

DESCRIPTION

Title of Invention

INFORMATION PROCESSING APPARATUS, INFERENCE APPARATUS,
MACHINE-LEARNING APPARATUS, INFORMATION PROCESSING METHOD,
5 INFERENCE METHOD, AND MACHINE-LEARNING METHOD

Technical Field

[0001] The present invention relates to an information processing apparatus, an
inference apparatus, a machine-learning apparatus, an information processing method, an
10 inference method, and a machine-learning method.

Background Art

[0002] A substrate processing apparatus that performs chemical mechanical polishing
(CMP) is known as a type of substrate processing apparatuses that performs various
processing on a substrate, such as a semiconductor wafer. In the substrate polishing
15 process, for example, a substrate is chemically and mechanically polished by pressing the
substrate against a polishing pad by a polishing head, which is referred to as a top ring,
with a polishing liquid (e.g., slurry) being supplied onto the polishing pad from a
polishing-fluid supply nozzle, while a polishing table having the polishing pad is being
rotated. Then, in order to remove foreign matter, such as polishing debris adhering to
20 the polished substrate, a cleaning tool is brought into contact with the polished substrate
while supplying substrate cleaning fluid onto the polished substrate, and the substrate is
then dried, so that a series of processes is completed. The next substrate is then
processed.

[0003] As the above-described series of processes is repeated, wear of a substrate
25 holding mechanism, such as a rotational holding member that holds a substrate, gradually
progresses. Conventionally, in order to extend the service life of the substrate holding
mechanism, a technique has been disclosed in which a distance between upper and lower
chuck members that sandwich a substrate can be changed (see, for example, Patent

document 1).

Citation List

Patent Literature

[0004] Patent document 1: Japanese laid-open patent publication No. 2018-29207

5 **Summary of Invention**

Technical Problem

[0005] In the Patent document 1, a vertical distance between an upper chuck member and a lower chuck member that hold an edge of a substrate is variable, so that it can handle substrates with different thicknesses. In addition, the upper and lower chuck
10 members can hold a substrate even if the upper and lower chuck members have become thin due to wear. Furthermore, since the edge of the substrate is sandwiched and supported vertically, it is possible to support substrates with different diameters.

[0006] On the other hand, in order to hold a substrate, operating conditions, such as a rotational state of the substrate, a holding position of the substrate, and a pressing load on
15 the substrate, are factors that can affect the state of the substrate holding mechanism. These factors act on the substrate holding mechanism complexly and interact with each other. Therefore, it is difficult to accurately analyze how each operating condition affects the state of the substrate holding mechanism.

[0007] In view of the above-mentioned problem, it is an object of the present invention
20 to provide an information processing apparatus, an inference apparatus, a machine-learning apparatus, an information processing method, an inference method, and a machine-learning method that can appropriately predict a state of a substrate holding mechanism according to an operating condition of a substrate processing apparatus.

Solution to Problem

25 [0008] In order to achieve the above object, an information processing apparatus according to one embodiment of the present invention comprises:

an information acquisition section configured to acquire operating condition information indicating operating conditions of a substrate processing device having a

substrate holder that includes a substrate holding mechanism configured to hold a substrate and a substrate rotating mechanism configured to rotate the substrate, the operating condition information including substrate rotating condition information indicating a rotating condition of the substrate, a substrate holding position information
5 indicating a substrate holding position of the substrate holder, and a substrate pressing load information indicating a substrate pressing load of the substrate holder; and

a state prediction section configured to predict substrate-holding-mechanism state information corresponding to the operating condition information by inputting the operating condition information acquired by the information acquisition section to a
10 learning model that has been generated by machine learning that causes the learning model to learn a correlation between the operating condition information and the substrate-holding-mechanism state information indicating a state of the substrate holding mechanism when the substrate processing device operates under the operating conditions indicated by the operating condition information.

15 **Advantageous Effects of Invention**

[0009] According to the information processing apparatus according to one aspect of the present invention, the operating condition information including the substrate rotating condition information, the substrate holding position information, and the substrate pressing load information is input to the learning model. Since the substrate-holding-
20 mechanism state information is predicted for the operating condition information, the state of the substrate holding mechanism can be appropriately predicted according to the operating condition of the substrate processing apparatus.

[0010] Objects, configurations, and effects other than those described above will be made clear in detailed descriptions of the invention described below.

25 **Brief Description of Drawings**

[0011]

[FIG. 1] FIG. 1 is an overall configuration diagram showing an example of a substrate processing system 1;

[FIG. 2] FIG. 2 is a plan view showing an example of a substrate processing device 2;

[FIG. 3] FIG. 3 is a perspective view showing an example of first to fourth polishing sections 22A to 22D;

[FIG. 4] FIG. 4 is a perspective view which shows an example of first and second roll
5 sponge cleaning sections 24A, 24B;

[FIG. 5] FIG. 5 is a perspective view which shows an example of first and second pen sponge cleaning sections 24C, 24D;

[FIG. 6] FIG. 6 is a perspective view showing an example of first and second drying sections 24E and 24F;

10 [FIG. 7] FIG. 7 is a block diagram showing an example of the substrate processing device 2;

[FIG. 8] FIG. 8 is a hardware configuration diagram showing an example of a computer 900;

[FIG. 9] FIG. 9 is a data configuration diagram showing an example of production history
15 information 30 managed by a database device 3;

[FIG. 10] FIG. 10 is a data configuration diagram showing an example of finishing-test information 31 managed by the database device 3;

[FIG. 11] FIG. 11 is a block diagram showing a first embodiment of a machine-learning device 4;

20 [FIG. 12] FIG. 12 is a diagram showing an example of a first learning model 10A and first learning data 11A;

[FIG. 13] FIG. 13 is a flowchart showing an example of a machine-learning method performed by the machine-learning apparatus 4;

[FIG. 14] FIG. 14 is a block diagram showing an example of an information processing
25 device 5 according to a first embodiment;

[FIG. 15] FIG. 15 is a function illustrating diagram of an example of the information processing device 5 according to the first embodiment;

[FIG. 16] FIG. 16 is a flowchart showing an example of an information processing

method performed by the information processing device 5;

[FIG. 17] FIG. 17 is a block diagram showing an example of a machine-learning apparatus 4a according to a second embodiment;

[FIG. 18] FIG. 18 is a diagram showing an example of a second learning model 10B and
5 second learning data 11B;

[FIG. 19] FIG. 19 is a showing an example of an information processing device 5a functioning as the information processing device 5a according to a second embodiment; and

[FIG. 20] FIG. 20 is a function illustrating diagram of an example of the information
10 processing device 5a according to the second embodiment.

Description of Embodiments

[0012] Embodiments for practicing the present invention will be described below with reference to the drawings. In the following descriptions, scope necessary for the
15 descriptions to achieve the object of the present invention will be schematically shown, scope necessary for the descriptions of relevant parts of the present invention will be mainly described, and parts omitted from the descriptions will be based on known technology.

[0013] (First embodiment)

20 FIG. 1 is an overall configuration diagram showing an example of a substrate processing system 1. The substrate processing system 1 according to the present embodiment functions as a system configured to manage a series of substrate processes including a chemical mechanical polishing (hereinafter referred to as “polishing process”) of planarizing a surface of a substrate (hereinafter referred to as a “wafer”) W, such as a
25 semiconductor wafer, a cleaning process of cleaning the surface of the wafer W after the polishing process by bringing the wafer W into contact with a cleaning tool, and a drying process of drying the surface of the cleaned wafer W with a drying tool. The cleaning process and the drying process constitute a finishing process, and the cleaning tool and

the drying tool are included in finishing tools.

[0014] The substrate processing system 1 includes, as its main components, substrate processing devices 2, a database device 3, a machine-learning device 4, an information processing device 5, and a user terminal device 6. Each of the devices 2 to 6 is configured with, for example, a general-purpose computer or dedicated computer (see FIG. 8 described later). The devices 2 to 6 are coupled to a wired or wireless network 7 so as to be able to transmit and receive various data (some data are shown in FIG. 1 with dotted arrows). The number of devices 2 to 6 and the connection configuration of the network 7 are not limited to the example shown in FIG. 1, and may be changed as appropriate.

[0015] Each substrate processing device 2 is composed of units and is configured to perform a series of substrate processes on one or more wafers W, such as loading, polishing, cleaning, drying, film-thickness measuring, and unloading. During the processes, the substrate processing device 2 controls operations of the units while referring to device setting information 265 including device parameters that have been set for the units and substrate recipe information 266 that determines operating conditions in the polishing process, the cleaning process, and the drying process.

[0016] The substrate processing device 2 is configured to transmit various reports R to the database device 3, the user terminal device 6, etc. according to the operation of each unit. The various reports R include, for example, process information that identifies a wafer W on which substrate processing is performed, device-state information that indicates a state of each unit when each process is performed, event information detected by the substrate processing device 2, and manipulation information of a user (an operator, a production manager, a maintenance manager, etc.) on the substrate processing device 2.

[0017] The database device 3 is an apparatus that manages production history information 30 on a history when substrate processing is performed using a finishing tool for proper production, and finishing-test information 31 on a history of a test of finishing process (hereinafter referred to as “finishing test”) that has been performed using a

finishing tool for test. In addition to the above information, the database device 3 may also store the device setting information 265 and the substrate recipe information 266. In that case, the substrate processing device 2 may refer to these information.

[0018] The database device 3 receives various reports R from the substrate processing
5 device 2 when the substrate processing device 2 has performed substrate processing using the finishing tool for proper production, and registers the various reports R in the production history information 30, so that the reports R on the substrate processing are accumulated in the production history information 30.

[0019] When the substrate processing device 2 performs the finishing test using the
10 finishing tool for test, the database device 3 receives the various reports R (including at least the device-state information) from the substrate processing device 2, registers the reports R in the finishing-test information 31, and registers test results of the finishing test associated with the various reports R, so that the reports R and the test results on the finishing test are accumulated in the finishing-test information 31. The finishing test
15 may be performed in the substrate processing device 2 for proper production, or may be performed in a finishing test device (not shown) for test that can perform the same finishing process as the substrate processing device 2. The finishing tool for test and the finishing test device include various finishing-tool measuring devices (not shown) for measuring conditions of the finishing tool, such as degree of contamination, degree of
20 wear, and degree of damage of a substrate holding mechanism. Measurement values of the finishing-tool measuring devices are registered as test results in the finishing-test information 31.

[0020] The machine-learning device 4 operates as a main configuration for a learning
phase in machine learning. For example, the machine-learning device 4 acquires, as first
25 learning data 11A, part of the finishing-test information 31 from the database device 3, and performs the machine learning to create a first learning model 10A to be used in the information processing device 5. The first learning model 10A as a learned model is provided to the information processing device 5 via the network 7, a storage medium, or

the like.

[0021] The information processing device 5 operates as a main configuration for an inference phase in the machine learning. When the finishing process is performed by the substrate processing device 2 using the substrate holding mechanism included in the finishing tool for proper production, the information processing device 5 predicts a state of the substrate holding mechanism using the first learning model 10A created by the machine-learning device 4, and transmits substrate-holding-mechanism state information, which is a result of the prediction, to the database device 3, the user terminal device 6, etc. The timing at which the information processing device 5 predicts the substrate-holding-mechanism state information may be after the finishing process (i.e., post-predicting process), during the finishing process (i.e., real-time-predicting process), or before the finishing process (i.e., pre-predicting process).

[0022] The user terminal device 6 is a terminal device used by a user. The user terminal device 6 may be a stationary device or a portable device. The user terminal device 6 receives various input manipulations via a display screen of an application program, a web browser, etc., and displays various information (e.g., a notification of event, the substrate-holding-mechanism state information, the production history information 30, the finishing-test information 31, etc.) via the display screen.

[0023] (Substrate processing device 2)

FIG. 2 is a plan view showing an example of the substrate processing device 2. The substrate processing device 2 includes a load-unload unit 21, a polishing unit 22, a substrate transport unit 23, a finishing unit 24, a film-thickness measuring unit 25, and a control unit 26 which are arranged inside a housing 20 that is substantially rectangular in a plan view. The load-unload unit 21 is isolated from the polishing unit 22, the substrate transport unit 23, and the finishing unit 24 by a first partition wall 200A. The substrate transport unit 23 is isolated from the finishing unit 24 by a second partition wall 200B.

[0024] (Load-unload unit)

The load-unload unit 21 includes first to fourth front load sections 210A to 210D

on which wafer cassettes (FOUPs, etc.), each capable of storing a large number of wafers W along a vertical direction, are placed, a transfer robot 211 that is movable along the storage direction (vertical direction) of the wafers W in each wafer cassette, and a horizontally-moving mechanism 212 for moving the transfer robot 211 along an arrangement direction of the first to fourth front load sections 210A to 210D (i.e., along a direction of a shorter side of the housing 20).

[0025] The transfer robot 211 is configured to be accessible to the wafer cassette placed on each of the first to fourth front load sections 210A to 210D, the substrate transport unit 23 (specifically, a lifter 232, which will be described later), the finishing unit 24 (specifically, first and second drying section 24E, 24F, which will be described later), and the film-thickness measuring unit 25. The transfer robot 211 includes upper and lower hands (not shown) for transporting the wafer W between the wafer cassette, the substrate transport unit 23, the finishing unit 24, and the film-thickness measuring unit 25. The lower hand is used when transporting the wafer W before processing of the wafer W, and the upper hand is used when transporting the wafer W after processing of the wafer W. When the wafer W is transported to and from the substrate transport unit 23 or the finishing unit 24, a shutter (not shown) provided on the first partition wall 200A is opened and closed.

[0026] (Polishing unit)

The polishing unit 22 includes first to fourth polishing sections 22A to 22D each configured to perform the polishing process (planarization) on the wafer W. The first to fourth polishing sections 22A to 22D are arranged in parallel along the longitudinal direction of the housing 20.

[0027] FIG. 3 is a perspective view showing an example of the first to fourth polishing sections 22A to 22D. The first to fourth polishing sections 22A to 22D have common basic configurations and functions.

[0028] Each of the first to fourth polishing sections 22A to 22D includes a polishing table 220 that rotatably supports a polishing pad 2200 having a polishing surface, a top

ring (polishing head) 221 configured to hold the wafer W and to polish the wafer W while pressing the wafer W against the polishing pad 2200 on the polishing table 220, a polishing-fluid supply nozzle 222 configured to supply a polishing fluid onto the polishing pad 2200, a dresser 223 that rotatably supports a dresser disk 2230 and
5 configured to dress the polishing pad 2200 by bringing the dresser disk 2230 into contact with the polishing surface of the polishing pad 2200, and an atomizer 224 configured to emit a cleaning fluid to the polishing pad 2200.

[0029] The polishing table 220 is supported by a polishing table shaft 220a. The polishing table 220 includes a rotating mechanism 220b configured to rotate the polishing
10 table 220 about its own axis, and a temperature regulating mechanism 220c configured to regulate a surface temperature of the polishing pad 2200.

[0030] The top ring 221 is supported by a top-ring shaft 221a that is movable in the vertical direction. The top ring 221 includes a rotating mechanism 221c configured to rotate the top ring 221 about an axis of the top ring 221, a vertical movement mechanism
15 221d configured to move the top ring 221 in the vertical direction, and an oscillation mechanism 221e configured to rotate (or oscillate) the top ring 221 around a support shaft 221b as a pivot center.

[0031] The polishing-fluid supply nozzle 222 is supported by a support shaft 222a. The polishing-fluid supply nozzle 222 includes an oscillation mechanism 222b configured
20 to rotate and move the polishing-fluid supply nozzle 222 around the support shaft 222a as a pivot center, a flow-rate regulator 222c configured to regulate a flow rate of the polishing fluid, and a temperature regulating mechanism 222d configured to regulate a temperature of the polishing fluid. The polishing fluid is a polishing liquid (e.g., slurry) or pure water, which may further include a chemical liquid, or may be a polishing liquid
25 to which a dispersant is added.

[0032] The dresser 223 is supported by a dresser shaft 223a that is movable in the vertical direction. The dresser 223 includes a rotating mechanism 223c configured to rotate about its own axis, a vertical movement mechanism 223d configured to move the

dresser 223 in the vertical direction, and an oscillation mechanism 223e configured to rotate and move the dresser 223 around a support shaft 223b as a pivot center.

[0033] The atomizer 224 is supported by a support shaft 224a. The atomizer 224 includes an oscillation mechanism 224b configured to rotate and move the atomizer 224 around the support shaft 224a as a pivot center, and a flow-rate regulator 224c configured to regulate a flow rate of the cleaning fluid. The cleaning fluid is a mixture of liquid (e.g., pure water) and gas (e.g., nitrogen gas), or liquid (e.g., pure water).

[0034] The wafer W is attracted and held on the lower surface of the top ring 221 and is moved to a predetermined polishing position above the polishing table 220. Thereafter, the wafer W is polished by being pressed by the top ring 221 against the polishing surface of the polishing pad 2200 on which the polishing fluid is supplied from the polishing-fluid supply nozzle 222.

[0035] (Substrate transport unit)

As shown in FIG. 2, the substrate transport unit 23 includes first and second linear transporters 230A, 230B that are horizontally movable along the arrangement direction of the first to fourth polishing sections 22A to 22D (i.e., the longitudinal direction of the housing 20), a swing transporter 231 arranged between the first and second linear transporters 230A, 230B, a lifter 232 arranged near the load-unload unit 21, and a temporary station 233 for the wafer W arranged near the finishing unit 24.

[0036] The first linear transporter 230A is arranged adjacent to the first and second polishing sections 22A and 22B and is configured to transport the wafer W to four transfer positions (which will be referred to as first to fourth transfer positions TP1 to TP4 in the order from the load-unload-unit-21-side). The second transfer position TP2 is a position where the wafer W is delivered to the first polishing section 22A, and the third transfer position TP3 is a position where the wafer W is delivered to the second polishing section 22B.

[0037] The second linear transporter 230B is arranged adjacent to the third and fourth polishing sections 22C and 22D and is configured to transport the wafer W to three

transfer positions (which will be referred to as fifth to seventh transfer positions TP5 and TP7 in the order from the load-unload-unit-21-side). The sixth transfer position TP6 is a position where the wafer W is delivered to the third polishing section 22C, and the seventh transfer position TP7 is a position where the wafer W is delivered to the fourth
5 polishing section 22D.

[0038] The swing transporter 231 is disposed adjacent to the fourth and fifth transfer positions TP4 and TP5. The swing transporter 231 has a hand that is movable between the fourth and fifth transfer positions TP4 and TP5. The swing transporter 231 is configured to transport the wafer W between the first and second linear transporters 230A
10 and 230B and place the wafer W temporarily on the temporary station 233. The lifter 232 is disposed adjacent to the first transfer position TP1. The lifter 232 is configured to transport the wafer W between the first transfer position TP1 and the transfer robot 211 of the load-unload unit 21. When the wafer W is transported, the shutter (not shown) provided on the first partition wall 200A is opened and closed.

15 [0039] (Finishing unit)

As shown in FIG. 2, the finishing unit 24 includes a substrate cleaning device using roll sponge 2400 that includes first and second roll sponge cleaning sections 24A and 24B arranged in upper and lower stages. The finishing unit 24 further includes a substrate cleaning device using pen sponge 2401 that includes first and second pen
20 sponge cleaning sections 24C and 24D arranged in upper and lower stages. The finishing unit 24 further includes a substrate drying device for drying the cleaned wafer W that includes first and second drying sections 24E and 24F arranged in upper and lower stages. The finishing unit 24 further includes first and second transport sections 24G and 24H configured to transport the wafer W. It is noted that the number and
25 arrangement of the roll sponge cleaning sections 24A, 24B, the pen sponge cleaning sections 24C, 24D, the drying sections 24E, 24F, and the transport sections 24G, 24H are not limited to the example in FIG. 2, and may be changed as appropriate.

[0040] The sections 24A to 24H of the finishing unit 24 are isolated from each other and

are arranged along the first and second linear transporters 230A and 230B, for example, in an order of the first and second roll sponge cleaning sections 24A, 24B, the first transport section 24G, the first and second pen sponge cleaning sections 24C, 24D, the second transport section 24H, and the first and second drying sections 24E, 24F (in an order of distance from the load-unload unit 21). The finishing unit 24 sequentially performs a primary cleaning process on the wafer W after the polishing process using one of the first and second roll sponge cleaning sections 24A and 24B, a secondary cleaning process on the wafer W using one of the first and second pen sponge cleaning section 24C and 24D, and a drying process on the wafer W using one of the first and second drying sections 24E and 24F.

[0041] The roll sponges 2400 and the pen sponges 2401 are made of synthetic resin, such as PVA or nylon, and have a porous structure. The roll sponges 2400 and the pen sponges 2401 function as cleaning tools for scrubbing the wafer W. The roll sponges 2400 and the pen sponges 2401 are removably attached to the first and second roll sponge cleaning sections 24A, 24B and the first and second pen sponge cleaning sections 24C, 24D, respectively.

[0042] The first transport section 24G includes therein a first transfer robot 246A that is movable in the vertical direction. The first transfer robot 246A is configured to be able to access the temporary station 233 of the substrate transport unit 23, the first and second roll sponge cleaning sections 24A, 24B, and the first and second pen sponge cleaning sections 24C, 24D, and has upper and lower hands (not shown) configured to transport the wafer W between them. For example, the lower hand is used to transport the wafer W before cleaning of the wafer W, and the upper hand is used to transport the wafer W after cleaning of the wafer W. When the wafer W is transported from the temporary station 233, a shutter (not shown) provided on the second partition wall 200B is opened and closed.

[0043] The second transport section 24H includes a second transfer robot 246B that is movable in the vertical direction. The second transfer robot 246B is configured to be

accessible to the first and second pen sponge cleaning sections 24C, 24D and the first and second drying sections 24E, 24F, and has a hand (not shown) configured to transport the wafer W between them.

[0044] FIG. 4 is a perspective view showing an example of the first and second roll sponge cleaning sections 24A and 24B. Basic configurations and functions of the first and second roll sponge cleaning sections 24A and 24B are common. In the example of FIG. 4, the first and second roll sponge cleaning sections 24A and 24B have a pair of roll sponges 2400 arranged one above the other so as to sandwich surfaces to be cleaned (front and back surfaces) of the wafer W.

[0045] Each of the first and second roll sponge cleaning sections 24A and 24B includes a substrate holder 241 configured to hold the wafer W, a cleaning-fluid supply structure 242 configured to supply substrate cleaning fluid onto the wafer W, a substrate cleaning structure 240 configured to rotatably support the roll sponges 2400 and clean the wafer W by bringing the roll sponges 2400 in contact with the wafer W, a cleaning-tool cleaning structure 243 configured to clean (self-clean) the roll sponges 2400 with a cleaning-tool cleaning fluid, and an environmental sensor 244 configured to measure a condition of an internal space of the housing 20 where the cleaning process is performed.

[0046] The substrate holder 241 includes substrate holding mechanisms 241a configured to hold multiple portions of the side edge of the wafer W, and substrate rotating mechanisms 241b configured to rotate the wafer W about a third rotation axis perpendicular to the cleaning target surface of the wafer W. In the example of FIG. 4, the substrate holding mechanisms 241a include four rollers. At least one of the rollers is configured to be movable in a holding direction or a releasing direction with respect to the side edge of the wafer W. The substrate rotating mechanisms 241b include two drive rollers. In the example of FIG. 4, the drive rollers that constitute the substrate rotating mechanisms 241b also serve as the substrate holding mechanisms 241a that hold the wafer W. The substrate holder 241 may include substrate holding mechanisms 241a constituted of a plurality of rollers and substrate rotating mechanism 241b constituted of

at least one drive roller.

[0047] The cleaning-fluid supply structure 242 includes cleaning-fluid supply nozzles 242a configured to supply substrate cleaning fluid to the cleaning target surface of the wafer W, swing movement mechanisms 242b configured to swing and move the cleaning-
5 fluid supply nozzles 242a, flow-rate regulators 242c configured to regulate flow rate and pressure of the substrate cleaning fluid, and a temperature regulating mechanism 242d configured to regulate temperature of the substrate cleaning fluid. The substrate cleaning fluid may be either pure water (rinsing liquid) or a chemical solution. The cleaning-fluid supply nozzles 242a may be a nozzle for pure water and a nozzle for
10 chemical solution which are arranged separately, as shown in FIG. 4. Further, the substrate cleaning fluid may be a liquid, a two-fluid mixture of a liquid and a gas, or a fluid containing a solid, such as dry ice.

[0048] The substrate cleaning structure 240 includes cleaning-tool rotating mechanisms 240a configured to rotate the roll sponges 2400 about first rotation axes parallel to the
15 cleaning target surface of the wafer W, a vertical movement mechanism 240b configured to move at least one of the pair of roll sponges 2400 in the vertical direction so as to change heights of the roll sponges 2400 and a distance between the roll sponges 2400. The vertical movement mechanism 240b and the linear movement mechanism 240c function as a cleaning-tool movement mechanism configured to move the relative
20 position of the roll sponges 2400 and the cleaning target surface of the wafer W.

[0049] The cleaning-tool cleaning structure 243 is arranged in a position that does not interfere with the wafer W. The cleaning-tool cleaning structure 243 includes a cleaning-tool cleaning tank 243a that can store and discharge cleaning-tool cleaning fluid, a cleaning-tool cleaning plate 243b disposed in the cleaning-tool cleaning tank 243a such
25 that the roll sponge 2400 can be pressed against the cleaning-tool cleaning plate 243b, a flow-rate regulator 243c configured to regulate flow rate and pressure of the cleaning-tool cleaning fluid supplied to the cleaning-tool cleaning tank 243a, and a flow-rate regulator 243c configured to regulate flow rate and pressure of the cleaning-tool cleaning fluid

flowing in the roll sponge 2400 and discharged through an outer circumferential surface of the roll sponge 2400 to the outside. The cleaning-tool cleaning fluid may be either pure water (rinsing liquid) or a chemical solution.

[0050] The environment sensor 244 includes, for example, a temperature sensor 244a and a humidity sensor 244b. The environment sensor 244 may include a camera (image sensor) capable of generating an image of the surfaces of the wafer W and the roll sponge 2400 during, or before, or after the cleaning process.

[0051] The first and second roll sponge cleaning sections 24A and 24B perform the primary cleaning process. Specifically, the wafer W is rotated by the substrate rotating mechanism 241b while the wafer W is held by the substrate holding mechanism 241a. Then, the substrate cleaning fluid is supplied from the cleaning-fluid supply nozzles 242a to the cleaning target surfaces of the wafer W. The roll sponges 2400 are rotated around their own axes by the cleaning-tool rotating mechanisms 240a and are placed in sliding contact with the cleaning target surfaces of the wafer W. The wafer W is cleaned by sliding contact with the roll sponges 2400. Thereafter, the substrate cleaning structure 240 moves the roll sponge 2400 into the cleaning-tool cleaning tank 243a, where the roll sponge 2400 is rotated, or pressed against the cleaning-tool cleaning plate 243b, or supplied with the cleaning-tool cleaning fluid by the flow-rate regulator 243d, so that the roll sponge 2400 is cleaned.

[0052] FIG. 5 is a perspective view showing an example of the first and second pen sponge cleaning sections 24C and 24D. Basic configurations and functions of the first and second pen sponge cleaning sections 24C and 24D are common.

[0053] Each of the first and second pen sponge cleaning sections 24C and 24D includes a substrate holder 241 configured to hold the wafer W, a cleaning-fluid supply structure 242 configured to supply substrate cleaning fluid onto the wafer W, a substrate cleaning structure 240 configured to rotatably support the pen sponge 2401 and clean the wafer W by bringing the pen sponge 2401 in contact with the wafer W, a cleaning-tool cleaning structure 243 configured to clean (self-clean) the pen sponge 2401 with a cleaning-tool

cleaning fluid, and an environmental sensor 244 configured to measure a condition of an internal space of the housing 20 where the cleaning process is performed. The following describes are focused on configurations of the pen sponge cleaning sections 24C and 24D different from the roll sponge cleaning sections 24A and 24B.

5 [0054] The substrate holder 241 includes a substrate holding mechanism 241c configured to hold multiple portions of the side edge of the wafer W, and substrate rotating mechanisms 241d configured to rotate the wafer W about a third rotation axis perpendicular to the cleaning target surface of the wafer W. In the example of FIG. 5, the substrate holding mechanisms 241c includes four rollers, and at least one of the rollers
10 is configured to be movable in a holding direction or a releasing direction with respect to the side edge of the wafer W. The substrate rotating mechanisms 241d include two drive rollers. In the example of FIG. 5, the drive rollers that constitute the substrate rotating mechanisms 241b also serve as the substrate holding mechanisms 241a that hold the wafer W. The substrate holder 241 may include substrate holding mechanisms 241c
15 constituted of a plurality of rollers and substrate rotating mechanism 241d constituted of at least one drive roller.

[0055] The cleaning-fluid supply structure 242 has the same configurations as that shown in FIG. 4, and includes a cleaning-fluid supply nozzle 242a, a swing movement mechanism 242b, a flow-rate regulator 242c, and a temperature regulating mechanism
20 242d.

[0056] The substrate cleaning structure 240 includes a cleaning-tool rotating mechanism 240d configured to rotate the pen sponge 2401 about a second rotation axis perpendicular to the cleaning target surface of the wafer W, a vertical movement mechanism 240e configured to move the pen sponge 2401 in the vertical direction, and a swing movement
25 mechanism 240f configured to swing and move the pen sponge 2401 in the horizontal direction. The vertical movement mechanism 240e and the swing movement mechanism 240f function as a cleaning-tool movement mechanism configured to move the relative position of the pen sponge 2401 and the cleaning target surface of the wafer

W.

[0057] The cleaning-tool cleaning structure 243 is arranged in a position that does not interfere with the wafer W. The cleaning-tool cleaning structure 243 includes a cleaning-tool cleaning tank 243e that can store and discharge cleaning-tool cleaning fluid, a cleaning-tool cleaning plate 243f disposed in the cleaning-tool cleaning tank 243e such that the pen sponge 2401 can be pressed against the cleaning-tool cleaning plate 243f, a flow-rate regulator 243g configured to regulate flow rate and pressure of the cleaning-tool cleaning fluid supplied to the cleaning-tool cleaning tank 243e, and a flow-rate regulator 243h configured to regulate flow rate and pressure of the cleaning-tool cleaning fluid flowing in the pen sponge 2401 and discharged through an outer circumferential surface of the pen sponge 2401 to the outside.

[0058] The environment sensor 244 includes, for example, a temperature sensor 244a and a humidity sensor 244b. The environment sensor 244 may include a camera (image sensor) capable of generating an image of the surfaces of the wafer W and the pen sponge 2401 during, or before, or after the cleaning process.

[0059] The first and second pen sponge cleaning sections 24C and 24D perform the secondary cleaning process. Specifically, the wafer W is rotated by the substrate rotating mechanism 241d while the wafer W is held by the substrate holding mechanism 241c. Then, the substrate cleaning fluid is supplied from the cleaning-fluid supply nozzles 242a to the cleaning target surface of the wafer W. The pen sponge 2401 is rotated around its own axis by the cleaning-tool rotating mechanisms 240d and is placed in sliding contact with the cleaning target surface of the wafer W. The wafer W is cleaned by sliding contact with the pen sponge 2401. Thereafter, the substrate cleaning structure 240 moves the pen sponge 2401 into the cleaning-tool cleaning tank 243e, where the pen sponge 2401 is rotated, or pressed against the cleaning-tool cleaning plate 243f, or supplied with the cleaning-tool cleaning fluid by the flow-rate regulator 243h, so that the pen sponge 2401 is cleaned.

[0060] FIG. 6 is a perspective view showing an example of the first and second drying

sections 24E and 24F. Basic configurations and functions of the first and second drying sections 24E and 24F are common.

[0061] Each of the first and second drying sections 24E and 24F includes a substrate holder 241 configured to hold the wafer W, a drying-fluid supply structure 245
5 configured to supply substrate drying fluid to the wafer W, a housing 20 where the drying process is performed, and an environment sensor 244 configured to measure a condition of an internal space of the housing 20 where the drying process is performed..

[0062] The substrate holder 241 includes substrate holding mechanisms 241e configured to hold multiple portions of the side edge of the wafer W, and a substrate rotating
10 mechanism 241g configured to rotate the wafer W about a third rotation axis perpendicular to the cleaning target surface of the wafer W. Each substrate holding mechanism 241e has one end that is rotatable about a horizontal axis relative to a vertical movement mechanism 241f configured to move in the vertical direction, and has other end constituting a gripper (e.g., a chuck) that is movable toward and away from the
15 peripheral edge of the wafer W. The substrate holding mechanisms 241e constitute an umbrella mechanism that allows the grippers to move in the direction of contacting the wafer W or separating from the wafer W as the vertical movement mechanism 241f moves in the vertical direction. The grippers may be configured with rollers.

[0063] The drying-fluid supply structure 245 includes drying-fluid supply nozzles 245a
20 configured to supply substrate drying fluid onto the cleaning target surface of the wafer W, a vertical movement mechanism 245b configured to move the drying-fluid supply nozzles 245a in the vertical direction, a swing movement mechanism 245c configured to swing and move the drying-fluid supply nozzles 245a in the horizontal direction, a flow-rate regulator 245d configured to regulate flow rate and pressure of the substrate drying
25 fluid, and a temperature regulating mechanism 245e configured to regulate a temperature of the substrate drying fluid. The vertical movement mechanism 245b and the swing movement mechanism 245c function as a drying-fluid supply nozzle movement mechanism configured to move a relative position of the drying-fluid supply nozzles 245a

and the cleaning target surface of the wafer W. The substrate drying fluid is, for example, IPA steam and pure water (rinsing liquid). The drying-fluid supply nozzles 245a have a nozzle for IPA steam and a nozzle for pure water provided separately, as shown in FIG. 6. Furthermore, the substrate drying fluid may be a liquid, a two-fluid mixture of a liquid and a gas, or a fluid containing a solid, such as dry ice.

[0064] The environment sensor 244 includes, for example, a temperature sensor 244a and a humidity sensor 244b. The environment sensor 244 may include a camera (image sensor) capable of generating an image of the surface of the wafer W during, or before, or after the drying process.

10 [0065] The first and second drying sections 24E and 24F are configured to perform the drying process. Specifically, the wafer W is rotated by the substrate rotating mechanism 241g while the wafer W is held by the substrate holding mechanism 241e. Then, the substrate drying fluid is supplied from the drying-fluid supply nozzles 245a onto the cleaning target surface of the wafer W, while the drying-fluid supply nozzles 245a are
15 moved toward the side edge of the wafer W (in the radially outward direction). Thereafter, the wafer W is dried by being rotated at high speed by the substrate rotating mechanism 241e.

[0066] In FIGS. 4 to 6, detailed configurations of the substrate holding mechanisms 241a, 241c, 241e, the substrate rotating mechanisms 241b, 241d, 241g, the vertical
20 movement mechanisms 240b, 240e, 241f, 245b, the linear movement mechanism 240c, and the swing movement mechanisms 240f, 242b, 245c, and the cleaning-tool rotating mechanisms 240a, 240d are omitted, but they may include a module for generating driving force (e.g., a motor or an air cylinder), a driving force transmission mechanism (e.g., a linear guide, a ball screw, a gear, a belt, a coupling, a bearing, etc.), and sensor
25 (e.g., a linear sensor, an encoder sensor, a limit sensor, a torque sensor, etc.), which may be appropriately combined.

[0067] Furthermore, in FIGS. 4 to 6, the specific configurations of the flow-rate regulators 243c, 243d, 243g, 243h, and 245d are omitted, but they may include a module

for fluid regulation (e.g., a pump, a valve, a regulator, etc.) and sensor (e.g., a flow-rate sensor, a pressure sensor, a liquid level sensor, etc.), which may be appropriately combined. In FIGS. 4 to 6, the specific configurations of the temperature regulating mechanisms 242d and 245e are omitted, but they may include a contact type or non-
5 contact type module for temperature regulation (e.g., a heater, a heat exchanger, etc.) and sensor (a temperature sensor, an electric current sensor, etc.).

[0068] (Film-thickness measuring unit)

The film-thickness measuring unit 25 is a measuring device that measures the film thickness of the wafer W before or after the polishing process. The film-thickness
10 measuring unit 25 is, for example, an optical film-thickness measuring device, an eddy current type film-thickness measuring device, or the like. The transfer robot 211 transports the wafer W to and from each film-thickness measuring module.

[0069] (Control unit)

FIG. 7 is a block diagram showing an example of the substrate processing device
15 2. The control unit 26 is electrically coupled to each of the units 21 to 25, and functions as a control section that comprehensively controls the units 21 to 25. In this embodiment, a control system (i.e., modules, sensors, and a sequencer) of the finishing unit 24 will be described as an example. Control systems of the other units 21 to 23 and 25 have common basic configurations and functions, and descriptions will be omitted.

20 [0070] The finishing unit 24 includes modules 2471 to 247r to be controlled, which are disposed in sub-units (e.g., the first and second roll sponge cleaning sections 24A, 24B, the first and second pen sponge cleaning sections 24C, 24D, the first and second drying sections 24E, 24F, the first and second transport sections 24G, 24H, etc.), respectively, sensors 2481 to 248s arranged in the modules 2471 to 247r, respectively, for detecting
25 data (i.e., detection values) necessary for controlling the modules 2471 to 247r, and a sequencer 249 for controlling the operations of the modules 2471 to 247r based on the detection values obtained by the sensors 2481 to 248s.

[0071] Examples of the sensors 2481 to 248s of the finishing unit 24 include a sensor

configured to detect the number of rotations of the wafer W itself, a sensor configured to detect the count number of a measurement target formed on the wafer W, a sensor configured to detect the number of rotations of the substrate rotating mechanisms 241b, 241d, and 241g, a sensor configured to detect a rotation torque of the substrate rotating mechanisms 241b, 241d, and 241g, a sensor configured to detect position coordinates at which the substrate holding mechanisms 241a, 241c, and 241e hold the wafer W, a sensor configured to detect a moving distance of the vertical movement mechanism 241f, a sensor configured to detect a holding load or holding pressure when the substrate holding mechanisms 241a, 241c, and 241e hold the substrate, a sensor configured to detect the number of rotations of the substrate holding mechanisms 241a, 241c, and 241e, a sensor configured to detect a rotational speed of the substrate holding mechanisms 241a, 241c, and 241e, a sensor configured to detect a rotation torque of the substrate holding mechanisms 241a, 241c, and 241e, and a sensor configured to detect a moving distance of the vertical movement mechanism 241f.

[0072] The control unit 26 includes a control section 260, a communication section 261, an input section 262, an output section 263, and a storage section 264. The control unit 26 is comprised of, for example, a general-purpose or dedicated computer (see FIG. 8, which will be described later).

[0073] The communication section 261 is coupled to the network 7 and functions as a communication interface for transmitting and receiving various data. The input section 262 receives various input operations. The output section 263 functions as a user interface by outputting various information via a display screen, lighting of signal tower, or buzzer sound.

[0074] The memory section 264 stores therein various programs (operating system (OS), application programs, web browser, etc.) and data (the device setting information 265, the substrate recipe information 266, etc.) used in the operations of the substrate processing device 2. The device setting information 265 and the substrate recipe information 266 are data that can be edited by the user via the display screen.

[0075] The control section 260 obtains detection values of the multiple sensors 2181 to 218q, 2281 to 228s, 2381 to 238u, 2481 to 248w, 2581 to 258y (hereinafter referred to as “sensor group”) via multiple sequencers 219, 229, 239, 249, 259 (hereinafter referred to as “sequencer group”). The control section 260 operates the multiple modules 2171 to 217p, 2271 to 227r, 2371 to 237t, 2471 to 247v, and 2571 to 257x (hereinafter referred to as “module group”) in cooperation to perform a series of substrate processes including loading, polishing, cleaning, drying, film-thickness measuring, and unloading.

[0076] (Hardware configuration of each device)

FIG. 8 is a hardware configuration diagram showing an example of a computer 900. Each of the control unit 26, the database device 3, the machine-learning device 4, the information processing device 5, and the user terminal device 6 of the substrate processing device 2 is configured by the general-purpose or dedicated computer 900.

[0077] As shown in FIG. 8, main components of the computer 900 include buses 910, a processor 912, a memory 914, an input device 916, an output device 917, a display device 918, a storage device 920, a communication I/F (interface) section 922, an external device I/F section 924, an I/O (input/output) device I/F section 926, and a media input/output section 928. The above components may be omitted as appropriate depending on an application in which the computer 900 is used.

[0078] The processor 912 includes one or more arithmetic processing unit(s) (CPU (Central Processing Unit), MPU (Micro-processing unit), DSP (digital signal processor), GPU (Graphics Processing Unit), etc.), and operates as a controller configured to control the entire computer 900. The memory 914 stores various data and programs 930, and includes, for example, a volatile memory (DRAM, SRAM, etc.) that functions as a main memory, a non-volatile memory (ROM), a flash memory, etc.

[0079] The input device 916 includes, for example, a keyboard, a mouse, a numeric keypad, an electronic pen, etc., and functions as an input section. The output device 917 includes, for example, a sound (voice) output device, a vibration device, etc., and functions as an output section. The display device 918 includes, for example, a liquid

crystal display, an organic EL display, electronic paper, a projector, etc., and functions as an output section. The input device 916 and the display device 918 may be configured integrally, such as a touch panel display. The storage device 920 includes, for example,

5 The storage device 920 stores various data necessary for executing the operating system and the programs 930.

[0080] The communication I/F section 922 is coupled to a network 940, such as the Internet or an intranet (which may be the same as the network 7 in FIG. 1), in a wired manner or a wireless manner, and transmits and receives data to and from another
10 computer according to a predetermined communication standard. The communication I/F section 922 functions as a communication unit that sends and receives information. The external device I/F section 924 is coupled to an external device 950, such as camera, printer, scanner, reader/writer, etc. in a wired manner or a wireless manner, and serves as a communication section that transmits and receives data to and from the external device
15 950 according to a predetermined communication standard. The I/O device I/F unit 926 is coupled to I/O devices 960, such as various sensors or actuators, and functions as a communication unit that transmits and receives various signals, such as detection signals from the sensors or control signals to the actuators, and data to and from the I/O devices 960. The media input/output unit 928 is constituted of a drive device, such as a DVD
20 drive or a CD drive, and writes and reads data into and from medium (non-transitory storage medium) 970, such as a DVD or a CD.

[0081] In the computer 900 having the above configurations, the processor 912 calls the program 930 stored in the storage device 920 into the memory 914 and executes the program 930, and controls each part of the computer 900 via the buses 910. The
25 program 930 may be stored in the memory 914 instead of the storage device 920. The program 930 may be stored in the medium 970 in an installable file format or an executable file format, and may be provided to the computer 900 via the media input/output unit 928. The program 930 may be provided to the computer 900 by being

downloaded via the network 940 and the communication I/F unit 922. The computer 900 performs various functions realized by the processor 912 executing the programs 930. The computer 900 may include hardware, such as an FPGA, an ASIC, etc. for executing the above-described various functions.

5 [0082] The computer 900 is, for example, a stationary computer or a portable computer, and is an electronic device in arbitrary form. The computer 900 may be a client computer, a server computer, or a cloud computer. The computer 900 may be applied to devices other than the devices 2 to 6.

[0083] (Production history information 30)

10 FIG. 9 is a data configuration diagram showing an example of the production history information 30 managed by the database device 3. The production history information 30 includes, for example, a wafer history table 300 with respect to each of the wafers W, and a finishing history table 301 with respect to the device-state information in the finishing process, as a table in which the reports R obtained in the substrate process
15 for proper production are classified and registered. The finishing history information 301 includes a cleaning history table with respect to the device-state information in the cleaning process, and a drying history table with respect to the device-state information in the drying process. The production history information 30 includes a polishing history table with respect to the device-state information in the polishing process, an event
20 history table with respect to the event information, a manipulation history table with respect to the manipulation information, and the like, in addition to the above-described tables, but detailed descriptions thereof are omitted.

[0084] For example, a wafer ID, a cassette number, a slot number, start time and end time of each process, a used unit ID, etc. are registered in each record of the wafer history
25 table 300. The polishing process, the cleaning process, and the drying process are illustrated as examples in FIG. 9. Data is registered in the other processes in the same manner.

[0085] For example, a wafer ID, substrate rotation speed information and substrate

rotation torque information constituting substrate rotating condition information, substrate holding position information, substrate pressing load information, etc. are registered in each record of the finishing history table 301.

[0086] The substrate rotation speed information is information indicating the rotation speed of the wafer W in the finishing process. The substrate rotation speed information includes, for example, a detection value of a sensor that measures the rotation speed of the wafer W itself, a detection value of a sensor that measures the number of rotations using a measuring target, such as a notch, formed in or installed on the wafer W, and detection values of sensors that measure the number of rotations of the substrate rotating mechanisms 241b, 241d, and 241g that rotate the wafer W.

[0087] The substrate rotation torque information is information indicating the rotation torque of the wafer W itself in the finishing process. The substrate rotation torque information is, for example, a detection value of a sensor that measures the torque of the substrate rotating mechanisms 241b, 241d, and 241g that rotate the wafer W.

[0088] The substrate holding position information is information indicating coordinates of the positions where the wafer W is held by the substrate holding mechanisms 241a, 241c, and 241e. The substrate holding position information may be obtained by measuring a horizontal positional shift from a preset reference position at which the wafer W is held at preset position coordinates. The substrate holding position information is, for example, a detection value of a sensor that measures the position where the wafer W is held by the substrate holding mechanisms 241a, 241c, and 241e. When the umbrella mechanism is used, the substrate holding position information may be obtained by measuring a movement distance of the vertical movement mechanism 241f. Furthermore, the substrate holding position information may be obtained by measuring a vertical positional shift of the substrate holding mechanisms 241a, 241c, and 241e from a preset reference position at which the wafer W is held.

[0089] The substrate pressing load information is information indicating the load with which the substrate holding mechanisms 241a, 241c, and 241e press the wafer W. The

substrate pressing load information may be obtained by measuring the load using a load cell, or if air is used to press the wafer W, pressure of the air may be measured.

[0090] By referring to the finishing history table 301, time-series data of each sensor (or time-series data of each module) can be extracted as a state of the substrate processing device 2 when the finishing process is performed on the wafer W identified by the wafer ID.

[0091] (Finishing-test information 31)

FIG. 10 is a data configuration diagram showing an example of the finishing-test information 31 managed by the database device 3. The finishing-test information 31 includes a finishing-test table 310 in which the reports R and the test results obtained in the finishing test performed using the substrate holder for test and the finishing test device are classified and registered.

[0092] For example, a test ID, the substrate rotation speed information and the substrate rotation torque information that constitute the substrate rotating condition information, the substrate holding position information, the substrate pressing load information, the test result information, etc. are registered in each record of the finishing test table 310. The substrate rotation speed information and the substrate rotation torque information that constitute the substrate rotating condition information of the finishing test table 310, the substrate holding position information, and the substrate pressing load information are information indicating the state or condition of each part in the finishing test. Their data configurations are the same as those of the finishing history table 301, and therefore detailed explanations will be omitted.

[0093] The test result information is information indicating the state of the substrate holding mechanism for test when the finishing process is performed in the finishing test.

The test result information is measurement values sampled at a predetermined time interval by a substrate-holding-mechanism measuring device provided in the substrate holding mechanism for test or the substrate holding mechanism testing device. The test result information shown in FIG. 10 includes measurement values TR1, TR2, and TR3 of

degree of contamination, degree of wear, and degree of damage at times $t_1, t_2, \dots, t_m, \dots, t_n$ within a finish-process period from start to end of the finishing process.

[0094] The test result information may be the detection values as the measurement results obtained by the substrate holding mechanism measuring device as described above.

5 Alternatively, a camera mounted to an optical microscope or a scanning electron microscope (SEM) may generate images of the substrate holding mechanism for test at predetermined time intervals, and the test result information may be obtained based on a result of image processing performed on the images, or based on a result of experimental analysis performed on the images by an experimenter. Further, the test result
10 information may be collected in one finishing test which is performed consecutively from start to end of the finishing process, or may be collected in multiple finishing tests which are performed repeatedly from start of the finishing process until a predetermined time is reached, with the predetermined time gradually lengthened.

[0095] By referring to the finishing-test table 310, time-series data (or time-series data
15 of each module) indicating a state of the substrate holding mechanisms 241a, 241c, 241e in the finishing test identified by the test ID, and time-series data indicating the state of the substrate holding mechanism for test at that time can be extracted.

[0096] (Machine-learning device 4)

FIG. 11 is a block diagram showing an example of the machine-learning device
20 4 according to the first embodiment. The machine-learning device 4 includes a control section 40, a communication section 41, a learning-data storage section 42, and a learned-model storage section 43.

[0097] The control section 40 functions as a learning-data acquisition section 400 and a machine-learning section 401. The communication section 41 is coupled to external
25 devices (e.g., the substrate processing device 2, the database device 3, the information processing device 5, the user terminal device 6, the finishing-test device (not shown), etc.) via the network 7. The communication section 41 serves as a communication interface configured to transmit and receive various data.

[0098] The learning-data acquisition section 400 is coupled to an external device via the communication section 41 and the network 7. The learning-data acquisition section 400 acquires the first learning data 11A including operating condition information as input data and the substrate-holding-mechanism state information as output data. The first
5 learning data 11A is data used as teacher data (or training data), verification data, and test data in supervised learning. The substrate-holding-mechanism state information is used as ground-truth label or correct label in the supervised learning.

[0099] The learning-data storage section 42 is a database that stores multiple sets of first learning data 11A acquired by the learning-data acquisition section 400. The specific
10 configuration of the database that constitutes the learning-data storage section 42 may be designed as appropriate.

[0100] The machine-learning section 401 performs the machine learning using the multiple sets of first learning data 11A stored in the learning-data storage section 42. Specifically, the machine-learning section 401 inputs the multiple sets of first learning
15 data 11A to the first learning model 10A and causes the first learning model 10A to learn a correlation between the operating condition information and the substrate-holding-mechanism state information included in the first learning data 11A to thereby create the first learning model 10A as a learned model.

[0101] The learned-model storage section 43 is a database configured to store the first
20 learning model 10A as the learned model (i.e., adjusted weight parameter group) created by the machine-learning section 401. The first learning model 10A as the learned model stored in the learned-model storage section 43 is provided to a real system (e.g., the information processing device 5) via the network 7, a storage medium, or the like. Although the learning-data storage section 42 and the learned-model storage section 43
25 are shown as separate storage sections in FIG. 11, they may be configured as a single storage section.

[0102] The number of first learning model 10A stored in the learned-model storage section 43 is not limited to one. For example, a plurality of learning models may be

stored in the learned-model storage section 43 for different conditions, such as for machine learning methods, types of substrate holding mechanisms 241a, 241c, 241e, a difference in mechanism of the substrate holding mechanisms 241a, 241c, 241e, types of data including in the operating condition information, types of data including in the substrate-holding-mechanism state information. In that case, a plurality of types of learning data having data configurations corresponding respectively to the plurality of learning models for the different conditions may be stored in the learning-data storage section 42.

[0103] FIG. 12 is a diagram showing an example of the first learning model 10A and the first learning data 11A. The first learning data 11A used for the machine learning of the first learning model 10A is composed of the operating condition information and the substrate-holding-mechanism state information (condition information). In this embodiment, the first learning model 10A and the first learning data 11A are prepared for at least three types corresponding to the roll sponge cleaning sections 24A and 24B using the roll sponges 2400, the pen sponge cleaning sections 24C and 24D using the pen sponge 2401, and the drying sections 24E and 24F. Since the basic data structure is common, they will be explained together below.

[0104] The operating condition information constituting the first learning data 11A includes the substrate rotating condition information indicating the rotation state of the wafer W, the substrate holding position information indicating the positions at which the substrate holding mechanisms 241a, 241c, and 241e hold the wafer W; and the substrate pressing load information indicating the load with which the substrate holding mechanisms 241a, 241c, and 241e press the wafer W.

[0105] The substrate rotating condition information included in the operating condition information includes the substrate rotation speed information indicating the rotation speed of the wafer W, and the substrate rotation torque information indicating the rotation torque of the wafer W. The substrate rotation speed information is information indicating the rotation speed of the wafer W. The substrate rotation speed information

includes, for example, the rotation speed of the wafer W itself, the count number of measuring target, such as a notch, formed in or installed on the wafer W, and the number of rotations of the substrate rotating mechanisms 241b, 241d, and 241g that rotate the wafer W. The substrate rotation torque information may be, for example, the torque of
5 the substrate rotating mechanisms 241b, 241d, and 241g that rotate the wafer W.

[0106] The substrate holding position information included in the operating condition information includes the positions at which the substrate holding mechanisms 241a, 241c, and 241e hold the wafer W. The substrate holding position information may be obtained by setting positional coordinates at the center of rotation of the wafer W or at a holding
10 position of holding the wafer W, and indicating a distance of horizontal positional shift from an original holding position. Alternately, the substrate holding position information may be obtained by measuring a horizontal positional shift from a preset reference position at which the wafer W is held. When the umbrella mechanism is used, the substrate holding position information may be obtained by measuring a movement
15 distance of the vertical movement mechanism 241f. Furthermore, the substrate holding position information may be obtained by measuring a vertical positional shift of the substrate holding mechanisms 241a, 241c, and 241e from a preset reference position at which the wafer W is held.

[0107] The substrate pressing load information included in the operating condition
20 information includes the load with which the substrate holding mechanisms 241a, 241c, and 241e press the wafer W. The substrate pressing load information may be obtained by measuring the load using a load cell, or if air is used to press the wafer W, pressure of the air may be measured.

[0108] The operating condition information may further include device internal-
25 environment information indicating an environment of a space in which the finishing process is performed. The device internal-environment information included in the operating condition information includes at least one of the temperature and the humidity of the internal space formed by the housing 20. Further, the operating condition

information may further include processing result information indicating a result of the finishing process. The processing result information included in the operating condition information may include at least one of the cumulative number of wafers W and the cumulative use time that has been used or spent in the finishing process using the substrate holding mechanisms 241a, 241c, and 241e since the substrate holding mechanisms 241a, 241c, and 241e have been replaced.

[0109] The substrate-holding-mechanism state information constituting the first learning data 11A is information indicating states or conditions of the substrate holding mechanisms 241a, 241c, and 241e when the substrate processing device 2 operates in the operating conditions indicated by the operating condition information. In this embodiment, the substrate-holding-mechanism state information includes at least one of degree of contamination, degree of wear, and degree of damage of the substrate holding mechanisms 241a, 241c, and 241e.

[0110] The learning-data acquisition section 400 acquires the first learning data 11A by referring to the finishing-test information 31 and receiving, as necessary, the input manipulations of the user through the user terminal device 6. For example, the learning-data acquisition section 400 refers to the finishing-test table 310 of the finishing-test information 31, thereby acquiring, as the operating condition information, the substrate rotating condition information, the substrate holding position information, and the substrate pressing load information when the finishing test identified by the test ID is performed.

[0111] In this embodiment, a case will be described where the operating condition information is acquired as the time-series data of the sensor group as shown in FIG. 12. The operating condition information may be changed as appropriate according to constructions of the substrate holder 241. In addition, a command value to the module, a parameter converted from a detected value of the sensor or the command value to the module, or a parameter calculated based on detected values of a plurality of sensors may be used as the operating condition information. Furthermore, the operating condition

information may be acquired as time-series data in the entire finishing-process period, may be acquired as time-series data in the target period that is part of the finishing-process period, or may be acquired as point-in-time data at a specific target point-in-time. When the definition of the operating condition information is changed as described above, the data structure of the input data in the first learning model 10A and the first learning data 11A may be changed as appropriate.

[0112] The learning-data acquisition section 400 refers to the finishing-test table 310 of the finishing-test information 31, thereby acquiring, as the substrate-holding-mechanism state information corresponding to the operating condition information, the test-result information (e.g., the time-series data (see FIG. 10) of the substrate-holding-mechanism measuring device when the finishing test identified by the same test ID is performed. When the substrate-holding-mechanism measuring device is configured to be able to perform planarly measuring operation on the substrate holding mechanisms 241a, 241c, and 241e, the learning data acquisition section 400 acquires an in-plane measurement value for the substrate holding mechanisms 241a, 241c, and 241 as the substrate-holding-mechanism state information.

[0113] In this embodiment, a case will be described where the substrate-holding-mechanism state information is the condition information as shown in FIG. 12, while the substrate-holding-mechanism state information may include at least one of the degree of contamination, the degree of wear, and the degree of damage. The substrate-holding-mechanism state information may be calculated by substituting the measurement value of the substrate-holding-mechanism measuring device into a predetermined calculation formula. Further, when the operating condition information is acquired as the time-series data in the entire finishing-process period or the time-series data in the target period that is part of the finishing-process period, the substrate-holding-mechanism state information may be acquired as time-series data in the entire finishing-process period or time-series data in the target period, or may be acquired as point-in-time data at the end of the finishing process or point-in-time data at the target point-in-time. When the

operating condition information is acquired as, for example, the point-in-time data at a specific target point-in-time, the substrate-holding-mechanism state information may be acquired as point-in-time data at the specific target point-in-time. When the definition of the substrate-holding-mechanism state information is changed as described above, the data structure of the output data in the first learning model 10A and the first learning data 11A may be changed as appropriate.

[0114] The first learning model 10A employs, for example, a neural network structure, and includes an input layer 100, an intermediate layer 101, and an output layer 102. Synapses (not shown) connecting neurons are placed between the layers, and each synapse is associated with a weight. A weight parameter group including weights of the synapses is adjusted by the machine learning.

[0115] The input layer 100 has neurons corresponding to the operating condition information as the input data, and each value of the operating condition information is input to each neuron. The output layer 102 has neuron(s) corresponding to the substrate-holding-mechanism state information as the output data, and a prediction result (inference result) of the substrate-holding-mechanism state information for the operating condition information is output as the output data. When the first learning model 10A is constituted of a regression model, the substrate-holding-mechanism state information is output as a numerical value normalized to a predetermined range (e.g., 0 to 1). When the first learning model 10A is constituted of a classification model, the substrate-holding-mechanism state information is output as a numerical value normalized to a predetermined range (e.g., 0 to 1) as a score (probability) for each class.

[0116] Inference results corresponding to numerical values are set in advance in the "predetermined range (0 to 1)". For example, in the case of the degree of contamination, the "predetermined range (0 to 1)" which is the inference results may be divided into a plurality of ranges, and the degree of contamination may be set for each divided range. In addition, in the case of presence or absence of the contamination, a predetermined threshold value is set between the "predetermined range (0 to 1)" that is the inference

results. If the output value is less than the threshold value, "no contamination" is determined. On the other hand, if the output value is more than the threshold value, "contaminated" is determined. The degree of contamination or the presence or absence of contamination is output according to the inference result.

5 [0117] (Machine learning method)

FIG. 13 is a flowchart illustrating an example of the machine learning method performed by the machine learning apparatus 4.

[0118] First, in step S100, the learning-data acquisition section 400 obtains, from the finishing-test information 31 or the like, a desired number of first learning data 11A as
10 advance preparation for starting the machine learning, and stores the obtained first learning data 11A in the learning-data storage section 42. The number of first learning data 11A to be prepared may be set in consideration of the inference accuracy required for the first learning model 10A finally obtained.

[0119] Next, in step S110, the machine-learning section 401 prepares the first learning
15 model 10A before learning for starting the machine learning. The first learning model 10A prepared before learning in this embodiment is composed of the neural network model, and the weight of each synapse is set to an initial value.

[0120] Next, in step S120, the machine-learning section 401 randomly obtains, for example, one set of first learning data 11A from the multiple sets of first learning data
20 11A stored in the learning-data storage section 42.

[0121] Next, in step S130, the machine-learning section 401 inputs the operating condition information (input data) included in the one set of first learning data 11A to the input layer 100 of the prepared first learning model 10A before learning (or during learning). As a result, the substrate-holding-mechanism state information (the output
25 data) is output as the inference result from the output layer 102 of the first learning model 10A. However, the output data is generated by the first learning model 10A before learning (or during learning). Therefore, in the state before learning (or during learning), the output data output as the inference result may indicate different information from the

substrate-holding-mechanism state information (ground-truth label or correct label) included in the first learning data 11A.

[0122] Next, in step S140, the machine-learning section 401 performs the machine learning by comparing the substrate-holding-mechanism state information (ground-truth label or correct label) included in the one set of first learning data 11A acquired in the step S120 with the substrate-holding-mechanism state information (output data) output as the inference result from the output layer in the step S130, and adjusting the weight of each synapse (backpropagation). In this way, the machine-learning section 401 causes the first learning model 10A to learn a correlation between the operating condition information and the substrate-holding-mechanism state information.

[0123] Next, in step S150, the machine-learning section 401 determines whether a predetermined learning end condition is satisfied. For example, this determination is made based on an evaluation value of an error function based on the substrate-holding-mechanism state information (ground-truth label or correct label) included in the first learning data 11A and the substrate-holding-mechanism state information (output data) output as the inference result, or the remaining number of unlearned first learning data 11A stored in the learning-data storage section 42.

[0124] In the step S150, if the machine-learning section 401 has determined that the learning end condition is not satisfied and the machine learning is to be continued (“No” in the step S150), the process returns to the step S120, and the steps S120 to S140 are performed on the first learning model 10A multiple times using the unlearned first learning data 11A. On the other hand, if the machine-learning section 401 has determined that the learning end condition is satisfied and the machine learning is to be terminated (“Yes” in the step S150) in the step S150, the process proceeds to step S160.

[0125] Then, in the step S160, the machine-learning section 401 stores, in the learned-model storage section 43, the first learning model 10A as the learned model (adjusted weight parameter group) created by adjusting the weight associated with each synapse. The sequence of machine-learning processes shown in FIG. 13 is completed. In the

machine-learning method, the step S100 corresponds to a learning-data storing process, the steps S110 to S150 correspond to a machine-learning process, and the step S160 corresponds to a learned-model storing process.

[0126] As described above, the machine-learning device 4 and the machine-learning method according to the present embodiment can provide the first learning model 10A capable of predicting (inferring) the substrate-holding-mechanism state information indicating the states or conditions of the substrate holding mechanisms 241a, 241c, and 241e from the operating condition information including the substrate rotating condition information, the substrate holding position information, and the substrate pressing load information.

[0127] (Information processing device 5)

FIG. 14 is a block diagram showing an example of the information processing apparatus 5 according to the first embodiment. FIG. 15 is a functional explanatory diagram showing an example of the information processing apparatus 5 according to the first embodiment. The information processing device 5 includes a control section 50, a communication section 51, and a learned-model storage section 52.

[0128] The control section 50 functions as an information acquisition section 500, a state prediction section 501, and an output processing section 502. The communication section 51 is coupled to the external devices (e.g., the substrate processing device 2, the database device 3, the machine-learning device 4, the user terminal device 6, etc.) via the network 7, and serves as a communication interface configured to transmit and receive various data.

[0129] The information acquisition section 500 is coupled to an external device via the communication section 51 and the network 7 and acquires the operating condition information including the substrate rotating condition information, the substrate holding position information, and the substrate pressing load information.

[0130] For example, when the “post-predicting process” of the substrate-holding-mechanism state information is performed for the wafer W on which the finishing process

has already been performed, the information acquisition section 500 refers to the polishing history table 301 of the production history information 30, thereby acquiring the operating condition information including the substrate rotating condition information, the substrate holding position information, and the substrate pressing load information
5 when the finishing process is performed on the wafer W.

[0131] When the “real-time-predicting process” of the substrate-holding-mechanism state information is performed for the wafer W during the finishing process, the information acquisition section 500 receives the report R on the device-state information from the substrate processing device 2 performing the finishing process, thereby
10 acquiring the operating condition information including the substrate rotating condition information, the substrate holding position information, and the substrate pressing load information during the finishing process of the wafer W.

[0132] When the “pre-predicting process” of the substrate-holding-mechanism state information is performed for the wafer W before the finishing process, the information acquisition section 500 receives the substrate recipe information 266 from the substrate
15 processing device 2 that is to perform the finishing process of the wafer W and simulates the device-state information when the substrate processing device 2 operates according to the substrate recipe conditions 266, thereby acquiring the operating condition information including the substrate rotating condition information, the substrate holding position
20 information, and the substrate pressing load information when the finishing process is to be performed on the wafer W.

[0133] As described above, the state prediction section 501 inputs the operating condition information acquired by the information acquisition section 500 as the input data to the first learning model 10A, thereby predicting the substrate-holding-mechanism
25 state information indicating the states of the substrate holding mechanisms 241a, 241c, and 241e when the substrate processing device 2 operates under the operating conditions indicated by the operating condition information.

[0134] The learned-model storage section 52 is a database configured to store the first

learning model 10A as the learned model for use in the state prediction section 501. The number of first learning model 10A stored in the learned-model storage section 52 is not limited to one. For example, a plurality of learned models 10A may be stored in the learned-model storage section 52 for different conditions, such as for machine learning
5 methods, types of finishing tools, a difference in mechanism of the substrate holding mechanisms 241a, 241c, 241e, types of data including in the operating condition information, types of data including in the substrate-holding-mechanism state information. The plurality of learned models 10A may be selectively used. The learned-model storage section 52 may be a storage section of an external computer (e.g., a server type
10 computer or a cloud type computer). In that case, the state prediction section 501 accesses the external computer.

[0135] The output processing section 502 performs output processing to output the substrate-holding-mechanism state information generated by the state prediction section 501. For example, the output processing section 502 may transmit the substrate-
15 holding-mechanism state information to the user terminal device 6, so that a display screen based on the substrate-holding-mechanism state information may be displayed on the user terminal device 6. The output processing section 502 may transmit the substrate-holding-mechanism state information to the database device 3, so that the substrate-holding-mechanism state information may be registered in the production
20 history information 30.

[0136] (Information processing method)

FIG. 16 is a flowchart illustrating an example of an information processing method performed by the information processing device 5. In this embodiment, an operation example will be described in a case where the user manipulates the user
25 terminal device 6 to perform the “post-predicting process” of the substrate-holding-mechanism state information for a specific wafer W.

[0137] First, in step S200, when the user performs an input operation of inputting a wafer ID for identifying a wafer W to be predicted on the user terminal device 6, the user

terminal device 6 transmits the wafer ID to the information processing device 5.

[0138] Next, in step S210, the information acquisition section 500 of the information processing device 5 receives the wafer ID transmitted in the step S200. In step S211, the information acquisition section 500 uses the wafer ID received in the step S210 to refer to the finishing history table 301 of the production history information 30, thereby acquiring the operating condition information when the finishing process is performed on the wafer W identified by the wafer ID.

[0139] Next, in step S220, the state prediction section 501 inputs the operating condition information acquired in the step S211 as input data to the first learning model 10A, thereby generating, as output data, the substrate-holding-mechanism state information corresponding to the operating condition information and predicting the states of the substrate holding mechanisms 241a, 241c, and 241e.

[0140] Next, in step S230, the output processing section 502 transmits the substrate-holding-mechanism state information to the user terminal device 6 as an output process for outputting the substrate-holding-mechanism state information generated in the step S220. The substrate-holding-mechanism state information may be transmitted to the database device 3 in addition to or instead of the user terminal device 6.

[0141] Next, in step S240, upon receiving the substrate-holding-mechanism state information transmitted in the step S230, the user terminal device 6 displays a display screen based on the substrate-holding-mechanism state information as a response to the transmission process in the step S200. As a result, the states of the substrate holding mechanisms 241a, 241c, and 241e can be visually recognized by the user. In the above information processing method, the steps S210 and S211 correspond to an information acquisition process, the step S220 corresponds to a state prediction process, and the step S230 corresponds to an output processing process.

[0142] As described above, the information processing device 5 and the information processing method according to the present embodiment inputs the operating condition information including the substrate rotating condition information, the substrate holding

position information, and the substrate pressing load information to the first learning model 10A, so that the substrate-holding-mechanism state information corresponding to the operating condition information can be predicted. Therefore, the states of the substrate holding mechanisms 241a, 241c, and 241e can be predicted appropriately according to the operating conditions of the substrate processing apparatus 2.

[0143] (Second embodiment)

A second embodiment differs from the first embodiment in that the substrate-holding-mechanism state information represents remaining service life information indicating the remaining service life of the substrate holding mechanisms 241a, 241c, and 241e. In this embodiment, a machine-learning device 4a and an information processing device 5a according to the second embodiment will be described, focusing on differences from the first embodiment.

[0144] FIG. 17 is a block diagram showing an example of the machine-learning device 4a according to the second embodiment. FIG. 18 is a diagram showing an example of a second learning model 10B and second learning data 11B. The second learning data 11B is used for machine learning for the second learning model 10B.

[0145] The substrate-holding-mechanism state information constituting the second learning data 11B is remaining service life information indicating the remaining service life of the substrate holding mechanisms 241a, 241c, and 241e. The remaining service life of the substrate holding mechanisms 241a, 241c, and 241e is determined, for example, by the number of times that the substrate holding mechanisms 241a, 241c, and 241e can be used until they reach the end of their lifetime, and the usable time. Note that the operating condition information constituting the second learning data 11B is the same as that in the first embodiment, so a description thereof will be omitted.

[0146] The learning-data acquisition section 400 acquires the second learning data 11B by referring to the finishing-test information 31 and receiving, as necessary, manipulations of the user through the user terminal device 6. Example of the finishing-test information 31 is as follows. When the finishing process is repeatedly performed as

a finishing test using the substrate holding mechanism for test, the remaining service life information at a point when the service lives of the substrate holding mechanisms 241a, 241c, and 241e have been reached is set to "0". A value representing the registered test result information increases as the time goes back to the past. The learning-data acquisition section 400 acquires the remaining service life information by acquiring the test result information of the finishing test specified by the test ID from the finishing test table 310 of the finishing-test information 31.

[0147] The machine-learning section 401 inputs multiple sets of second learning data 11B to the second learning model 10B, and causes the second learning model 10B to learn a correlation between the operating condition information and the substrate-holding-mechanism state information (the remaining service life information) included in the second learning data 11B, thereby creating the second learning model 10B as a learned model.

[0148] FIG. 19 is a block diagram showing an example of an information processing device 5a functioning as the information processing device 5a according to the second embodiment. FIG. 20 is a functional explanatory diagram showing an example of the information processing device 5a according to the second embodiment.

[0149] The information acquisition section 500 acquires the operating condition information including the substrate rotating condition information, the substrate holding position information, and the substrate pressing load information, as well as the first embodiment.

[0150] As described above, the state prediction section 501 inputs the operating condition information acquired by the information acquiring section 500 as input data to the second learning model 10B, thereby predicting the substrate-holding-mechanism state information (the remaining service life information) indicating the states of the substrate holding mechanisms 241a, 241c, and 241e when the substrate processing device 2 operates under the operating conditions indicated by the operating condition information.

[0151] As described above, the information processing device 5a and the information

processing method according to the present embodiment input the operating condition information including the substrate rotating condition information, the substrate holding position information, and the substrate pressing load information in the finishing process is to the learning model 10B, so that the substrate-holding-mechanism state information (remaining service life information) corresponding to the operating condition information can be predicted. Therefore, the states of the substrate holding mechanisms 241a, 241c, and 241e can be predicted appropriately according to the operating conditions of the substrate processing apparatus 2.

[0152] (Other embodiments)

10 The present invention is not limited to the above-described embodiments, and various modifications can be made and used without deviating from the scope of the present invention. All of them are included in the technical concept of the present invention.

[0153] In the above-described embodiments, the database device 3, the machine-learning device 4, and the information processing device 5 are described as being configured as separate devices, but these three devices may be configured as a single device. In one embodiment, any two of these three devices may be configured as a single device. Further, at least one of the machine-learning device 4, and the information processing device 5 may be incorporated into the control unit 26 of the substrate processing device 2 or the user terminal device 6.

[0154] In the above-described embodiments, the substrate processing device 2 has been described as having the units 21 to 25, but the substrate processing device 2 may have at least one of the function of holding the wafer W during the cleaning process of the finishing unit 24 and the function of holding the wafer W during the drying process, and the other units may be omitted.

[0155] In the embodiments described above, the neural network is employed as the learning model that implements the machine learning performed by the machine-learning section 401, while any other machine-learning model may be employed. Examples of

the other machine-learning model include tree type (e.g., decision tree, regression tree), ensemble learning (e.g., bagging, boosting), neural network type including deep learning (e.g., recurrent neural network, convolutional neural network, LSTM), clustering type (e.g., hierarchical clustering, non-hierarchical clustering, k-nearest neighbor algorithm, k-means clustering), multivariate analysis (e.g., principal component analysis, factor analysis, logistic regression), and support vector machine.

[0156] In the above-described embodiments, the test result information is information indicating the state or condition of the substrate holding mechanism when the finishing process is performed in the finishing test using a dummy wafer in the test apparatus. In one embodiment, the test result information may be continuously acquired as information indicating the states of the substrate holding mechanism 241a, 241c, and 241e when the actual finishing process of the wafer W is performed using the actual finishing unit 24 equipped with a sensor for detecting the states of the substrate holding mechanism 241a, 241c, and 241e. The continuously acquired test result information is continuously learned by the machine learning apparatus 4.

[0157] In one embodiment, the test result information may be continuously acquired from human. Specifically, a human determines the degree of contamination, the degree of wear, or the degree of damage of the substrate holding mechanisms 241a, 241c, and 241e in the finishing unit 24 where no sensor is installed, and then the human labels the data.

[0158] Furthermore, the information continuously acquired using the actual finishing unit 24 may be uploaded to a cloud. After the machine learning is performed in the cloud, the learned model may be deployed to the substrate processing device 2. In one embodiment, the substrate processing device 2 may learn the processing method therein without uploading the data to the cloud.

[0159] (Machine learning program and information processing program)

The present invention can be provided in a form of a program (machine learning program) that causes the computer 900 to function as each section of the machine-

learning devices 4, and in a form of a program (machine learning program) that causes the computer 900 to execute each process of the machine-learning method. Further, the present invention can be provided in a form of a program (information processing program) that causes the computer 900 to function as each section included in the information processing devices 5, and in a form of a program (information processing program) that causes the computer 900 to execute each process of the information processing method according to the above-described embodiments.

[0160] (Inference apparatus, inference method, and inference program)

The present invention can be provided not only in a form of the information processing devices 5 (information processing method or information processing program) according to the above-described embodiments, but also in a form of an inference apparatus (inference method or inference program) used for inferring the substrate-holding-mechanism state information. In that case, the inference apparatus (inference method or inference program) may include a memory and a processor. The processor may execute a series of processes. The series of processes includes an information acquisition processing (information acquisition process) of acquiring the operating condition information, and an inference processing (inference process) of inferring the substrate-holding-mechanism state information (condition information or remaining service life information) indicating the state or condition of the substrate holding mechanism of the substrate processing device 2 that operates under the operating conditions indicated by the operation condition information that is acquired in the information acquisition processing.

[0161] The form of the inference apparatus (inference method or inference program) can be applied to various devices more easily than when the information processing device 5 is implemented. It is readily understood by a person skilled in the art that the inference method performed by the state prediction section 501 may be applied with use of the learning model as the learned model created by the machine-learning device 4 and the machine-learning method according to the above-described embodiments when the

inference apparatus (inference method or inference program) infers the substrate-holding-mechanism state information.

Industrial Applicability

[0162] The present invention is applicable to an information processing apparatus, an inference apparatus, a machine-learning apparatus, an information processing method, an inference method, and a machine-learning method.

Reference Signs List

[0163]

1...substrate processing system, 2...substrate processing device, 3...database device,
10 4, 4a...machine-learning device, 5, 5a...information processing device,
6...user terminal device, 7...network,
10...learning model, 10A...first learning model, 10B...second learning model,
11A...first learning data, 11B...second learning data,
20...housing, 21...load-unload unit,
15 22...polishing unit, 22A~22D...polishing section, 23...substrate transport unit,
24...finishing unit, 24A, 24B...roll sponge cleaning section,
24C, 24D...pen sponge cleaning section, 24E, 24F...drying section,
24G, 24H...transport section,
25...film-thickness measuring unit, 26...control unit,
20 30...production history information, 31...finishing-test information,
40...control section, 41...communication section, 42...learning-data storage section,
43...learned-model storage section,
50...control section, 51...communication section, 52...learned-model storage section,
220...polishing table, 221...top ring, 222...liquid supply nozzle,
25 223...dresser, 224...atomizer, 240...substrate cleaning section,
241...substrate holder, 242...cleaning fluid supplying section,
243...cleaning-tool cleaning section, 244...environment sensor,
245...drying-fluid supplying section,

260...control section, 21...communication section, 262...input section, 263...output section,
264...memory section,
300...wafer history table, 301...finishing history table, 310... finishing-test table,
400...learning-data acquisition section, 401...machine-learning section,
5 500...information acquisition section, 501...state prediction section,
502...output processing section, 900...computer
2200...polishing pad, 2230...dresser disk, 2400...roll sponge,
2401...pen sponge

CLAIMS

[Claim 1] An information processing apparatus comprising:

an information acquisition section configured to acquire operating condition information indicating operating conditions of a substrate processing device having a substrate holder that includes a substrate holding mechanism configured to hold a substrate and a substrate rotating mechanism configured to rotate the substrate, the operating condition information including substrate rotating condition information indicating a rotating condition of the substrate, a substrate holding position information indicating a substrate holding position of the substrate holder, and a substrate pressing load information indicating a substrate pressing load of the substrate holder; and

a state prediction section configured to predict substrate-holding-mechanism state information corresponding to the operating condition information by inputting the operating condition information acquired by the information acquisition section to a learning model that has been generated by machine learning that causes the learning model to learn a correlation between the operating condition information and the substrate-holding-mechanism state information indicating a state of the substrate holding mechanism when the substrate processing device operates under the operating conditions indicated by the operating condition information.

[Claim 2] The information processing apparatus according to claim 1, wherein the substrate rotating condition information includes at least one of:

substrate rotation speed information indicating a rotation speed of the substrate;

and

substrate rotation torque information indicating a rotation torque of the substrate.

25

[Claim 3] The information processing apparatus according to claim 2, wherein the substrate rotation speed information included in the operating condition information includes at least one of:

the number of rotations of the substrate;
the count number of a measurement target formed on the substrate; and
the number of rotations of the substrate rotating mechanism.

5 [Claim 4] The information processing apparatus according to claim 2 or 3,
wherein the substrate rotation torque information included in the operating condition
information includes a rotation torque of the substrate rotating mechanism.

[Claim 5] The information processing apparatus according to any one of claims 1
10 to 4, wherein the substrate holding position information included in the operating
condition information includes a holding position where the substrate is held by the
substrate holding mechanism.

[Claim 6] The information processing apparatus according to any one of claims 1
15 to 5, wherein the substrate-holding-mechanism state information includes at least one of:
information on a degree of contamination of the substrate holding mechanism;
information on a degree of wear of the substrate holding mechanism; and
information on a degree of damage to the substrate holding mechanism.

20 [Claim 7] The information processing apparatus according to any one of claims 1
to 5, wherein the substrate-holding-mechanism state information includes remaining
service life information of the substrate holding mechanism.

[Claim 8] An inference apparatus comprising:
25 a memory; and
a processor configured to perform:
an information acquisition process of acquiring operating condition
information indicating operating conditions of a substrate processing device having a

substrate holder that includes a substrate holding mechanism configured to hold a substrate and a substrate rotating mechanism configured to rotate the substrate, the operating condition information including substrate rotating condition information indicating a rotating condition of the substrate, a substrate holding position information
5 indicating a substrate holding position of the substrate holding mechanism, and a substrate pressing load information indicating a substrate pressing load of the substrate holding mechanism; and

an inference process of inferring substrate-holding-mechanism state information indicating a state of the substrate holding mechanism of the substrate
10 processing device when operating under the operating conditions indicated by the operating condition information when the operating condition information is acquired in the information acquisition process.

[Claim 9] A machine-learning apparatus comprising:

15 a learning-data storage section storing multiple sets of learning data including operating condition information and substrate-holding-mechanism state information, the operating condition information indicating operating conditions of a substrate processing device having a substrate holder that includes a substrate holding mechanism configured to hold a substrate and a substrate rotating mechanism configured to rotate the substrate,
20 the operating condition information including substrate rotating condition information indicating a rotating condition of the substrate, a substrate holding position information indicating a substrate holding position of the substrate holding mechanism, and a substrate pressing load information indicating a substrate pressing load of the substrate holding mechanism, the substrate-holding-mechanism state information indicating a state
25 of the substrate holding mechanism when the substrate processing device operates under the operating conditions indicated by the operating condition information;

a machine-learning section configured to cause a learning model to learn a correlation between the operating condition information and the substrate-holding-

mechanism state information by inputting the multiple sets of learning data to the learning model; and

a learned-model storage section configured to store the learning model that has learned the correlation by the machine-learning section.

5

[Claim 10] An information processing method comprising:

an information acquisition process of acquiring operating condition information indicating operating conditions of a substrate processing device having a substrate holder that includes a substrate holding mechanism configured to hold a substrate and a substrate
10 rotating mechanism configured to rotate the substrate, the operating condition information including substrate rotating condition information indicating a rotating condition of the substrate, a substrate holding position information indicating a substrate holding position of the substrate holding mechanism, and a substrate pressing load information indicating a substrate pressing load of the substrate holding mechanism; and

15 a state prediction process of predicting substrate-holding-mechanism state information corresponding to the operating condition information by inputting the operating condition information acquired by the information acquisition process to a learning model that has been generated by machine learning that causes the learning model to learn a correlation between the operating condition information and the
20 substrate-holding-mechanism state information indicating a state of the substrate holding mechanism when the substrate processing device operates under the operating conditions indicated by the operating condition information.

[Claim 11] An inference method executed by an inference apparatus including a
25 memory and a processor, the processor performing:

an information acquisition process of acquiring operating condition information indicating operating conditions of a substrate processing device having a substrate holder that includes a substrate holding mechanism configured to hold a substrate and a substrate

rotating mechanism configured to rotate the substrate, the operating condition information including substrate rotating condition information indicating a rotating condition of the substrate, a substrate holding position information indicating a substrate holding position of the substrate holding mechanism, and a substrate pressing load information indicating a
5 substrate pressing load of the substrate holding mechanism; and

an inference process of inferring substrate-holding-mechanism state information indicating a state of the substrate holding mechanism of the substrate processing device when operating under the operating conditions indicated by the operating condition information when the operating condition information is acquired in the information
10 acquisition process.

[Claim 12] A machine-learning method comprising:

a learning-data storage process of storing multiple sets of learning data including operating condition information and substrate-holding-mechanism state information, the
15 operating condition information indicating operating conditions of a substrate processing device having a substrate holder that includes a substrate holding mechanism configured to hold a substrate and a substrate rotating mechanism configured to rotate the substrate, the operating condition information including substrate rotating condition information indicating a rotating condition of the substrate, a substrate holding position information
20 indicating a substrate holding position of the substrate holding mechanism, and a substrate pressing load information indicating a substrate pressing load of the substrate holding mechanism, the substrate-holding-mechanism state information indicating a state of the substrate holding mechanism when the substrate processing device operates under the operating conditions indicated by the operating condition information;

25 a machine-learning process of causing a learning model to learn a correlation between the operating condition information and the substrate-holding-mechanism state information by inputting the multiple sets of learning data to the learning model; and

a learned-model storage process of storing the learning model that has learned

the correlation by the machine-learning section.