetermined temperature range (process S**207**).

[0235] If it is determined that the temperature of the processing liquid L is within the predetermined temperature range (process S**207**, Yes), the controller **5** performs a second circulation processing of operating the pump **33** so that the processing set flow rate F**2** for processing the wafer W is achieved in the circulation path **32** (process S**208**). Then, the series of processes of the start-up processing are completed.
[0236] In addition, in the process S**206**, if it is determined that the flow rate of the processing liquid L in the circulation path **32** has not reached the initial set flow rate F**1** (process S**206**, No), the processing returns back to the process S**205**.
[0237] Also, in the process S**207**, if it is determined that the temperature of the processing liquid L is not within the predetermined temperature range (process S**207**, No), the processing returns back to the process S**205**.
[0238] FIG. **11** is a flowchart showing still another example sequence of the control processing performed by the processing liquid supply system **3** according to one or more embodiments.
[0239] In the control processing shown in FIG. **11**, the controller **5** first performs a charging processing of operating the pump **33** to allow the processing liquid L to flow through the circulation path **32**, thereby filling the circulation path **32** with the processing liquid L (process S**301**).
[0240] Next, the controller **5** determines whether the circulation path **32** is filled with the processing liquid L (process S**302**). If it is determined that the circulation path **32** is filled with the processing liquid L (process S**302**, Yes), the controller **5** performs a stop processing of stopping the pump **33** to stop the circulation of the processing liquid L in the circulation path **32** (process S**303**).
[0241] On the other hand, if it is determined that the circulation path **32** is not filled with the processing liquid L (process S**302**, No), the processing returns back to the process S**301**.
[0242] Following the stop processing (process S**303**), the controller **5** determines whether or not the circulation of the processing liquid L is stopped in the circulation path **32** (process S**304**). If it is determined that the circulation of the processing liquid L is stopped in the circulation path **32** (process S**304**, Yes), the controller **5** performs a first circulation processing of circulating the processing liquid L so that the processing liquid L flowing through the circulation path **32** reaches the predetermined initial set flow rate F**1** (process S**305**).
[0243] On the other hand, if it is determined that the circulation of the processing liquid L in the circulation path **32** is not stopped (process S**304**, No), the processing returns back to the process S**303**.
[0244] Following the first circulation processing (process S**305**), the controller **5** determines whether the flow rate of the processing liquid L in the circulation path **32** has reached the initial set flow rate F**1** (process S**306**). If it is determined that the flow rate of the processing liquid L in the circulation path **32** has reached the initial set flow rate F**1** (process S**306**, Yes), the controller **5** determines whether the concentration of the processing liquid L is within a predetermined concentration range (process S**307**).
[0245] If it is determined that the concentration of the processing liquid L is within the predetermined concentration range (process S**307**, Yes), the controller **5** performs a second circulation processing of operating the pump **33** so that the processing set flow rate F**2** for processing the wafer W is achieved in the circulation path **32** (process S**308**). Then, the series of processes of the start-up processing are completed.
[0246] In addition, in the process S**306**, if it is determined that the flow rate of the processing liquid L in the circulation path **32** has not reached the initial set flow rate F**1** (process S**306**, No), the processing returns back to the process S**305**.
[0247] Also, in the process S**307**, if it is determined that the concentration of the processing liquid L is not within the predetermined concentration range (process S**307**, No), the processing returns back to the process S**305**.
[0248] A processing liquid supply method according to one or more embodiments includes a

storage processing, a charging processing (processes S**101**, S**201** and S**301**), a first circulation processing (processes S**105**, S**205** and S**305**), and a second circulation processing (processes S**109**, S**208** and S**308**). In the storage processing, the processing liquid L is supplied to and stored in the processing tub **21** in which the substrate (wafer W) is to be immersed and processed. In the charging processing, the pump **33** (**33**A and **33**B) provided in the circulation path **32** (**32**A and **32**B) is operated to allow the processing liquid L to flow through the circulation path **32** (**32**A and **32**B), thus filling the circulation path **32** (**32**A and **32**B) with the processing liquid L. The circulation path **32** (**32**A and **32**B) allows the processing liquid L to flow out from the processing tub **21** and then return to the processing tub **21**. In the first circulation processing, the processing liquid L is circulated through the circulation path **32** (**32**A and **32**B) by operating, after the charging processing, the pump **33** (**33**A and **33**B) so that the processing liquid L flowing through the circulation path **32** (**32**A and **32**B) reaches the predetermined initial set flow rate F**1**. In the second circulation processing, after the timepoint when the processing liquid L flowing through the circulation path **32** (**32**A and **32**B) has reached the initial set flow rate F**1**, the pump **33** (**33**A and **33**B) is operated so that the processing liquid L reaches the predetermined processing set flow rate F**2** for processing the substrate (wafer W). This enables an increase of the flow rate of the processing liquid L sent from the circulation path **32** back into the processing tub **21**.
[0249] So far, one or more embodiments of the present disclosure have been described. However, the present disclosure is not limited to the above-described exemplary embodiments, and various changes and modifications may be made without departing from the spirit of the present disclosure.
[0250] Here, it should be noted that the above-described exemplary embodiments are illustrative in all aspects and are not anyway limiting. The above-described exemplary embodiments may be omitted, replaced and modified in various ways without departing from the scope and the spirit of claims.
[0251] According to one or more embodiments, it is possible to increase the flow rate of the processing liquid returned back into the processing tub from the circulation path.
[0252] From the foregoing, it will be appreciated that various embodiments of the present disclosure have been described herein for purposes of illustration, and that various modifications may be made without departing from the scope and spirit of the present disclosure. Accordingly, the various embodiments disclosed herein are not intended to be limiting. The scope of the inventive concept is defined by the following claims and their equivalents rather than by the detailed description of one or more embodiments. It shall be understood that all modifications and embodiments conceived from the meaning and scope of the claims and their equivalents are included in the scope of the inventive concept.

Claims

1. A processing liquid supply system, comprising: a processing tub; a processing liquid supply configured to supply a processing liquid into the processing tub in which a substrate is immersed to be processed; a circulation path configured to allow the processing liquid to flow out from the processing tub and return back into the processing tub; a pump and a flowmeter provided in the circulation path; and a controller having a processor and a memory with a computer readable program stored therein that upon execution of the computer readable program by the processor configures the controller to control each component, wherein the controller performs: storing the processing liquid in the processing tub by supplying the processing liquid from the processing liquid supply; filling the circulation path with the processing liquid by operating the pump to allow the processing liquid to flow through the circulation path; circulating the processing liquid through the circulation path by operating, after the filling of the circulation path, the pump such that the processing liquid flowing through the circulation path reaches a predetermined initial set flow rate; and operating, after a timepoint when a measurement value of the flowmeter has reached the initial

set flow rate, the pump to achieve a predetermined processing set flow rate at which the substrate is processed.
2. The processing liquid supply system of claim 1, further comprising: a heater provided in the circulation path, and a thermometer configured to measure a temperature of the processing liquid flowing through the circulation path, wherein the controller operates the heater to heat the processing liquid in the circulating of the processing liquid, and starts the operating of the pump to achieve the predetermined processing set flow rate when the measurement value of the flowmeter has reached the initial set flow rate and a measurement value of the thermometer has reached a predetermined temperature range.
3. The processing liquid supply system of claim 2, further comprising: a concentration meter configured to measure a concentration of the processing liquid flowing through the circulation path, wherein the controller operates the heater to heat the processing liquid in the circulating of the processing liquid, and starts the operating of the pump to achieve the predetermined processing set flow rate when the measurement value of the flowmeter has reached the initial set flow rate, the measurement value of the thermometer has reached the predetermined temperature range, and a measurement value of the concentration meter has reached a predetermined concentration range.
4. The processing liquid supply system of claim 1, further comprising: a heater provided in the circulation path, and a concentration meter configured to measure a concentration of the processing liquid flowing through the circulation path, wherein the controller operates the heater to heat the processing liquid in the circulating of the processing liquid, and starts the operating of the pump to achieve the predetermined processing set flow rate when the measurement value of the flowmeter has reached the initial set flow rate and a measurement value of the concentration meter has reached a predetermined concentration range.
5. The processing liquid supply system of claim 1, wherein the circulation path includes multiple circulation paths, the pump includes multiple pumps, the flowmeter includes multiple flowmeters, one of the multiple pumps and one of the multiple flowmeters are provided in each circulation path, and the controller operates the pump provided in each circulation path to fill each circulation path with the processing liquid in the filling of the circulation path, and performs stopping all of the multiple pumps to stop circulation of the processing liquid in all of the multiple circulation paths between the filling of the circulation path and the circulating of the processing liquid.
6. The processing liquid supply system of claim 5, wherein, in the circulating of the processing liquid, the controller starts the operating of the multiple pumps to achieve the predetermined processing set flow rate when measurement values of all of the multiple flowmeters have reached the initial set flow rate.
7. The processing liquid supply system of claim 1, wherein the circulation path is branched downstream of the pump into multiple branch circulation paths, the flowmeter includes multiple flowmeters, the flowmeter is provided in each of the multiple branch circulation paths, and the controller operates the pump to fill all of the multiple branch circulation paths with the processing liquid in the filling of the circulation path, and performs stopping the pump to stop circulation of the processing liquid in all of the multiple branch circulation paths between the filling of the circulation path and the circulating of the processing liquid.
8. The processing liquid supply system of claim 7, wherein, in the circulating of the processing liquid, the controller starts the operating of the pump to achieve the predetermined processing set flow rate when measurement values of all of the multiple flowmeters have reached the initial set flow rate.
9. The processing liquid supply system of claim 1, wherein the pump is a magnetic levitation pump configured to force-feed the processing liquid as a rotator of the magnetic levitation pump is rotated in the processing liquid while being magnetically levitated, and the controller performs force-feeding of the processing liquid while controlling a rotation speed of the rotator based on the measurement value of the flowmeter.

10. The processing liquid supply system of claim 9, wherein, in the filling of the circulation path, the controller operates the pump while fixing the rotation speed of the rotator to a preset rotation speed.

11. A processing liquid supply method, comprising: storing, by supplying a processing liquid into a processing tub in which a substrate is immersed to be processed, the processing liquid in the processing tub; filling a circulation path, which is configured to allow the processing liquid to flow out from the processing tub and return back into the processing tub, with the processing liquid by operating a pump provided in the circulation path; circulating the processing liquid through the circulation path by operating, after the filling of the circulation path, the pump such that the processing liquid flowing through the circulation path reaches a predetermined initial set flow rate; and operating, after a timepoint when the processing liquid flowing through the circulation path has reached the initial set flow rate, the pump to achieve a predetermined processing set flow rate at which the substrate is processed.

12. The processing liquid supply method of claim 11, further comprising operating a heater to heat the processing liquid in the circulating of the processing liquid, and starting the operating of the pump to achieve the predetermined processing set flow rate when the measurement value of the flowmeter has reached the initial set flow rate and a measurement value of a thermometer has reached a predetermined temperature range.

13. The processing liquid supply method of claim 12, further comprising operating the heater to heat the processing liquid in the circulating of the processing liquid, and starting the operating of the pump to achieve the predetermined processing set flow rate when the measurement value of the flowmeter has reached the initial set flow rate, the measurement value of the thermometer has reached the predetermined temperature range, and a measurement value of a concentration meter has reached a predetermined concentration range.

14. The processing liquid supply method of claim 11, further comprising operating a heater to heat the processing liquid in the circulating of the processing liquid, and starting the operating of the pump to achieve the predetermined processing set flow rate when the measurement value of the flowmeter has reached the initial set flow rate and a measurement value of a concentration meter has reached a predetermined concentration range.

15. The processing liquid supply method of claim 11, wherein the circulation path includes multiple circulation paths, the pump includes multiple pumps, the flowmeter includes multiple flowmeters, one of the multiple pumps and one of the multiple flowmeters are provided in each circulation path, and the method further comprises operating the pump provided in each circulation path to fill each circulation path with the processing liquid in the filling of the circulation path, and performing stopping all of the multiple pumps to stop circulation of the processing liquid in all of the multiple circulation paths between the filling of the circulation path and the circulating of the processing liquid.

16. The processing liquid supply method of claim 15, wherein, in the circulating of the processing liquid, the multiple pumps are operated to achieve the predetermined processing set flow rate when measurement values of all of the multiple flowmeters have reached the initial set flow rate.

17. The processing liquid supply method of claim 11, wherein the circulation path is branched downstream of the pump into multiple branch circulation paths, the flowmeter includes multiple flowmeters, the flowmeter is provided in each of the multiple branch circulation paths, and the method further comprises operating the pump to fill all of the multiple branch circulation paths with the processing liquid in the filling of the circulation path, and performing stopping the pump to stop circulation of the processing liquid in all of the multiple branch circulation paths between the filling of the circulation path and the circulating of the processing liquid.

18. The processing liquid supply method of claim 17, wherein, in the circulating of the processing liquid, the pump is operated to achieve the predetermined processing set flow rate when measurement values of all of the multiple flowmeters have reached the initial set flow rate.

19. The processing liquid supply method of claim 11, wherein the pump is a magnetic levitation pump configured to force-feed the processing liquid as a rotator of the magnetic levitation pump is rotated in the processing liquid while being magnetically levitated, the method further comprises performing force-feeding of the processing liquid while controlling a rotation speed of the rotator based on the measurement value of the flowmeter, and in the filling of the circulation path, the pump is operated while fixing the rotation speed of the rotator to a preset rotation speed.

20. A computer-readable recording medium having stored thereon computer-executable instructions that, in response to execution, cause a processing liquid supply system to perform a processing liquid supply method as claimed in claim 11.