DESCRIPTION

TITLE:

POLISHING APPARATUS

BACKGROUND

Technical Field

[0001] The disclosure relates to a polishing apparatus.

Description of Related Art

[0002] In the related art, a polishing apparatus polishing a substrate is known (for example, see Patent Literature 1). The polishing apparatus includes a polishing machine that polishes a substrate and a flow channel that supplies a polishing solution to the polishing machine.

Citation List

Patent Documents

[0003] [Patent Document 1] Japanese Patent Laid-Open No. 2014-161927

SUMMARY

Problems to be Solved

[0004] In the aforementioned polishing apparatus according to the related art, as the number of substrates polished by the polishing machine increases, for example, polishing solution remaining in the channel dries to become deposits which become partially fixed to the flow channel, the flow channel becomes partially clogged, and thus the discharged polishing solution is disturbed, which may decrease the polishing performance. When a discharge nozzle having a discharge hole narrower than the flow channel is used downstream in a pipe, the polishing solution is likely to remain in the discharge hole and thus clogging is more likely to occur. The polishing apparatus according to the related art is not configured to detect that clogging has occurred in the flow channel (including the discharge nozzle). In this case, deposits may grow to completely close the flow channel.

[0005] The disclosure was made in consideration of the aforementioned circumstances and provides a technique that can curb occurrence of clogging in a flow channel due to a polishing solution remaining in the flow channel and detect occurrence of clogging when clogging has occurred in the flow channel.

Means for Solving the Problems

[0006] (Aspect 1)

According to an aspect of the disclosure, there is provided a polishing apparatus including: a polishing machine polishing a substrate; a flow channel supplying a polishing solution or a cleaning solution to the polishing machine; a switching device disposed in the flow channel and configured to switch between the polishing solution and the cleaning solution and to cause the solution to flow in the flow channel; a sensor detecting a pressure or a flow rate of the cleaning solution flowing in the flow channel; and a control device, wherein the control device performs: a cleaning process of controlling the switching device such that the cleaning solution flows in the flow channel and then controlling the switching device such that the polishing solution flows in the flow channel when the number of substrates polished by the polishing machine reaches a predetermined number; and a clogging detecting process of detecting whether clogging has occurred in the flow channel based on the pressure or the flow rate of the cleaning solution detected by the sensor when the cleaning solution flows in the flow channel.

[0007] According to this aspect, when the number of substrates polished by the polishing machine reaches a predetermined number, the flow channel can be cleaned with the cleaning solution. Accordingly, it is possible to curb occurrence of clogging in a flow channel due to a polishing solution remaining in the flow channel. According to this embodiment, when clogging has occurred in the flow channel, it is possible to detect occurrence of clogging through the clogging detecting process.

[0008] (Aspect 2)

The polishing apparatus according to Aspect 1 may further include a flow rate adjusting device disposed at a position downstream from the switching device in the flow channel and configured to adjust a flow rate of the cleaning solution flowing in the flow channel to a predetermined range, and the sensor may be a pressure sensor disposed at a position downstream from the flow rate adjusting device in the flow channel.

[0009] According to this aspect, since the flow rate adjusting device is provided, a pressure at a position downstream from the flow rate adjusting device in the flow channel can be effectively increased when clogging has occurred in the flow channel. Accordingly, it is possible to effectively detect an increase in pressure of the flow channel using the pressure sensor disposed at a position downstream from the flow rate adjusting device. As a result, it is possible to effectively detect that clogging has occurred in the flow channel.

[0010] (Aspect 3)

In Aspect 2, the control device may detect whether clogging has occurred in the flow channel based on a maximum value, an average value, or a minimum value of values of the

pressure detected by the pressure sensor when the flow rate of the cleaning solution is in the predetermined range.

[0011] (Aspect 4)

In Aspect 2 or 3, the control device may determine that clogging has occurred in the flow channel when the value of the pressure detected by the pressure sensor is equal to or greater than a preset first threshold value, and the control device may determine that a degree of clogging in the flow channel is low when the value of the pressure detected by the pressure sensor is equal to or greater than the first threshold value and is less than a second threshold value greater than the first threshold value and determine that a degree of clogging in the flow channel is high when the value of the pressure detected by the pressure sensor is equal to or greater than the second threshold value.

[0012] (Aspect 5)

The polishing apparatus according to any one of Aspects 1 to 4 may further include a notification device, and the control device may cause the notification device to notify that clogging has occurred in the flow channel when detecting in the clogging detecting process that clogging has occurred in the flow channel.

[0013] (Aspect 6)

In Aspect 4 or 5, the control device may prohibit the polishing machine from polishing a substrate when determining that a degree of clogging in the flow channel is high.

[0014] With this configuration, it is possible to curb polishing of a substrate by the polishing machine when a degree of clogging in the flow channel is high.

[0015] (Aspect 7)

In any one of Aspects 1 to 6, the flow channel may include a single pipe, and a downstream end of the flow channel may be constituted by an end of the pipe.

[0016] (Aspect 8)

In any one of Aspects 1 to 6, the flow channel may include a single pipe and a discharge nozzle connected to a downstream end of the pipe and including at least one discharge hole.

[0017] (Aspect 9)

In any one of Aspects 1 to 8, the control device may store the number of substrates which have been polished by the polishing machine each time the polishing machine polishes a substrate, and the control device may reset the stored number of substrates to zero when the cleaning solution flows in the flow channel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 is a diagram schematically illustrating a configuration of a polishing apparatus according to an embodiment.

(A) and (B) of FIG. 2 are plan views schematically illustrating a polishing machine according to the embodiment.

(A) and (B) of FIG. 3 are diagrams schematically illustrating specific examples of a discharge nozzle that can be connected to a downstream end of a pipe according to the embodiment.

FIG. 4 is a flowchart illustrating an example of a cleaning process according to the embodiment.

FIG. 5 is a flowchart illustrating an example of a clogging detecting process according to the embodiment.

(A) of FIG. 6 is a diagram schematically illustrating threshold values of a pressure used for the clogging detecting process according to the embodiment, and (B) of FIG. 6 is a diagram schematically illustrating an example of change of a flow rate of a cleansing solution flowing in a flow channel when the clogging detecting process according to the embodiment is performed.

FIG. 7 is a diagram schematically illustrating a configuration of a polishing apparatus according to Modified Example 1 of the embodiment.

FIG. 8 is a diagram schematically illustrating threshold values used in a clogging detecting process according to Modified Example 2 of the embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0019] Hereinafter, an embodiment of the disclosure will be described with reference to the accompanying drawings. The drawings are schematically illustrated for the purpose of easy understanding of features, and dimensional ratios of constituents or the like are not limited to actual ones.

[0020] FIG. 1 is a diagram schematically illustrating a configuration of a polishing apparatus 1 according to an embodiment. The polishing apparatus 1 includes a polishing machine 10, a polishing solution supply device 20, a cleaning solution supply device 30, a switching device 40, a flow rate adjusting device 50, various flow channels (a flow channel 70a, a flow channel 70c, and a flow channel 70b), various sensors (a pressure sensor 60 and a flow rate sensor 61), a

notification device 80, and a control device 90.

[0021] The polishing machine 10 will be first described below. (A) and (B) of FIG. 2 are plan views schematically illustrating the polishing machine 10. Specifically, (A) of FIG. 2 schematically illustrates a state in which the polishing machine 10 is polishing a substrate Wf, and (B) of FIG. 2 schematically illustrates a state in which polishing is not performed by the polishing machine 10. In (A) of FIG. 2, a flow channel 70a which will be described later is located at a "first position." In (B) of FIG. 2, the flow channel 70a is located at a "second position."

[0022] Referring to FIG. 1, (A) of FIG. 2, and (B) of FIG. 2, the polishing machine 10 is a device that polishes a substrate Wf. The polishing machine 10 according to this embodiment is, for example, a chemical mechanical polishing (CMP) machine that can perform CMP.

[0023] As illustrated in (A) and (B) of FIG. 2, the polishing machine 10 according to this embodiment includes a polishing table 11 and a polishing head 12. The polishing machine 10 may further include a dresser 13 and an atomizer 14. The polishing table 11 holds a polishing pad Pd. Specifically, the polishing table 11 according to this embodiment includes a disc-shape member, and the polishing pad Pd is attached to the top surface thereof. While a substrate Wf is being polished, the substrate Wf which is a polishing object is pressed onto the top surface (the surface) of the polishing pad Pd. The top surface of the polishing pad Pd corresponds to a polishing surface for polishing a substrate Wf. The polishing table 11 is rotationally driven by a driving mechanism such as a rotary motor. A rotating operation of the polishing table 11 is controlled by the control device 90. A rotating direction of the polishing table 11 may be clockwise or counterclockwise in a plan view. In (A) of FIG. 2, the polishing table 11 rotates, for example, clockwise in a plan view.

[0024] A specific type of the polishing pad Pd is not particularly limited, and various polishing pads such as a hard foamed type polishing pad, an unwoven fabric type polishing pad, and a suede type polishing pad can be used.

[0025] The polishing head 12 is a member for holding a substrate Wf. In (A) of FIG. 2, the substrate Wf is held on the bottom surface of the polishing head 12. The polishing head 12 is configured to rotate while pressing a bottom surface (that is, a polished surface) of a substrate Wf against the polishing pad Pd. Specifically, the polishing head 12 according to this embodiment is driven, for example, by a driving mechanism to rotate in a predetermined rotating direction (for example, the same rotating direction as the polishing table 11 in (A) of FIG. 2).

[0026] The substrate Wf illustrated in (A) of FIG. 2 is, for example, a circular substrate, but

the shape of the substrate Wf is not limited thereto. The shape of the substrate Wf may be a polygonal shape or another shape.

[0027] When a substrate Wf is polished by the polishing machine 10, a polishing solution flows in the flow channel 70a. The polishing solution discharged from the flow channel 70a is supplied to the polishing pad Pd. The polishing machine 10 polishes (CMP-polishes) a substrate Wf while rubbing the substrate Wf with the polishing pad Pd under presence of the polishing solution.

[0028] The dresser 13 is a device for dressing the polishing surface of the polishing pad Pd. Polishing particles (for example, diamond) are provided on the bottom surface of the dresser 13. The atomizer 14 is a device for cleaning the polishing pad Pd by spraying pure water with a high pressure (a pressure higher than a predetermined pressure) to the polishing pad Pd. The polishing machine 10 may not include the dresser 13 or the atomizer 14.

[0029] In this embodiment, a predetermined area (at least an area within a predetermined distance upward from the downstream end) of the flow channel 70a is configured to rotate about a rotary shaft 15. Accordingly, the flow channel 70a can move between a “first position (or a polishing position)” at which the downstream end of the flow channel 70a is located above the polishing pad Pd as illustrated in (A) of FIG. 2 and a “second position (or a retracting position)” at which the downstream end of the flow channel 70a is not located above the polishing pad Pd as illustrated in (B) of FIG. 2. A rotating operation of the rotary shaft 15 is controlled by the control device 90. The flow channel 70a is located at the first position at least when a substrate Wf is being polished.

[0030] The flow channel 70a may be configured to swing within a predetermined swinging angle range about the rotary shaft 15. In this case, the control device 90 may cause the flow channel 70a to swing, for example, when a substrate Wf is being polished. In (A) of FIG. 2, the swinging angle range is indicated by “A1.”

[0031] Referring to FIG. 1, the polishing solution supply device 20 is a device for supplying a polishing solution. The polishing solution supply device 20 communicates with a first inlet 41 of the switching device 40 via a flow channel 70c. A specific configuration of the polishing solution supply device 20 is not particularly limited, and the polishing solution supply device 20 according to this embodiment includes, for example, a tank storing a polishing solution and a pump feeding the polishing solution in the tank. A polishing solution supply operation which is performed by the polishing solution supply device 20 is controlled by the control device 90.

[0032] A solution including a polishing agent such as silica or cerium oxide can be used as the

polishing solution. Specific components of the polishing solution are not particularly limited and can be appropriately set according to the type of the substrate Wf.

[0033] The cleaning solution supply device 30 is a device for supplying a cleaning solution. The cleaning solution supply device 30 communicates with a second inlet 42 of the switching device 40 via a flow channel 70b. A specific configuration of the cleaning solution supply device 30 is not particularly limited, and the cleaning solution supply device 30 according to this embodiment includes, for example, a tank storing a cleaning solution and a pump feeding the polishing solution in the tank. A cleaning solution supply operation which is performed by the cleaning solution supply device 30 is controlled by the control device 90.

[0034] Specific components of the cleaning solution are not particularly limited as long as the polishing solution remaining in the flow channel 70a can be cleaned therewith. Water, preferably, pure water, can be used as a specific example of the cleaning solution. Alternatively, a fluid mixture of water or pure ware and gas or a fluid mixture of water or pure water and bubbles may be used as a specific example of the cleaning solution. As the gas or bubbles, specifically, gas or bubbles of nitrogen, inert gas, ozone, or the like can be used. In this embodiment, pure water is used as an example of the cleaning solution. Specifically, pure water with electrical resistivity of 0.1 (MΩ·cm) or more can be used as the pure water.

[0035] The switching device 40 is disposed in the flow channel 70a. Specifically, the switching device 40 according to this embodiment is disposed at an upstream end of the flow channel 70a. More specifically, the upstream end of the flow channel 70a is connected to an outlet 43 of the switching device 40. The switching device 40 is configured to switch between a polishing solution supplied from the polishing solution supply device 20 and a cleaning solution supplied from the cleaning solution supply device 30 to flow in the flow channel 70a. The operation of the switching device 40 is controlled by the control device 90. For example, a flow channel switching valve that can switch an inlet communicating with the outlet 43 between the first inlet 41 and the second inlet 42 can be used as the switching device 40.

[0036] Specifically, the switching device 40 according to this embodiment switches between a “first state (or a polishing solution flowing state)” in which the first inlet 41 and the outlet 43 are connected and the second inlet 42 and the outlet 43 are disconnected and a “second state (or a cleaning solution flowing state)” in which the second inlet 42 and the outlet 43 are connected and the first inlet 41 and the outlet 43 are disconnected according to an instruction from the control device 90. In the first state, the polishing solution supplied from the polishing solution supply device 20 can flow in the flow channel 70c and the flow channel 70a. On the other

hand, in the second state, the cleaning solution supplied from the cleaning solution supply device 30 can flow in the flow channel 70b and the flow channel 70a.

[0037] The flow channel 70a is a flow channel (that is, a "main flow channel") for supplying a liquid (Lq) (specifically, the polishing solution or the cleaning solution) discharged from the switching device 40 to the polishing machine 10. The flow channel 70a according to this embodiment is configured to allow the outlet 43 of the switching device 40 to communicate with the polishing machine 10. When a substrate Wf is polished, a polishing solution flows in the flow channel 70a. On the other hand, when the flow channel 70a is cleaned, a cleaning solution flows in the flow channel 70a.

[0038] The flow channel 70a according to this embodiment is constituted by a pipe 71 (the flow channel 70b or the flow channel 70c is formed of the same pipe 71 as the pipe 71 of the flow channel 70a). Specifically, the flow channel 70a according to this embodiment is constituted by, for example, a single pipe 71. A specific value of an inner diameter of the pipe 71 (a diameter of a cavity through which a liquid flows in the pipe 71) is not particularly limited and ranges, for example, from 1 mm to 5 mm in this embodiment.

[0039] The downstream end of the flow channel 70a (that is, an "outlet of a liquid in the flow channel 70a") in this embodiment is constituted by an end (a downstream end) of the single pipe 71. As illustrated in FIG. 1, a liquid Lq flowing in the pipe 71 is discharged from the end of the pipe 71. For example, a state in which a liquid Lq is discharged in an axial direction of the pipe 71 from the end of the pipe 71 is illustrated in FIG. 1. In this embodiment, "downstream in the flow channel 70a" specifically means "downstream in a flowing direction of a liquid flowing in the flow channel 70a."

[0040] The configuration of the flow channel 70a is not limited to the aforementioned configuration. For example, a discharge nozzle 72 which will be described below may be connected to the downstream end of the pipe 71 serving as the flow channel 70a.

[0041] (A) and (B) of FIG. 3 are diagrams schematically illustrating specific examples of a discharge nozzle 72 that can be connected to a downstream end of a pipe 71. As illustrated in (A) of FIG. 3, a discharge nozzle 72 including a plurality of discharge holes 73 may be connected to the downstream end of the pipe 71. Each discharge hole 73 is configured to discharge a liquid Lq (a polishing solution or a cleaning solution) downward. Each discharge hole 73 is configured to discharge a liquid Lq straightly (in a non-fan shape). The disclosure is not limited to this configuration and, for example, the discharge hole 73 may be configured to discharge a liquid Lq in a fan shape.

[0042] As illustrated in (B) of FIG. 3, a discharge nozzle 72a including a single discharge hole 73a may be connected to the downstream end of the pipe 71. The discharge hole 73a is configured to discharge a liquid Lq downward. The discharge hole 73a is configured to discharge a liquid Lq in a fan shape as illustrated in (B) of FIG. 3. The disclosure is not limited to this configuration and, for example, the discharge hole 73a may be configured to discharge a liquid Lq straightly.

[0043] Referring to FIG. 1, the pressure sensor 60 is disposed in the flow channel 70a. The pressure sensor 60 detects a pressure (kPa) of a liquid (a polishing solution or a cleaning solution) flowing in the flow channel 70a and transmits the detected pressure to the control device 90. A specific position at which the pressure sensor 60 is disposed in the flow channel 70a is not particularly limited and may be a position upstream or downstream from the flow rate adjusting device 50 in the flow channel 70a. The pressure sensor 60 according to this embodiment is disposed, for example, at a position downstream from the flow rate adjusting device 50 in the flow channel 70a.

[0044] In FIG. 1, the pressure sensor 60 is disposed ta a position downstream from the flow rate sensor 61 which will be described later, but the disclosure is not limited to this configuration. The pressure sensor 60 may be disposed at a position upstream from the flow rate sensor 61 (a position downstream from the flow rate adjusting device 50 in this embodiment).

[0045] The flow rate sensor 61 according to this embodiment is disposed at a position downstream from the flow rate adjusting device 50 in the flow channel 70a. The flow rate sensor 61 detects a flow rate (ml/sec) of a liquid (a polishing solution or a cleaning solution) flowing in the flow channel 70a and transmits the detected flow rate to the control device 90. The control device 90 controls the flow rate adjusting device 50 based on the flow rate detected by the flow rate sensor 61.

[0046] The flow rate sensor 61 may be formed as a unified body with the flow rate adjusting device 50 which will be described later. In other words, the flow rate adjusting device 50 which will be described later may be a “flow rate adjusting device with a flow rate sensor.”

[0047] The flow rate adjusting device 50 according to this embodiment is disposed at a position downstream from the switching device 40 in the flow channel 70a. The flow rate adjusting device 50 is configured to adjust at least a flow rate of a cleaning solution flowing in the flow channel 70a to a predetermined range in a cleaning process which will be described later. Specifically, the flow rate adjusting device 50 adjusts a flow rate of a cleaning solution

flowing in the flow channel 70a based on the flow rate detected by the flow rate sensor 61.

[0048] More specifically, the flow rate adjusting device 50 according to this embodiment adjusts a flow rate of a cleaning solution flowing in the flow channel 70a such that the flow rate of the cleaning solution detected by the flow rate sensor 61 is within a predetermined range (in a range equal to or greater than a lower limit F1 and equal to or less than an upper limit F2 in (B) of FIG. 6 which will be described later) according to an instruction from the control device 90.

[0049] The flow rate adjusting device 50 may additionally adjust a flow rate of a polishing solution flowing in the flow channel 70a to a predetermined range in a process of polishing a substrate Wf. In this case, the predetermined range of the flow rate of the cleaning solution and the predetermined range of the flow rate of the polishing solution may have the same value or different values. It is preferable that the predetermined range of the flow rate of the cleaning solution be greater than the predetermined range of the flow rate of the polishing solution in that the flow channel 70a can be effectively cleaned using the cleaning solution in comparison with the other case.

[0050] However, in this embodiment, the predetermined range of the flow rate of the cleaning solution is greater than the predetermined range of the flow rate of the polishing solution. That is, in this embodiment, the flow rate of the cleaning solution flowing in the flow channel 70a in the cleaning process which will be described later is greater than the flow rate of the polishing solution flowing in the flow channel 70a at the time of polishing of a substrate Wf.

[0051] The notification device 80 is a device that notifies a user of the polishing apparatus 1 of predetermined information. Specifically, the notification device 80 according to this embodiment is configured to notify at least that clogging has occurred in the flow channel 70a according to an instruction from the control device 90. For example, a display can be used as the notification device 80.

[0052] The control device 90 is a device that comprehensively controls the operation of the polishing apparatus 1. Specifically, the control device 90 according to this embodiment includes a microcomputer. The microcomputer includes a processor 91 and a storage device 92 which is a non-transitory storage medium. The control device 90 controls the operation of the polishing apparatus 1 by causing the processor 91 to operate based on commands of a program stored in the storage device 92.

[0053] The “cleaning process” which is performed by the control device 90 will be described below. FIG. 4 is a flowchart illustrating an example of the cleaning process according to this embodiment. The control device 90 repeatedly performs the flowchart illustrated in FIG. 4

with a predetermined cycle.

[0054] First, the control device 90 according to this embodiment stores the number of substrates Wf polished by the polishing machine 10 in the storage device 92 whenever the polishing machine 10 polishes a substrate Wf. The control device 90 according to this embodiment resets the number of substrates Wf stored in the storage device 92 (the number of substrates Wf polished by the polishing machine 10) to zero when a cleaning solution is made to flow in the flow channel 70a (when Step S20 which will be described later is performed or when a cleaning solution is made to flow in the flow channel 70a through a manual operation or the like). As a result, the number of substrates Wf polished by the polishing machine 10 in a period from the time at which the cleaning solution previously has flown in the flow channel 70a to the time at which the cleaning solution flows in the flow channel 70a in the next time is stored in the storage device 92.

[0055] In Step S10, the control device 90 determines whether the number of substrates Wf polished by the polishing machine 10 (the number of substrates) has reached a predetermined number. Specifically, the control device 90 according to this embodiment determines whether the number of substrates stored in the storage device 92 (which is a sum of the number of substrates Wf polished by the polishing machine 10 after the cleaning process has been previously performed) has reached the predetermined number.

[0056] A specific value of the predetermined number is not particularly limited, and a number in which clogging is considered to occur in the flow channel 70a when the number of substrates reaches the predetermined number can be used. As the predetermined number, an appropriate number can be calculated by experiment or the like in advance and stored in the storage device 92.

[0057] When the determination result of Step S10 is YES (when the number of substrates is the predetermined number), the control device 90 performs a cleaning process (Step S20). Specifically, in Step S20, the control device 90 stops polishing of a substrate Wf using the polishing machine 10 and controls the cleaning solution supply device 30 and the switching device 40 such that a cleaning solution flows in the flow channel 70a (a “main cleaning process”). Subsequently, the control device 90 controls the polishing solution supply device 20 and the switching device 40 such that a polishing solution flows in the flow channel 70a (a “replacement process”).

[0058] More specifically, in the main cleaning process, the control device 90 causes the cleaning solution supply device 30 to start supply of a cleaning solution and causes the switching

device 40 to switch to the "second state." Accordingly, the cleaning solution supplied from the cleaning solution supply device 30 flows in the flow channel 70b and then flows in the flow channel 70a. As a result, the flow channel 70a can be cleaned with the cleaning solution. Specifically, it is possible to wash the polishing solution remaining in the flow channel 70a away using the cleaning solution and to wash deposits deposited in the flow channel 70a away using the cleaning solution.

[0059] On the other hand, in the replacement process, the control device 90 causes the polishing solution supply device 20 to start supply of a polishing solution and causes the switching device 40 to switch the "first state." Accordingly, the polishing solution supplied from the polishing solution supply device 20 flows in the flow channel 70c and then flows in the flow channel 70a. As a result, the cleaning solution remaining in the flow channel 70a can be replaced with the polishing solution.

[0060] In this cleaning process, the control device 90 may control the cleaning solution supply device 30 and the flow rate adjusting device 50 such that the cleaning solution flows in the flow channel 70a at a predetermined flow rate (ml/sec) for a preset cleaning time (sec).

[0061] As the predetermined flow rate of the cleaning solution, a flow rate in the predetermined range (in the range equal to or greater than the lower limit F1 and equal to or less than the upper limit F2), that is, a flow rate selected from the predetermined range, can be used. Specifically, an average value of the lower limit F1 and the upper limit F2 may be used as an example of the predetermined flow rate.

[0062] In this case, it is preferable that the "predetermined cleaning time" be set to a predetermined time equal to or greater than a "minimum cleaning time." For example, a value obtained by dividing a volume (ml) of the flow channel 70a from the switching device 40 to the downstream end by the predetermined flow rate (ml/sec) can be used as the minimum cleaning time.

[0063] The control device 90 may perform Step S20 in a state in which the flow channel 70a is located at the "first position (see (A) of FIG. 2)." This configuration is preferable in that the flow channel 70a does not have to be returned to the first position when a substrate Wf is next polished (when Step S30 which will be described later is started).

[0064] Alternatively, the control device 90 may perform Step S20 in a state in which the flow channel 70a is located at the "second position (see (B) of FIG. 2)." This configuration is preferable in that the cleaning solution discharged from the flow channel 70a can be prevented form remaining on the polishing pad Pd of the polishing table 11. When Step S20 is performed

in the state in which the flow channel 70a is located at the "second position" in this way, it is preferable, for example, that the control device 90 return the flow channel 70a to the "first position" in a period from the time at which Step S20 is ended to the time at which Step S30 which will be described later is started.

[0065] Referring to FIG. 4, subsequently to Step S20, the control device 90 causes the polishing machine 10 to polish a next substrate Wf (Step S30). That is, in Step S30, polishing of a substrate Wf by the polishing machine 10 is restarted. Specifically, in this case, the polishing machine 10 polishes a substrate Wf while rubbing the substrate Wf on the polishing pad Pd under presence of the polishing solution supplied from the polishing solution supply device 20 as described above. When the determination result of Step S10 is NO, the control device 90 does not perform Step S20 but performs Step S30.

[0066] As described above, according to this embodiment, when the number of substrates Wf polished by the polishing machine 10 reaches a predetermined number, the cleaning process of Step S20 is performed and thus it is possible to clean the flow channel (specifically, the flow channel 70a in this embodiment) with the cleaning solution. Accordingly, it is possible to curb occurrence of clogging in the flow channel 70a due to the polishing solution remaining in the flow channel 70a.

[0067] Specifically, according to this embodiment, it is possible to curb drying of the polishing solution remaining in the pipe 71 of the flow channel 70a and fixation thereof to an inner wall of the pipe 71 or fixation thereof to the downstream end (the outlet) of the pipe 71. When the discharge nozzle 72 or 72a is connected to the pipe 71, it is also possible to curb occurrence of clogging in the discharge nozzle 72 or 72a due to fixation of the polishing solution to the discharge nozzle 72 or 72a.

[0068] According to this embodiment, in the cleaning process of Step S20, since the cleaning solution remaining in the flow channel 70a is replaced with the polishing solution after the flow channel 70a has been cleaned with the cleaning solution, it is possible to curb dilution of the polishing solution supplied from the polishing machine 10 due to the cleaning solution remaining in the flow channel 70a in Step S30. Accordingly, it is possible to curb a decrease in polishing rate of a substrate Wf due to dilution of the polishing solution by the cleaning solution.

[0069] In this embodiment, "the flow channel 70a is clogged" includes, for example, a phenomenon in which deposits of the polishing solution are fixed to a part of the inner wall of the flow channel 70a and a liquid has difficulty flowing in the flow channel 70a in addition to a phenomenon in which the flow channel 70a is completely closed such that a liquid cannot flow

in the flow channel 70a. When the discharge nozzle 72 illustrated in (A) of FIG. 3 is connected to the downstream end of the pipe 71, “the flow channel 70a is clogged” includes a phenomenon in which clogging occurs in at least one of the plurality of discharge holes 73 of the discharge nozzle 72.

[0070] A “clogging detecting process” which is performed by the control device 90 will be described below. FIG. 5 is a flowchart illustrating an example of a clogging detecting process according to this embodiment. The control device 90 according to this embodiment starts Step S40 when the cleaning process of Step S20 is being performed. In Step S40, the control device 90 detects whether clogging has occurred in the flow channel 70a based on the pressure detected by the pressure sensor 60 (that is, the pressure of the cleaning solution in the flow channel 70a) when the cleaning solution flows in the flow channel 70a in the cleaning process. Details thereof are the same as follows with reference to the drawings.

[0071] (A) of FIG. 6 is a diagram schematically illustrating threshold values of the pressure used in the clogging detecting process. Specifically, a first threshold value P1 and a second threshold value P2 are illustrated as threshold values of the pressure used to determine whether clogging has occurred in the flow channel 70a in (A) of FIG. 6. The second threshold value P2 is a value greater than the first threshold value P1. The first threshold value P1 and the second threshold value P2 are stored in the storage device 92 of the control device 90 in advance. Lines L1, L2, and L3 illustrated in (A) of FIG. 6 schematically represent temporal change of the pressure of the cleaning solution detected by the pressure sensor 60.

[0072] In Step S40, the control device 90 acquires a value of the pressure of the cleaning solution detected by the pressure sensor 60 and determines whether the acquired value of the pressure is equal to or greater than the preset first threshold value P1. When the value of the pressure detected by the pressure sensor 60 is equal to or greater than the first threshold value P1, the control device 90 determines that clogging has occurred in the flow channel 70a (that is, detects that clogging has occurred in the flow channel 70a).

[0073] On the other hand, when the value of the pressure detected by the pressure sensor 60 is less than the first threshold value P1, the control device 90 determines that clogging has not occurred in the flow channel 70a (that is, that the flow channel 70a is “normal”).

[0074] When the value of the pressure detected by the pressure sensor 60 is equal to or greater than the first threshold value P1 and less than the second threshold value P2, the control device 90 determines that a degree of clogging in the flow channel 70a is low (or determines that a “light defect” has occurred in the flow channel 70a). When the value of the pressure detected

by the pressure sensor 60 is equal to or greater than the second threshold value P2, the control device 90 determines that the degree of clogging in the flow channel 70a is high (or determines that a “heavy defect” has occurred in the flow channel 70a).

[0075] That is, in (A) of FIG. 6, the control device 90 determines that clogging has not occurred in the flow channel 70a when the pressure detected by the pressure sensor 60 represents the line L1, determines that the degree of clogging in the flow channel 70a is low when the detected pressure represents the line L2, and determines that the degree of clogging in the flow channel 70a is high when the detected pressure represents the line L3.

[0076] A specific value of the first threshold value P1 is not particularly limited, and a value obtained by preparing a flow channel 70a in a state in which clogging has not occurred (a normal flow channel 70a), measuring a pressure of a cleaning solution flowing through a predetermined position of the normal flow channel 70a in advance, and adding a predetermined pressure to the value of the measured pressure (that is, a normal value of the pressure) is used in this embodiment. It is preferable that a value greater by a measurement accuracy value (that is, a measurement error of the pressure sensor 60) secured by a manufacturer of the pressure sensor 60 be used as the predetermined pressure.

[0077] A specific value of the second threshold value P2 is nor particularly limited as long as it is greater than the first threshold value P1 and can be appropriately set, for example, by experiment.

[0078] The control device 90 according to this embodiment compares the value of the pressure of the cleaning solution detected by the pressure sensor 60 with two threshold values (the first threshold value P1 and the second threshold value P2) in the clogging detecting process as described above, but is not limited to this configuration. The control device 90 may determine whether clogging has occurred in the flow channel 70a by comparing the value of the pressure of the cleaning solution detected by the pressure sensor 60 with one threshold value (only the first threshold value P1 or only the second threshold value P2) in the clogging detecting process.

[0079] (B) of FIG. 6 is a diagram schematically illustrating an example of change of a flow rate of a cleaning solution flowing in the flow channel 70a when the clogging detecting process is being performed. Specifically, a line L4 in (B) of FIG. 6 represents an example of the change of a flow rate of the cleaning solution flowing in the flow channel 70a.

[0080] In Step S40, the control device 90 may cause the pressure sensor 60 to detect the pressure of the cleaning solution when a flow rate of the cleaning solution flowing in the flow channel 70a is within a predetermined range. Specifically, the predetermined range is a range

equal to or greater than a lower limit F1 and equal to or less than an upper limit F2 in (B) of FIG. 6, which is also a control target range of the flow rate in the flow rate adjusting device 50.

[0081] Specifically, in this case, the pressure sensor 60 monitors a pressure when the flow rate of the cleaning solution (which is acquired by the flow rate sensor 61) flowing in the flow channel 70a is in the range equal to or greater than the lower limit F1 and equal to or less than the upper limit F2 and transmits the monitored pressure to the control device 90. Then, the control device 90 may detect whether clogging has occurred in the flow channel 70a by comparing a maximum value, an average value, or a minimum value of the pressure detected by the pressure sensor 60 when the flow rate of the cleaning solution is in the predetermined range with the aforementioned threshold values (the first threshold value P1 and the second threshold value P2).

[0082] Referring to FIG. 5, the control device 90 performs Step S41 subsequently to Step S40. In Step S41, the control device 90 causes the notification device 80 to notify whether clogging has occurred in the flow channel 70a. Specifically, the control device 90 according to this embodiment causes the display which is an example of the notification device 80 to display that clogging has occurred in the flow channel 70a. With this configuration, a user can early ascertain that clogging as occurred in the flow channel 70a.

[0083] In addition, the control device 90 preferably causes the notification device 80 to notify that the degree of clogging in the flow channel 70a is low (or that a light defect has occurred in the flow channel 70a) or that degree of clogging in the flow channel 70a is high (or that a heavy defect has occurred in the flow channel 70a). With this configuration, a user can early ascertain the degree of clogging in the flow channel 70a.

[0084] When it is determined in Step S40 that the degree of clogging in the flow channel 70a is high, the control device 90 may prohibit the polishing machine 10 from polishing a substrate Wf. That is, in this case, polishing of a substrate Wf by the polishing machine 10 is not performed. With this configuration, it is possible to curb polishing of a substrate Wf by the polishing machine 10 when the degree of clogging in the flow channel 70a is high.

[0085] In this case, the control device 90 can release the prohibition of polishing when a "prohibition release command" indicating that the prohibition of polishing of a substrate Wf by the polishing machine 10 is released is received. Specifically, in this case, the prohibition release command may be delivered to the control device 90, for example, by allowing a user to press a "prohibition release button" installed in the polishing apparatus 1.

[0086] According to the aforementioned embodiment, since the cleaning process is performed,

the flow channel 70a can be cleaned with the cleaning solution when the number of substrates Wf polished by the polishing machine 10 has reached a predetermined number. Accordingly, it is possible to curb occurrence of clogging in a flow channel (specifically the flow channel 70a) due to the polishing solution remaining in the flow channel 70a. Even when clogging has occurred in the flow channel 70a, it is possible to detect occurrence of clogging in the flow channel 70a through the clogging detecting process.

[0087] According to this embodiment, since the flow rate adjusting device 50 is provided, it is possible to effectively increase the pressure at a position downstream from the flow rate adjusting device 50 in the flow channel 70a when clogging has occurred in the flow channel 70a. Accordingly, it is possible to effectively detect an increase in pressure in the flow channel 70a using the pressure sensor 60 disposed at a position downstream from the flow rate adjusting device 50. As a result, it is possible to effectively detect that clogging has occurred in the flow channel 70a.

[0088] In the aforementioned embodiment, the control device 90 determines whether the number of substrates Wf polished by the polishing machine 10 has reached a predetermined number by actually measuring the number of substrates Wf polished by the polishing machine 10 in Step S10, but may determine whether the number of substrates Wf polished by the polishing machine 10 has reached the predetermined number based on other parameters associated with the number of substrates Wf polished by the polishing machine 10.

[0089] For example, an operating time of the polishing machine 10 (that is, a total time in which the process of polishing a substrate Wf is performed), a supply time of the polishing solution from the polishing solution supply device 20, a supply quantity of the polishing solution from the polishing solution supply device 20 can be used as the parameters. Alternatively, for example, when a flow channel switching valve for switching between supply and supply stop of a polishing solution is provided in the flow channel 70a, the switching frequency of the flow channel switching valve may be used as the parameter. The number of substrates Wf polished by the polishing machine 10 increases as the operating time of the polishing machine 10 increases, as the supply time of the polishing solution increases, as the supply quantity of the polishing solution increases, or as the switching frequency of the flow channel switching valve increases.

[0090] (Modified Example 1 of embodiment)

In the aforementioned embodiment, the installation positions of the flow rate adjusting device 50, the flow rate sensor 61, and the pressure sensor 60 are not limited to the

flow channel 70a. FIG. 7 is a diagram schematically illustrating a configuration of a polishing apparatus 1a according to Modified Example 1 of the embodiment. In FIG. 7, the polishing machine 10, the notification device 80, and the control device 90 are not illustrated.

[0091] The polishing apparatus 1a according to this modified example is different from the polishing apparatus 1 according to the embodiment illustrated in FIG. 1, in that the flow rate adjusting device 50, the flow rate sensor 61, and the pressure sensor 60 are not provided in the flow channel 70a, the flow rate adjusting device 50 and the flow rate sensor 61 are provided in each of the flow channel 70b and the flow channel 70c, and the pressure sensor 60 is provided in the flow channel 70b. The other configuration of the polishing apparatus 1a according to this modified example is the same as that of the polishing apparatus 1.

[0092] The flow rate adjusting device 50 provided in the flow channel 70b adjusts the flow rate of the cleaning solution flowing in the flow channel 70b to a predetermined range based on the flow rate of the cleaning solution detected by the flow rate sensor 61 provided in the flow channel 70b. The method of adjusting the flow rate of the cleaning solution in the flow rate adjusting device 50 is the same as that in the flow rate adjusting device 50 according to the aforementioned embodiment (the flow rate adjusting device 50 provided in the flow channel 70a).

[0093] On the other hand, the flow rate adjusting device 50 provided in the flow channel 70c adjusts the flow rate of the polishing solution flowing in the flow channel 70c to a predetermined range based on the flow rate of the polishing solution detected by the flow rate sensor 61 provided in the flow channel 70c. When the flow rate of the polishing solution is not adjusted, the polishing apparatus 1a may not include the flow rate adjusting device 50 and the flow rate sensor 61 for the polishing solution.

[0094] The control device 90 according to this modified example also performs the flowcharts illustrated in FIGS. 4 and 5.

[0095] When clogging has occurred in the flow channel 70a, the pressure of the cleaning solution flowing in the flow channel 70a increases and thus the pressure of the cleaning solution flowing in the flow channel 70b communicating with the flow channel 70a via the switching device 40 also increases. Accordingly, according to this modified example, it is possible to detect that clogging has occurred in the flow channel 70a using the same method as in the aforementioned embodiment based on the pressure detected by the pressure sensor 60 provided in the flow channel 70b.

[0096] According to this modified example, since the flow rate adjusting device 50, the flow

rate sensor 61, and the pressure sensor 60 are not provided in the flow channel 70a, it is possible to provide the switching device 40 at a position closer to the downstream end of the flow channel 70a in comparison with a case in which such members are provided in the flow channel 70a. In this case, it is possible to achieve a decrease of an amount of polishing solution in the flow channel 70a which is discarded in the cleaning process.

[0097] (Modified Example 2 of embodiment)

A polishing apparatus 1 according to Modified Example 2 of the embodiment will be described below. The polishing apparatus 1 according to this modified example is different from the polishing apparatus 1 according to the embodiment mainly in that a detection value from the flow rate sensor 61 instead of the detection value from the pressure sensor 60 is used to detect whether clogging has occurred in the flow channel 70a. In this case, referring to FIG. 1, the polishing apparatus 1 according to this embodiment may be configured not to include the pressure sensor 60.

[0098] The control device 90 according to this modified example performs the flowcharts illustrated in FIGS. 4 and 5, and details of Step S40 in the flowchart illustrated in FIG. 5 are different from those in the aforementioned embodiment.

[0099] Specifically, the control device 90 according to this modified example detects whether clogging has occurred in the flow channel 70a based on the flow rate detected by the flow rate sensor 61 when the cleaning solution flows in the flow channel 70a (that is, the flow rate of the cleaning solution in the flow channel 70a) in Step S40.

[0100] Specifically, in Step S40, the control device 90 according to this modified example acquires a flow rate detected by the flow rate sensor 61 (that is, a flow rate of a cleaning solution flowing in the flow channel 70a). Subsequently, the control device 90 calculates a difference between a preset reference flow rate and the flow rate detected by the flow rate sensor 61 (referred to as a “flow rate difference”).

[0101] For example, a flow rate of a cleaning solution when clogging has not occurred in the flow channel 70a can be used as the reference flow rate. Specifically, a control target value of the flow rate (the “predetermined flow rate”) of the cleaning solution in the flow rate adjusting device 50 can be used as the reference flow rate. More specifically, an average value of the upper limit F2 and the lower limit F1 in (B) of FIG. 6 or the like can be used as the reference flow rate. As the reference flow rate, an appropriate value is calculated by experiment or the like in advance and stored in the storage device 92.

[0102] As the degree of clogging in the flow channel 70a increases, the flow rate of the

cleaning solution flowing in the flow channel 70a decreases. Accordingly, the "flow rate difference" has a greater value as the degree of clogging in the flow channel 70a becomes higher. Therefore, the control device 90 according to this modified example determines the degree of clogging in the flow channel 70a based on the flow rate difference as will be described below.

[0103] FIG. 8 is a diagram schematically illustrating threshold values used for the clogging detecting process according to this modified example. Specifically, in FIG. 8, a third threshold value P3 and a fourth threshold value P4 are illustrated as the threshold values of the "flow rate difference" which is used to determine whether clogging has occurred in the flow channel 70a. The fourth threshold value P4 is greater than the third threshold value P3. Lines L5, L6, and L7 illustrated in FIG. 8 schematically represent temporal change of the flow rate difference.

[0104] In Step S40, when the difference between the reference flow rate and the flow rate detected by the flow rate sensor 61 (referred to as a "flow rate difference") is equal to or greater than the preset third threshold value P3, the control device 90 according to this modified example determines that clogging has occurred in the flow channel 70a. When the flow rate difference is equal to or greater than the third threshold value P3 and less than the fourth threshold value P4, the control device 90 determines that the degree of clogging in the flow channel 70a is low. When the flow rate difference is equal to or greater than the fourth threshold value P4, the control device 90 determines that the degree of clogging in the flow channel 70a is high.

[0105] That is, in FIG. 8, the control device 90 determines that clogging has not occurred in the flow channel 70a in case of the line L5, determines that the degree of clogging in the flow channel 70a is low in case of the line L6, and determines that the degree of clogging in the flow channel 70a is high in case of the line L7.

[0106] In this modified example, it is also preferable that the control device 90 cause the notification device 80 to notify that the determined degree of clogging in the flow channel 70a.

[0107] In this modified example, the same operations and advantages as in the aforementioned embodiment can be achieved.

[0108] In the aforementioned embodiment or Modified Example 1 or Modified Example 2 of the embodiment, when the pressure of the polishing solution flowing in the flow channel 70a is equal to or greater than a predetermined threshold value or when the flow rate of the polishing solution flowing in the flow channel 70a is less than a predetermined threshold value, the control device 90 may cause the notification device 80 to notify that fact. With this configuration, a user can early ascertain that it is necessary to clean the flow channel 70a.

[0109] It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed embodiments without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the disclosure covers modifications and variations provided that they fall within the scope of the following claims and their equivalents.

[Reference Signs List]

[0110] 1 Polishing apparatus
10 Polishing machine
40 Switching device
50 Flow rate adjusting device
60 Pressure sensor (“sensor”)
61 Flow rate sensor (“sensor”)
70a, 70b, 70c Flow channel
71 Pipe
72 Discharge nozzle
73, 73a Discharge hole
90 Control device
Wf Substrate

CLAIMS

Claim 1: A polishing apparatus comprising:

a polishing machine for polishing a substrate;

a flow channel for supplying a polishing solution or a cleaning solution to the polishing machine;

a switching device disposed in the flow channel and configured to switch between the polishing solution and the cleaning solution and to cause the solution to flow in the flow channel;

a sensor for detecting a pressure or a flow rate of the cleaning solution flowing in the flow channel; and

a control device,

wherein the control device performs:

a cleaning process of controlling the switching device such that the cleaning solution flows in the flow channel and then controlling the switching device such that the polishing solution flows in the flow channel when the number of substrates polished by the polishing machine reaches a predetermined number; and

a clogging detecting process of detecting whether clogging has occurred in the flow channel based on the pressure or the flow rate of the cleaning solution detected by the sensor when the cleaning solution flows in the flow channel.

Claim 2: The polishing apparatus according to claim 1, further comprising a flow rate adjusting device disposed at a position downstream from the switching device in the flow channel and configured to adjust a flow rate of the cleaning solution flowing in the flow channel to a predetermined range,

wherein the sensor is a pressure sensor disposed at a position downstream from the flow rate adjusting device in the flow channel.

Claim 3: The polishing apparatus according to claim 2, wherein the control device detects whether clogging has occurred in the flow channel based on a maximum value, an average value, or a minimum value of values of the pressure detected by the pressure sensor when the flow rate of the cleaning solution is in the predetermined range.

Claim 4: The polishing apparatus according to claim 2, wherein the control device determines that clogging has occurred in the flow channel when the value of the pressure

detected by the pressure sensor is equal to or greater than a preset first threshold value, and

wherein the control device determines that a degree of clogging in the flow channel is low when the value of the pressure detected by the pressure sensor is equal to or greater than the first threshold value and is less than a second threshold value greater than the first threshold value and determines that a degree of clogging in the flow channel is high when the value of the pressure detected by the pressure sensor is equal to or greater than the second threshold value.

Claim 5: The polishing apparatus according to claim 1, further comprising a notification device,

wherein the control device causes the notification device to notify that clogging has occurred in the flow channel when detecting in the clogging detecting process that clogging has occurred in the flow channel.

Claim 6: The polishing apparatus according to claim 4, wherein the control device prohibits the polishing machine from polishing a substrate when determining that a degree of clogging in the flow channel is high.

Claim 7: The polishing apparatus according to claim 1, wherein the flow channel includes a single pipe, and

wherein a downstream end of the flow channel is constituted by an end of the pipe.

Claim 8: The polishing apparatus according to claim 1, wherein the flow channel includes a single pipe and a discharge nozzle connected to a downstream end of the pipe and including at least one discharge hole.

Claim 9: The polishing apparatus according to claim 1, wherein the control device stores the number of substrates polished by the polishing machine whenever the polishing machine polishes the substrate, and

wherein the control device resets the stored number of substrates to zero when the cleaning solution flows in the flow channel.