

DESCRIPTION

Title of Invention

SUBSTRATE PROCESSING DEVICE, METHOD FOR REPLACING
PROCESSING TOOL, AND REPLACEMENT TOOL

5 Technical Field

[0001] The present disclosure relates to a substrate processing apparatus,
a method of replacing a processing tool used for substrate processing, and
a replacement tool for replacing a processing tool used for substrate
processing.

10 Background Art

[0002] Patent Literature 1 discloses a substrate processing apparatus. The
substrate processing apparatus includes a holding unit configured to
rotatably hold a substrate, and a supply unit configured to supply a
processing liquid to the surface of the substrate held by the holding unit
through a nozzle.

15 indicates.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application
20 Publication No. 2022-059723

Summary of Invention

Technical Problem

[0004] The present disclosure describes a substrate processing apparatus,
a method of replacing a processing tool, and a replacement tool that can
25 efficiently replace a processing tool with a simple configuration.

Solution to Problem

[0005] An example of a substrate processing apparatus includes: a holding unit configured to hold a substrate; a rotating unit configured to rotate the holding unit; a processing tool configured to process a surface of the substrate held by the holding unit; a replacement tool configured to be detachably attached to the holding unit; a holding and transport unit configured to hold and transport the processing tool; and a control unit. The replacement tool includes; a main body configured to be engageable with an engagement part of the processing tool; and a flange portion projecting from a peripheral surface of the main body for attachment to and detachment from the holding unit. The processing tool includes another fastening part configured to be fastenable to a fastening part provided on the holding and transport unit. The control unit is configured to execute a first process of attaching and detaching the processing tool to and from the holding and transport unit by controlling the rotating unit to rotate the holding unit in a state where the replacement tool is attached to the holding unit via the flange portion and the engagement part of the processing tool is engaged with the main body of the replacement tool. In this specification, "attachment and detachment" shall mean at least one of attaching and detaching.

Effects of Invention

[0006] According to the substrate processing apparatus of the present disclosure, it is possible to efficiently replace a processing tool with a simple configuration.

Brief Description of Drawings

[0007] FIG. 1 is a schematic top view illustrating an example of a substrate processing system.

FIG. 2 is a schematic side view illustrating an example of a substrate processing system.

FIG. 3 is a schematic side view illustrating an example of a thin film processing apparatus.

5 FIG. 4 is a schematic top view illustrating an example of a holding unit.

FIG. 5 is a schematic cross-sectional view illustrating an example of a processing tool unit.

10 FIG. 6 is a schematic perspective view illustrating an example of a processing tool.

FIG. 7 is a schematic perspective view illustrating an example of a holding unit and a replacement tool.

FIG. 8 is a schematic cross-sectional view illustrating an example of a holding unit and a replacement tool.

15 FIG. 9 is a partially cutaway perspective view illustrating an example of a holder.

FIG. 10 is a block diagram illustrating an example of a main part of the substrate processing system.

20 FIG. 11 is a schematic diagram illustrating an example of a hardware configuration of a controller.

FIG. 12 is a diagram illustrating a procedure for detaching a processing tool from a processing tool unit using a replacement tool.

FIG. 13 is a diagram illustrating a procedure for detaching a processing tool from a processing tool unit using a replacement tool.

25 FIG. 14 is a diagram illustrating a procedure for detaching a processing tool from a processing tool unit using a replacement tool.

FIG. 15 is a diagram illustrating a procedure for attaching a processing tool to a processing tool unit using a replacement tool.

FIG. 16 is a diagram illustrating a procedure for attaching a processing tool to a processing tool unit using a replacement tool.

5 FIG. 17 is a cross-sectional view illustrating another example of a processing tool.

FIG. 18(a) is a schematic cross-sectional view illustrating another example of a processing tool, and FIG. 18(b) is a schematic cross-sectional view illustrating another example of a processing tool.

10 FIG. 19 is a schematic perspective view illustrating another example of a replacement tool.

FIG. 20 is a schematic perspective view illustrating another example of a holding unit.

15 FIG. 21(a) is a schematic side view illustrating a state where a gripping piece of the holding unit of FIG. 20 releases the replacement tool of FIG. 19, and FIG. 21(b) is a schematic side view illustrating a state where the gripping piece of the holding unit of FIG. 20 grips the replacement tool of FIG. 19.

20 FIG. 22 is a schematic perspective view illustrating another example of a replacement tool.

FIG. 23 is a top view illustrating a main body of the replacement tool of FIG. 22.

FIG. 24 is a diagram illustrating how a processing tool is attached to the replacement tool of FIG. 23.

25 FIG. 25 is a schematic top view illustrating another example of a replacement tool.

FIG. 26 is a schematic cross-sectional view illustrating a holding unit and the replacement tool of FIG. 22.

Description of Embodiments

[0008] In the following description, the same elements or elements having the same function will be denoted by the same reference signs, and redundant description will be omitted. In this specification, the terms "up," "down," "right," and "left" are based on the orientation of the reference signs in the drawings. Some of the drawings show an orthogonal coordinate system defined by an X-axis, a Y-axis, and a Z-axis. In this specification, the X-axis and the Y-axis correspond to the horizontal direction, and the Z-axis corresponds to the vertical direction.

[0009] [Substrate Processing System]

First, a substrate processing system 1 (substrate processing apparatus) configured to process a substrate W will be described with reference to FIGS. 1 and 2. The substrate processing system 1 may be configured, for example, to perform a photolithography process on the substrate W. The photolithography process may include, for example, a process of forming a photosensitive thin film (e.g., a resist film) on a surface of the substrate W, a process of developing the photosensitive thin film after exposure, and the like.

[0010] The substrate W may have a disk shape, or may have a non-circular plate shape such as a polygon. The substrate W may have a cutout portion where a part is cut out. The cutout portion may be, for example, a notch (a U-shaped, V-shaped, or other groove) or a straight portion extending in a straight line (a so-called orientation flat). The substrate W may be, for example, a semiconductor substrate (silicon wafer), a glass

substrate, a mask substrate, an FPD (Flat Panel Display) substrate, or various other substrates. The diameter of the substrate W may be, for example, approximately 200 mm to 450 mm.

[0011] The substrate processing system 1 includes a loading/unloading station 2, at least one processing station 3, an interface station 4, and a controller Ctr (control unit). The loading/unloading station 2, the at least one processing station 3, and the interface station 4 may be arranged in a line in this order along the Y direction, for example. As illustrated in FIGS. 1 and 2, the at least one processing station 3 may include two or more processing stations 3 arranged between the loading/unloading station 2 and the interface station 4.

[0012] The loading/unloading station 2 includes a plurality of placement tables 2a and substrate transport apparatuses 2b and 2c. The plurality of placement tables 2a may be arranged, for example, along the X direction (the width direction of the substrate processing system 1). Each of the plurality of placement tables 2a is configured to be capable of placing one carrier 5. The carrier 5 is configured to house at least one substrate W in a sealed state.

[0013] The substrate transport apparatuses 2b and 2c are each configured to be movable in the X direction (horizontal direction), the Y direction (horizontal direction), the Z direction (vertical direction), and around a vertical axis (θ direction), for example. The substrate transport apparatuses 2b and 2c may each include a drive mechanism for movement in these directions. The substrate transport apparatuses 2b and 2c are configured to transfer the substrate W between the carrier 5 and the processing station 3. The transfer of the substrate W to and from the

processing station 3 by the substrate transport apparatuses 2b and 2c may include the transfer of the substrate W to and from a block G3. The block G3 may be arranged in the loading/unloading station 2 so as to be located in the vicinity of a substrate transport space 3b (described later) in the processing station 3. The block G3 may include a plurality of transfer apparatuses (not shown) arranged in the vertical direction. Each transfer apparatus may be configured to be accessible by the substrate transport apparatuses 2b and 2c and a substrate transport apparatus 3c (described later) of the processing station 3, respectively. The block G3 may be arranged in the processing station 3 instead of in the loading/unloading station 2.

[0014] The processing station 3 is configured to perform various photolithography processes on the substrate W. As illustrated in FIG. 2, the processing station 3 may include a plurality of modules 3a stacked in the vertical direction. As illustrated in FIGS. 1 and 2, each module 3a may include, for example, blocks G1 and G2, and a substrate transport space 3b extending along the Y direction. The block G1 and the block G2 may be arranged in the X direction so as to face each other with the substrate transport space 3b therebetween.

[0015] The block G1 includes at least one thin film processing apparatus U1. The thin film processing apparatus U1 may be an apparatus that performs film processing by supplying a processing liquid to the substrate W, or an apparatus that performs film processing by supplying a predetermined gas to the substrate W. The thin film processing apparatus U1 may include, for example, a thin film forming apparatus, a developing apparatus, and the like. The thin film forming apparatus may include, for

example, a photosensitive thin film forming apparatus, an antireflection film forming apparatus, and the like. Thin film processing may include forming a thin film and developing. In the example of FIG. 1, a plurality of thin film processing apparatuses U1 are arranged along the Y direction, but the number, arrangement, and type of the thin film processing apparatuses U1 can be arbitrarily selected.

[0016] The block G2 includes a plurality of heat treatment apparatuses U2, a hydrophobizing apparatus (not shown), and a peripheral exposure apparatus U3. The plurality of heat treatment apparatuses U2 are configured to perform heat treatment (e.g., heating, cooling) of the substrate W. The plurality of heat treatment apparatuses U2 may be arranged vertically and horizontally in the block G2. The hydrophobizing apparatus is configured to make the surface of the substrate W hydrophobic in order to enhance the adhesion between the processing liquid for forming the photosensitive thin film and the substrate W. The peripheral exposure apparatus U3 is configured to expose a portion of the photosensitive thin film formed on the surface of the substrate W that is located at the peripheral edge. The hydrophobizing apparatus and the peripheral exposure apparatus U3 may be arranged vertically and horizontally in the block G2. The number and arrangement of the heat treatment apparatuses U2, the hydrophobizing apparatus, and the peripheral exposure apparatus U3 can be arbitrarily selected. The peripheral exposure apparatus U3 may be arranged in the interface station 4 instead of or in addition to the processing station 3 (block G2).

[0017] The substrate transport apparatus 3c is arranged in the substrate transport space 3b. The substrate transport apparatus 3c is configured to

be movable in the Y direction (horizontal direction), the Z direction (vertical direction), and around a vertical axis (θ direction), for example. The substrate transport apparatus 3c may include a drive mechanism for movement in these directions. The substrate transport apparatus 3c is configured to move in the substrate transport space 3b and transfer the substrate W among the blocks G1 to G5.

[0018] In the example of FIG. 1, the block G4 is arranged in the substrate transport space 3b at the boundary between the two processing stations 3. The block G4 may include a plurality of transfer apparatuses (not shown) arranged in the vertical direction. Each transfer apparatus may be configured to be accessible by the substrate transport apparatus 3c of one of the two processing stations 3 and the substrate transport apparatus 3c of the other of the two processing stations 3, respectively.

[0019] In the example of FIG. 1, the block G5 may be arranged in the interface station 4 so as to be located in the vicinity of the substrate transport space 3b in the processing station 3. The block G5 may include a plurality of transfer apparatuses (not shown) arranged in the vertical direction. Each transfer apparatus may be configured to be accessible by the substrate transport apparatus 3c and substrate transport apparatuses 4a and 4b (described later) of the interface station 4.

[0020] The interface station 4 connects the processing station 3 and an exposure apparatus (not shown) so as to transfer the substrate W between them. The exposure apparatus may be adjacent to the interface station 4, for example, so as to be located on the opposite side of the interface station 4 from the processing station 3.

[0021] The interface station 4 includes substrate transport apparatuses 4a

and 4b. The substrate transport apparatuses 4a and 4b are each configured to be movable in the X direction (horizontal direction), the Y direction (horizontal direction), the Z direction (vertical direction), and around a vertical axis (θ direction), for example. The substrate transport apparatuses 4a and 4b may each include a drive mechanism for movement in these directions. The substrate transport apparatuses 4a and 4b are configured to transfer the substrate W among the processing station 3, the interface station 4, and the exposure apparatus. The transfer of the substrate W to and from the processing station 3 by the substrate transport apparatuses 4a and 4b may include the transfer of the substrate W to and from the block G5. The block G5 may be arranged in the interface station 4 so as to be located in the vicinity of the substrate transport space 3b in the processing station 3. The block G5 may include a plurality of transfer apparatuses (not shown) arranged in the vertical direction. Each transfer apparatus may be configured to be accessible by the substrate transport apparatuses 4a and 4b and the substrate transport apparatus 3c of the processing station 3. The block G5 may be arranged in the processing station 3 instead of in the interface station 4.

[0022] The controller Ctr is configured to partially or entirely control the substrate processing system 1.

[0023] [Details of Thin Film Processing Apparatus]

Next, the thin film processing apparatus U1 will be described in detail with reference to FIGS. 3 to 6. The thin film processing apparatus U1 the thin film processing apparatus U1 includes a chamber 10, a holding unit 20, a suction unit 30, a rotating unit 40, a supply unit 50, a cup member 60, an imaging unit 70, and a cleaning cup 80.

[0024] The chamber 10 is a housing configured to allow the substrate W to be loaded into and unloaded from its interior. A loading/unloading port (not shown) is formed in a side wall of the chamber 10. The substrate W is transported into the chamber 10 and unloaded from the chamber 10 to the outside through the loading/unloading port by the substrate transport apparatus 3c.

[0025] The holding unit 20 operates based on a control signal from the controller Ctr and is configured to hold the substrate W. As illustrated in FIG. 4, the holding unit 20 includes a substantially horizontal circular upper surface 21, a suction hole 22, and a plurality of ridges 23 to 27. The suction hole 22 is provided on the upper surface 21 so as to substantially coincide with the central axis Ax1 which is the center of rotation of the holding unit 20. Therefore, the suction hole 22 includes an opening formed on the upper surface 21 and opened upward.

[0026] The plurality of ridges 23 to 27 are provided on the upper surface 21 and project upward from the upper surface 21. The plurality of ridges 23 to 27 are configured to support the substrate W placed on the holding unit 20 at their distal ends.

[0027] Each of the plurality of ridges 23 has an arc shape (e.g., a circular arc shape). The plurality of ridges 23 are arranged in the vicinity of the suction hole 22 so as to surround the suction hole 22 and form an annular shape as a whole. Therefore, the ends of adjacent ridges 23 are spaced apart. Each of the plurality of ridges 24 has an arc shape (e.g., a circular arc shape). The plurality of ridges 24 are arranged outside the ridges 23 so as to surround the ridges 23 and form an annular shape as a whole. Therefore, the ends of adjacent ridges 24 are spaced apart.

[0028] Each of the plurality of ridges 25 has an arc shape (e.g., a circular arc shape). The plurality of ridges 25 are arranged outside the ridges 24 so as to surround the ridges 24 and form an annular shape as a whole. Therefore, the ends of adjacent ridges 25 are spaced apart. Each of the plurality of ridges 26 has an arc shape (e.g., a circular arc shape). The plurality of ridges 26 are arranged outside the ridges 25 so as to surround the ridges 25 and form an annular shape as a whole. Therefore, the ends of adjacent ridges 26 are spaced apart.

[0029] The ridge 27 (first ridge) has an annular shape (e.g., a circular ring shape). The ridge 27 is arranged outside the ridges 26 so as to surround the ridges 26. The ridge 27 may be arranged along the vicinity of the outer peripheral edge of the upper surface 21. Therefore, in the radial direction of the central axis Ax1, the plurality of ridges 23 to 26 are arranged on the upper surface 21 inward of the ridge 27.

[0030] The suction unit 30 is connected to the suction hole 22. The suction unit 30 operates based on a control signal from the controller Ctr and is configured to suction the atmosphere in the vicinity of the suction hole 22 through the suction hole 22. Therefore, when the suction unit 30 operates in a state where the substrate W is supported by the plurality of ridges 23 to 27, the atmosphere in the space between the substrate W and the upper surface 21 of the holding unit 20 is suctioned through the suction hole 22, and a negative pressure is created in the space. As a result, the substrate W is held by suction to the holding unit 20 with the posture of the substrate W being substantially horizontal. In other words, the holding unit 20 and the suction unit 30 constitute a so-called vacuum chuck.

[0031] As illustrated in FIG. 3, the rotating unit 40 includes a drive unit 41 and a shaft 42. The drive unit 41 operates based on an operation signal from the controller Ctr and is configured to rotate the shaft 42. The drive unit 41 may be a drive source such as an electric motor. The shaft 42 connects the drive unit 41 and the holding unit 20 and extends along the vertical direction. Therefore, the substrate W held by the holding unit 20 rotates around the vertical central axis Ax1 in a substantially horizontal posture. In other words, the holding unit 20 and the rotating unit 40 constitute a so-called spin chuck.

[0032] The supply unit 50 is configured to supply a plurality of different types of processing liquids from a nozzle 100 (processing tool) to the surface Wa of the substrate W held by the holding unit 20. The supply unit 50 includes a liquid source 51, a pipe 52, a holding base 53 (holding and transport unit), a drive unit 54 (holding and transport unit), and at least one nozzle N.

[0033] The liquid source 51 may be configured as a supply source of the processing liquid. The processing liquid may be, for example, an acid-based processing liquid or an alkali-based processing liquid. The pipe 52 connects the liquid source 51 and the at least one nozzle 100. A valve (not shown) is provided in the pipe 52. The valve is configured to open and close based on an operation signal from the controller Ctr.

[0034] The holding base 53 is configured to hold the at least one nozzle 100. As illustrated in FIG. 5, the holding base 53 includes at least one recess 53a. The holding base 53 may include a number of recesses 53a corresponding to the number of nozzles 100.

[0035] The recess 53a includes a bottom surface 53b and a main portion

53c. A flow path 53e connected to the pipe 52 is provided on the bottom surface 53b. A base end portion 101 (described later) of the nozzle 100 is housed in the main portion 53c. The inner peripheral surface of the main portion 53c may be, for example, a substantially cylindrical surface. A female screw 53f (fastening part) is provided on the inner peripheral surface of the main portion 53c.

[0036] The drive unit 54 is connected to the holding base 53. The drive unit 54 operates based on an operation signal from the controller Ctr and is configured to move the holding base 53 horizontally or vertically. Therefore, the at least one nozzle N is configured to move horizontally or vertically above the holding unit 20. That is, the holding base 53 and the drive unit 54 constitute a holding and transport unit for holding and transporting the at least one nozzle 100.

[0037] The at least one nozzle 100 is configured to supply the processing liquid from the liquid source 51 to the surface Wa of the substrate W when located above the substrate W held by the holding unit 20. Therefore, a flow path 100a extending along the extending direction of the nozzle 100 is provided inside the nozzle 100. The at least one nozzle 100 may include two or more nozzles 100.

[0038] As illustrated in FIGS. 5 and 6, the nozzle 100 includes a base end portion 101, a tip portion 102, and an deformed shape portion 103 (engagement part).

[0039] The base end portion 101 has an outer shape corresponding to the inner peripheral surface of the main portion 53c. A male screw 101a (another fastening part) is provided on the outer peripheral surface of the base end portion 101. The nozzle 100 is attached to the holding base 53

by the male screw 101a being fastened to the female screw 53f. On the other hand, the nozzle 100 is detached from the holding base 53 by the male screw 101a being loosened from the female screw 53f. That is, the nozzle 100 includes the male screw 101a configured to be fastenable to the female screw 53f provided on the main portion 53c of the holding base 53.

[0040] The tip portion 102 has a tapered shape that decreases in diameter toward the tip. The deformed shape portion 103 is located between the base end portion 101 and the tip portion 102. The outer peripheral surface of the deformed shape portion 103 has a non-circular (a shape other than a perfect circle) deformed shape. The overall outer diameter of the deformed shape portion 103 may be larger than the inner diameter of the main portion 53c. As illustrated in FIGS. 5 and 6, the outer peripheral surface of the deformed shape portion 103 may have a substantially hexagonal shape as a whole. As illustrated in FIGS. 5 and 6, the outer peripheral surface of the deformed shape portion 103 may have a shape in which the central part of each side of the substantial hexagon is recessed inward in an arc shape.

[0041] The outer diameter of the deformed shape portion 103 may be larger than the outer shape of the base end portion 101 (male screw 101a). Therefore, the upper end of the deformed shape portion 103 includes a shoulder portion 103a projecting radially outward beyond the base end portion 101. In a state where the nozzle 100 is attached to the recess 53a, the upper surface of the shoulder portion 103a contacts the lower surface of the holding base 53, and the end face of the base end portion 101 contacts the bottom surface of the recess 53a. This prevents leakage of

the processing liquid from the gap between the recess 53a and the nozzle 100. The base end portion 101 may be configured to be elastically deformable. In this case, when fastening the male screw 101a to the female screw 53f to attach the nozzle 100 to the recess 53a, the end face of the base end portion 101 first contacts the bottom surface of the recess 53a. Thereafter, the male screw 101a is further fastened to the female screw 53f while the base end portion 101 is compressed, until the upper surface of the shoulder portion 103a contacts the lower surface of the holding base 53.

[0042] The cup member 60 is provided so as to surround the periphery of the holding unit 20, as illustrated in FIG. 3. The cup member 60 is configured to collect the processing liquid scattered to the surroundings from the outer peripheral edge of the substrate W when the substrate W is held and rotated by the holding unit 20 and the rotating unit 40. A drain port 61 and an exhaust port 62 are provided at the bottom of the cup member 60.

[0043] The drain port 61 is configured to discharge the processing liquid collected by the cup member 60 to the outside of the thin film processing apparatus U1. The exhaust port 62 is configured to discharge a downward flow formed around the substrate W by a blower (not shown) to the outside of the thin film processing apparatus U1. The downward flow is accompanied by gas generated around the substrate W as the substrate W is processed by the processing liquid.

[0044] The imaging unit 70 is disposed above the holding unit 20. The imaging unit 70 operates based on a control signal from the controller Ctr and is configured to capture an image of the center of rotation of the

holding unit 20 and its surroundings. The imaging unit 70 is configured to transmit the captured image to the controller Ctr. The imaging unit 70 may be, for example, a CCD camera, a COMS camera, or the like. The installation location of the imaging unit 70 is not particularly limited as long as it can capture an image of the center of rotation of the holding unit 20 and its surroundings.

[0045] The cleaning cup 80 is configured to clean the tip portion 102 of the nozzle 100 with a cleaning liquid after the processing liquid has been supplied to the surface Wa of the substrate W. The cleaning cup 80 is located outside the cup member 60 and spaced apart from the cup member 60. The cleaning cup 80 has a bottomed tubular shape open at the top so that it can retain a cleaning liquid. The cleaning liquid retained in the cleaning cup 80 may be, for example, a solvent.

[0046] [Configuration of Replacement Tool]

Incidentally, when the holding unit 20 does not hold the substrate W, by attaching a replacement tool 200 to the holding unit 20, the nozzle 100 is attached to and detached from the holding base 53 by the replacement tool 200. That is, the replacement tool 200 is configured to be detachably attached to the holding unit 20. Therefore, the replacement tool 200 will be described in detail with reference to FIGS. 7 to 9.

[0047] As illustrated in FIGS. 7 to 9, the replacement tool 200 includes a main body 210, a flange portion 220, and an annular elastic member 230 (e.g., an O-ring).

[0048] The main body 210 has a tubular shape as a whole and extends along a predetermined direction. The main body 210 includes a base portion 211 (transmission portion), an outer tubular portion 212

(transmission portion), a slide portion 213, a biasing unit 214, and at least one projection 215 (transmission portion).

[0049] The base portion 211 has a bottomed tubular shape and is configured to house the tip portion 102 of the nozzle 100 in a state where the nozzle 100 is attached to the replacement tool 200. As illustrated in FIGS. 8 and 9, the base portion 211 includes an upper part 211a and a lower part 211b.

[0050] The outer peripheral surface of the upper part 211a has a non-circular (a shape other than a perfect circle) deformed shape. The outer peripheral surface of the upper part 211a may have, for example, a substantially hexagonal shape as a whole. The peripheral wall of the upper part 211a may be provided with a number of receiving parts 211c (transmission portion) corresponding to the number of the at least one projection 215. The receiving part 211c may be a through-hole penetrating the peripheral wall of the upper part 211a, or a recessed groove recessed inward from the outer peripheral surface of the upper part 211a. The receiving part 211c may extend in the extending direction of the main body 210. A tubular portion 211d is provided near the inner peripheral edge of the upper end of the upper part 211a. The tubular portion 211d extends upward along the extending direction of the replacement tool 200. In a state where the outer tubular portion 212 is attached to the base portion 211, the outer peripheral surface of the tubular portion 211d is spaced apart from the inner peripheral surface of the outer tubular portion 212.

[0051] The lower part 211b extends downward from the lower end of the upper part 211a. The lower part 211b is inserted into the suction hole 22

of the holding unit 20 when the replacement tool 200 is attached to the holding unit 20. In this case, the central axis Ax1 of the holding unit 20 and the central axis Ax2 of the replacement tool 200 substantially coincide. Therefore, when the holding unit 20 and the replacement tool 200 rotate, the holding unit 20 and the replacement tool 200 rotate around the substantially coaxial central axes Ax1 and Ax2.

[0052] The lower part 211b may be integrally formed with the upper part 211a. A cutout 211e may be partially provided on the outer peripheral surface of the lower part 211b. Therefore, as illustrated in FIG. 8, in a state where the replacement tool 200 is held by the holding unit 20, a space V1 is formed between the outer peripheral surface of the cutout 211e and the inner peripheral surface of the suction hole 22. The cutout 211e may be, for example, a recessed groove (a U-shaped, V-shaped, or other groove) extending in the extending direction of the main body 210. The cutout 211e may be, for example, a flat portion (a so-called D-cut) extending in the extending direction of the main body 210.

[0053] The outer tubular portion 212 is disposed outside the base portion 211 and is configured to be slidable relative to the base portion 211. The outer tubular portion 212 includes a lower part 212a and an upper part 212b.

[0054] The inner peripheral surface of the lower part 212a has a shape corresponding to the outer peripheral surface of the upper part 211a of the base portion 211. That is, the inner peripheral surface of the lower part 212a has a non-circular (a shape other than a perfect circle) deformed shape. The inner peripheral surface of the lower part 212a may have, for example, a substantially hexagonal shape as a whole. The inner shape of

the lower part 212a may be configured to be slightly larger than the outer shape of the upper part 211a. Therefore, when the upper part 211a is inserted into the lower part 212a, the lower part 212a and the upper part 211a engage with each other. Therefore, when the base portion 211 rotates around the central axis Ax2 of the replacement tool 200, the outer tubular portion 212 rotates together with the base portion 211 without idle rotation. That is, the inner peripheral surface of the lower part 212a and the outer peripheral surface of the upper part 211a constitute a transmission portion that transmits a rotational force between the base portion 211 and the outer tubular portion 212. The peripheral wall of the lower part 212a may be provided with through-holes 212c in a number corresponding to the number of the at least one projection 215. A female screw may be formed on the inner peripheral surface of the through-hole 212c.

[0055] The inner peripheral surface of the upper part 212b (the inner peripheral surface of the opening OP of the main body 210) has a shape corresponding to the outer peripheral surface of the deformed shape portion 103 of the nozzle 100. That is, the inner peripheral surface of the upper part 212b has a non-circular (a shape other than a perfect circle) deformed shape. The inner peripheral surface of the upper part 212b may have, for example, a substantially hexagonal shape as a whole. The inner shape of the upper part 212b may be configured to be larger than the inner shape of the lower part 212a. Therefore, when the deformed shape portion 103 of the nozzle 100 is inserted into the upper part 212b, the outer tubular portion 212 (replacement tool 200) and the nozzle 100 fit together (engage), and the tip portion 102 and the deformed shape portion 103 of

the nozzle 100 are housed in the main body 210. Therefore, when the replacement tool 200 rotates around the central axis Ax2 of the replacement tool 200, the nozzle 100 rotates together with the replacement tool 200 via the deformed shape portion 103 without idle rotation. That is, the inner peripheral surface of the upper part 212b and the outer peripheral surface of the deformed shape portion 103 constitute a transmission portion that transmits a rotational force between the nozzle 100 and the replacement tool 200. The upper end of the upper part 212b (near the entrance of the opening OP) may have a shape that widens upward so that the deformed shape portion 103 can be smoothly inserted into the upper part 212b. The upper part 212b may be integrally formed with the lower part 212a.

[0056] The slide portion 213 is disposed inside the lower part 212a. The slide portion 213 is configured to be slidable in the extending direction of the replacement tool 200 between the base portion 211 and the outer tubular portion 212. The slide portion 213 includes a tubular portion 213a and a flange portion 213b. The tubular portion 213a extends along the extending direction of the replacement tool 200. The tubular portion 213a is configured to house the tip portion 102 of the nozzle 100 in a state where the nozzle 100 is attached to the replacement tool 200. In a state where the slide portion 213 is disposed inside the outer tubular portion 212, the outer peripheral surface of the tubular portion 213a is spaced apart from the inner peripheral surface of the outer tubular portion 212.

[0057] The flange portion 213b extends (projects) radially outward of the central axis Ax2 from the vicinity of the upper end of the tubular portion 213a. The flange portion 213b may be a plate-like body having an annular

shape. The outer shape of the flange portion 213b is configured to be smaller than the inner shape of the lower part 212a but larger than the inner shape of the upper part 212b. Therefore, the upper part 212b functions as a stopper that restricts the upward movement of the flange portion 213b. Thus, the flange portion 213b is prevented from coming out of the opening OP of the upper part 212b (replacement tool 200). The flange portion 213b may be integrally formed with the tubular portion 213a.

[0058] The biasing unit 214 is configured to apply a biasing force to the outer tubular portion 212 in a direction to separate the base portion 211 and the outer tubular portion 212 from each other in the extending direction of the replacement tool 200. The biasing unit 214 may be, for example, a compression coil spring.

[0059] The biasing unit 214 is disposed inside the lower part 212a. The upper end of the biasing unit 214 is located between the outer peripheral surface of the tubular portion 213a and the inner peripheral surface of the lower part 212a, and is in contact with the lower surface of the flange portion 213b. The lower end of the biasing unit 214 is located between the outer peripheral surface of the tubular portion 211d and the inner peripheral surface of the lower part 212a, and is in contact with the upper surface of the upper part 211a. Therefore, in the examples of FIGS. 8 and 9, the biasing unit 214 is configured to apply a biasing force to the outer tubular portion 212 via the slide portion 213.

[0060] The at least one projection 215 is configured to be attachable to the corresponding through-hole 212c. The projection 215 may be, for example, a male screw, and may be configured to be fastenable to the

female screw of the corresponding through-hole 212c. The at least one projection 215 may include two or more projections 215.

[0061] The tip of the projection 215 projects from the inner peripheral surface of the outer tubular portion 212 toward the base portion 211 in a state where it is attached to the through-hole 212c. The tip of the projection 215 is received in the receiving part 211c of the base portion 211 in a state where the outer tubular portion 212 is attached to the base portion 211. Therefore, when the outer tubular portion 212 is biased upward by the biasing unit 214, the tip of the projection 215 comes into contact with the upper end of the receiving part 211c, and further upward movement of the outer tubular portion 212 is prevented. That is, the projection 215 and the receiving part 211c function as a stopper that restricts the upward movement of the outer tubular portion 212. Further, when the base portion 211 rotates around the central axis Ax2 of the replacement tool 200, the tip of the projection 215 comes into contact with the side wall of the receiving part 211c. Therefore, the outer tubular portion 212 rotates together with the base portion 211 without idle rotation. That is, the tip of the projection 215 and the side wall of the receiving part 211c constitute a transmission portion that transmits a rotational force between the base portion 211 and the outer tubular portion 212.

[0062] The flange portion 220 extends (projects) radially outward with respect to the central axis Ax2 from the vicinity of the upper end of the lower part 211b. The flange portion 213b may be a plate-like body having an annular shape. The flange portion 220 may be integrally formed with the base portion 211.

[0063] The flange portion 220 may include a ridge 221 (second ridge) projecting downward (toward the lower part 211b from the flange portion 220). The ridge 221 has an annular shape (e.g., a circular ring shape). The ridge 221 is disposed outside the lower part 211b so as to surround the lower part 211b. The ridge 221 may be disposed along the vicinity of the outer peripheral edge of the lower surface of the flange portion 220.

[0064] The outer shape of the flange portion 220 may be configured to be smaller than the outer shape of the substrate W. That is, in a state where the replacement tool 200 is held by the holding unit 20, the ridge 221 may be located inside the ridge 27. In the example of FIG. 7, the outer shape of the flange portion 220 is configured to be smaller than a virtual annular shape (virtual circle) formed by the plurality of ridges 23. In this case, in a state where the replacement tool 200 is held by the holding unit 20, the lower end of the ridge 221 comes into contact with a region of the upper surface 21 of the holding unit 20 inside the plurality of ridges 23. The outer shape of the flange portion 220 may be of such a size that the ridge 221 is located between adjacent ridges of the ridges 23 to 27 in the radial direction of the central axis Ax2 in a state where the replacement tool 200 is held by the holding unit 20.

[0065] In a state where the replacement tool 200 is held by the holding unit 20, the flange portion 220 is slightly spaced apart from the upper surface 21 of the holding unit 20 due to the presence of the ridge 221. That is, as illustrated in FIG. 8, in a state where the replacement tool 200 is held by the holding unit 20, a space V2 surrounded by the lower surface of the flange portion 220, the ridge 221, and the upper surface 21 of the holding unit 20 is formed. The space V2 communicates with the space

V1. Therefore, when the suction unit 30 operates, the atmosphere in the space V2 is suctioned through the suction hole 22 and the space V1, and the space V2 is dispressurized. As a result, the flange portion 220 is suctioned to the holding unit 20.

5 [0066] As illustrated in FIGS. 7 to 9, the elastic member 230 is attached to the outer peripheral surface (end face) of the flange portion 220. In a state where the replacement tool 200 is held by the holding unit 20, when the suction unit 30 operates and the flange portion 220 is suctioned to the holding unit 20, the elastic member 230 is pressed downward. This
10 prevents leakage of gas from the gap between the lower end of the ridge 221 and the upper surface 21 of the holding unit 20.

[0067] [Details of Controller]

The controller Ctr is configured to partially or entirely control the substrate processing system 1. As illustrated in FIG. 10, the controller Ctr
15 includes, as functional modules, a reading unit M1, a storage unit M2, a processing unit M3, an instruction unit M4, and a communication unit M5. These functional modules are merely a division of the functions of the controller Ctr into a plurality of modules for convenience, and do not necessarily mean that the hardware constituting the controller Ctr is
20 divided into such modules. Each functional module is not limited to being realized by the execution of a program, but may be realized by a dedicated electric circuit (e.g., a logic circuit) or an integrated circuit (ASIC: Application Specific Integrated Circuit) in which such a circuit is integrated.

25 [0068] The reading unit M1 is configured to read a program from a computer-readable recording medium RM. The recording medium RM

stores a program for operating each part of the substrate processing system 1. The recording medium RM may be, for example, a semiconductor memory, an optical recording disk, a magnetic recording disk, or a magneto-optical recording disk. Hereinafter, each part of the substrate processing system 1 may include the holding unit 20, the suction unit 30, the drive units 41 and 54, and the imaging unit 70.

[0069] The storage unit M2 is configured to store various data. The storage unit M2 may store, for example, a program read from the recording medium RM by the reading unit M1, setting data input from an operator via an external input device (not shown), and the like. The storage unit M2 may store, for example, data of processing conditions (processing recipe) for processing the substrate W. The storage unit M2 may store, for example, data of a captured image from the imaging unit 70.

[0070] The processing unit M3 is configured to process various data. The processing unit M3 may generate, for example, a control signal for operating the components of the substrate processing system 1 based on various data stored in the storage unit M2.

[0071] The processing unit M3 may, for example, control the rotating unit 40 to rotate the holding unit 20 in a state where the replacement tool 200 is attached to the holding unit 20 via the flange portion 220 and the deformed shape portion 103 of the nozzle 100 is engaged with the upper part 212b of the replacement tool 200 (first process). As a result, the male screw 101a of the nozzle 100 is fastened to or loosened from the female screw 53f of the holding base 53, so that the nozzle 100 is attached to and detached from the holding base 53.

[0072] The processing unit M3 may, for example, operate the suction unit 30 to cause the flange portion 220 to be suctioned to the holding unit 20 before the first process (second process). In this case, the processing unit M3 may, for example, operate the suction unit 30 in a state where the lower part 211b of the main body 210 is inserted into the suction hole 22 to generate a negative pressure in the space V2, thereby causing the flange portion 220 to be suctioned to the holding unit 20.

[0073] The processing unit M3 may, for example, control the drive unit 54 to apply pressure to the slide portion 213 via the nozzle 100 by the holding base 53 until the biasing unit 214 is compressed by a predetermined amount before the first process (third process). The third process may be executed in a state where the deformed shape portion 103 of the nozzle 100 is inserted into the outer tubular portion 212 (upper part 212b) of the replacement tool 200 attached to the holding unit 20, and the deformed shape portion 103 of the nozzle 100 is supported by the slide portion 213.

[0074] The processing unit M3 may, for example, determine the state of the replacement tool 200 and/or the nozzle 100 based on the data of the image captured by the imaging unit 70. The determination of the state may include, for example, determining the presence or absence of the replacement tool 200 on the holding unit 20, determining the presence or absence of the nozzle 100 on the replacement tool 200, determining the appropriateness of the installation state of the replacement tool 200 with respect to the holding unit 20, determining the appropriateness of the installation state of the nozzle 100 with respect to the replacement tool 200, and the like. The determination of the appropriateness of the

installation state may include, for example, determining whether the replacement tool 200 is tilted with respect to the holding unit 20, determining whether the flange portion 220 and the elastic member 230 of the replacement tool 200 are in contact with the upper surface 21 of the holding unit 20, determining whether the nozzle 100 is tilted with respect to the replacement tool 200, determining whether the deformed shape portion 103 of the nozzle 100 is inserted into the opening OP of the main body 210, and the like. The processing unit M3 may, for example, determine the presence or absence by comparison between a reference image and the captured image (so-called pattern matching), or may use a result obtained by machine learning using past captured images to determine the presence or absence in the current captured image. When detaching the nozzle 100 from the holding base 53, if the replacement tool 200 is not held by the holding unit 20 or if another nozzle 100 is already present on the replacement tool 200, the processing unit M3 may cause a notification unit (not shown) to issue an alarm. Similarly, when attaching the nozzle 100 to the holding base 53, if the replacement tool 200 is not held by the holding unit 20 or if the nozzle 100 to be attached is not present on the replacement tool 200, the processing unit M3 may cause a notification unit (not shown) to issue an alarm. The alarm notification by the notification unit may include, for example, displaying an alarm (e.g., characters, figures, etc.) on a display (not shown), or issuing an alarm sound or alarm guidance from a speaker (not shown).

[0075] The processing unit M3 may, for example, attach and detach the nozzle 100 to and from one recess 53a designated by an operator among a plurality of recesses 53a when the holding base 53 includes the plurality

of recesses 53a (when the holding base 53 can hold a plurality of nozzles 100). In this case, the processing unit M3 may, for example, cause the position of the holding base 53 to be adjusted by the drive unit 54 so that the recess 53a designated by the operator is located directly above the replacement tool 200 held by the holding unit 20.

[0076] The instruction unit M4 is configured to transmit the control signal generated by the processing unit M3 to the components of the substrate processing system 1.

[0077] The hardware of the controller Ctr may be configured with, for example, one or more control computers. As illustrated in FIG. 11, the controller Ctr may include a circuit C1 as a hardware configuration. The circuit C1 may be configured with circuitry. The circuit C1 may include, for example, a processor C2, a memory C3, storage C4, a driver C5, and an input/output port C6.

[0078] The processor C2 may be configured to implement each of the above-described functional modules by executing a program in cooperation with at least one of the memory C3 and the storage C4, and executing input/output of signals via the input/output port C6. The memory C3 and the storage C4 may function as the storage unit M2. The driver C5 may be a circuit configured to drive the components of the substrate processing system 1. The input/output port C6 may be configured to mediate input/output of signals between the driver C5 and the components of the substrate processing system 1.

[0079] The substrate processing system 1 may include one controller Ctr, or may include a controller group (control unit) configured with a plurality of controllers Ctr. When the substrate processing system 1

includes a controller group, each of the above-described functional modules may be implemented by one controller Ctr, or may be implemented by a combination of two or more controllers Ctr. When the controller Ctr is configured with by a plurality of computers (circuits C1),
5 each of the above-described functional modules may be implemented by one computer (circuit C1), or may be implemented by a combination of two or more computers (circuits C1). The controller Ctr may include a plurality of processors C2. In this case, each of the above-described functional modules may be implemented by one processor C2, or may be
10 implemented by a combination of two or more processors C2.

[0080] [Method of Replacing Nozzle using Replacement Tool]

Next, a method of detaching the nozzle 100 from the holding base 53 using the replacement tool 200 will be described with reference to FIGS. 12 to 14. Before detaching the nozzle 100 from the holding base
15 53, the flange portion 220 is caused to be suctioned to the holding unit 20 in accordance with an instruction from the controller Ctr to the suction unit 30. Further, the holding unit 20 is rotated clockwise as viewed from above the replacement tool 200, in accordance with an instruction from the controller Ctr to the rotating unit 40. The rotation speed of the holding
20 unit 20 may be, for example, approximately 30 rpm. As a result, the replacement tool 200 rotates together with the holding unit 20. The timing of rotating the holding unit 20 may be before the holding base 53 is lowered.

[0081] First, as illustrated in FIG. 12(a), the recess 53a to which the
25 nozzle 100 to be replaced is attached is positioned directly above the replacement tool 200 in accordance with an instruction from the

controller Ctr to the drive unit 54. Further, the holding base 53 is lowered in accordance with an instruction from the controller Ctr to the drive unit 54, and the tip portion 102 of the nozzle 100 is inserted into the main body 210 of the replacement tool 200. The lowering speed of the holding base 53 may be, for example, approximately 1 mm/sec.

[0082] Since the nozzle 100 is lowered together with the holding base 53 while the replacement tool 200 is rotating, when the deformed shape portion 103 of the nozzle 100 reaches the opening OP of the main body 210 (upper part 212b), the deformed shape portion 103 may not enter the opening OP. That is, as illustrated in FIG. 12(b), the deformed shape portion 103 may push the outer tubular portion 212 and the slide portion 213 downward against the biasing force of the biasing unit 214. In this case, when the replacement tool 200 rotates until the outer shape of the deformed shape portion 103 and the inner shape of the opening OP substantially coincide when viewed from above, the outer tubular portion 212 and the slide portion 213 are pushed upward by the biasing force of the biasing unit 214. As a result, as illustrated in FIG. 13(a), the deformed shape portion 103 is inserted into the main body 210 (upper part 212b).

[0083] When the deformed shape portion 103 is inserted into the main body 210 (upper part 212b), the lowering of the holding base 53 is stopped in accordance with an instruction from the controller Ctr to the drive unit 54. At this time, since the rotation of the replacement tool 200 continues, the male screw 101a of the base end portion 101 is loosened from the female screw 53f of the recess 53a, as illustrated in FIG. 13(b). At this time, while the lower end of the deformed shape portion 103 is supported by the slide portion 213, the deformed shape portion 103

pushes the outer tubular portion 212 and the slide portion 213 downward against the biasing force of the biasing unit 214.

[0084] When the male screw 101a of the base end portion 101 is completely disengaged from the female screw 53f of the recess 53a, the holding base 53 is raised in accordance with an instruction from the controller Ctr to the drive unit 54, as illustrated in FIG. 14. Further, the rotation of the holding unit 20 is stopped in accordance with an instruction from the controller Ctr to the rotating unit 40. Thus, the process of detaching the nozzle 100 from the holding base 53 is completed.

[0085] Before the process of detaching the nozzle 100 from the holding base 53, the suction hole 22 of the holding unit 20 and its surroundings may be imaged by the imaging unit 70. The controller Ctr may determine the state of the replacement tool 200 and/or the nozzle 100 based on the captured image. If the result of the determination detects the absence of the replacement tool 200, the presence of another nozzle 100 on the replacement tool 200, an inappropriate installation state of the replacement tool 200 and/or the nozzle 100, etc., this indicates a situation unsuitable for detaching the nozzle 100, and thus the controller Ctr may cause the notification unit to issue an alarm. On the other hand, if, as a result of the determination, the absence of the replacement tool 200 or the presence of another nozzle 100 on the replacement tool 200 is not detected, the controller Ctr may proceed with the process of detaching the nozzle 100 from the holding base 53.

[0086] Further, after the process of detaching the nozzle 100 from the holding base 53, the suction hole 22 of the holding unit 20 and its

surroundings may be imaged by the imaging unit 70. The controller Ctr may determine whether the nozzle 100 is present on the replacement tool 200 based on the captured image. If the result of the determination does not indicate the presence of the nozzle 100 on the replacement tool 200, indicating that the detachment of the nozzle 100 from the holding base 53 has failed, the controller Ctr may cause the notification unit to issue an alarm. On the other hand, if the result of the determination indicates the presence of the nozzle 100 on the replacement tool 200, the controller Ctr may execute a process of attaching a new nozzle 100 to the vacant recess 53a of the holding base 53 from which the nozzle 100 has been detached. Alternatively, the controller Ctr may execute a process of detaching the nozzle 100 from another recess 53a. Alternatively, the controller Ctr may terminate the process.

[0087] Next, a method of attaching the nozzle 100 to the holding base 53 using the replacement tool 200 will be described with reference to FIGS. 15 and 16. Before attaching the nozzle 100 to the holding base 53, the flange portion 220 is caused to be suctioned to the holding unit 20 in accordance with an instruction from the controller Ctr to the suction unit 30. Further, a new nozzle 100 is pre-attached to the replacement tool 200 so that the deformed shape portion 103 is inserted into the main body 210 (upper part 212b). Furthermore, the holding unit 20 is rotated counterclockwise as viewed from above the replacement tool 200, in accordance with an instruction from the controller Ctr to the rotating unit 40. The rotation speed of the holding unit 20 may be, for example, approximately 30 rpm. As a result, the replacement tool 200 also rotates together with the holding unit 20. The timing of rotating the holding unit

20 may be before the holding base 53 is lowered.

[0088] First, as illustrated in FIG. 15(a), the vacant recess 53a is positioned directly above the replacement tool 200 holding the nozzle 100 in accordance with an instruction from the controller Ctr to the drive unit 54. Further, the holding base 53 is lowered in accordance with an instruction from the controller Ctr to the drive unit 54, and the base end portion 101 of the nozzle 100 is inserted into the recess 53a of the holding base 53. The lowering speed of the holding base 53 may be, for example, approximately 1 mm/sec.

[0089] Since the holding base 53 is lowered while the replacement tool 200 and the nozzle 100 are rotating, when the male screw 101a of the base end portion 101 of the nozzle 100 reaches the female screw 53f of the main portion 53c of the holding base 53, the male screw 101a may not enter the female screw 53f. At this time, the controller Ctr continues to lower the holding base 53. In this case, as illustrated in FIG. 15(b), the deformed shape portion 103 pushes the slide portion 213 downward by a predetermined amount against the biasing force of the biasing unit 214. That is, pressure is applied to the slide portion 213 via the nozzle 100 until the biasing unit 214 is compressed by a predetermined amount. As a result, due to the restoring force of the biasing unit 214, the slide portion 213 presses the male screw 101a of the base end portion 101 and the female screw 53f of the main portion 53c against each other. During this time, since the rotation of the replacement tool 200 and the nozzle 100 continues, the tip of the thread of the male screw 101a is naturally guided to the entrance of the thread groove of the female screw 53f. As a result, the male screw 101a of the base end portion 101 is fastened to the female

screw 53f of the recess 53a.

[0090] Thereafter, the controller Ctr determines whether a predetermined torque has been reached in the rotating unit 40 that is rotating the holding unit 20. If the controller Ctr determines that the predetermined torque has not been reached, it maintains the rotation of the holding unit 20. On the other hand, if the controller Ctr determines that the predetermined torque has been reached, it stops the rotation of the holding unit 20 and the lowering of the holding base 53 in accordance with instructions from the controller Ctr to the rotating unit 40 and the drive unit 54. As a result, as illustrated in FIG. 16(a), the fastening of the male screw 101a to the female screw 53f is completed.

[0091] When the fastening of the male screw 101a to the female screw 53f is completed, the holding base 53 is raised in accordance with an instruction from the controller Ctr to the drive unit 54, as illustrated in FIG. 16(b). Thus, the process of attaching the nozzle 100 to the holding base 53 is completed.

[0092] Before the process of attaching the nozzle 100 to the holding base 53, the suction hole 22 of the holding unit 20 and its surroundings may be imaged by the imaging unit 70. The controller Ctr may determine the state of the replacement tool 200 and/or the nozzle 100 based on the captured image. If the result of the determination detects the absence of the replacement tool 200, the absence of the nozzle 100 on the replacement tool 200, an inappropriate installation state of the replacement tool 200 and/or the nozzle 100, etc., this indicates a situation unsuitable for attaching the nozzle 100, and thus the controller Ctr may cause the notification unit to issue an alarm. On the other hand, if, as a

result of the determination, the absence of the replacement tool 200 or the absence of the nozzle 100 on the replacement tool 200 is not detected, the controller Ctr may proceed with the process of attaching the nozzle 100 to the holding base 53.

5 [0093] Further, after the process of attaching the nozzle 100 to the holding base 53, the suction hole 22 of the holding unit 20 and its surroundings may be imaged by the imaging unit 70. The controller Ctr may determine whether the nozzle 100 remains on the replacement tool 200 based on the captured image. If the result of the determination
10 indicates that the nozzle 100 remains on the replacement tool 200, indicating that the attachment of the nozzle 100 to the holding base 53 has failed, the controller Ctr may cause the notification unit to issue an alarm. On the other hand, if the result of the determination does not indicate that the nozzle 100 remains on the replacement tool 200, the
15 controller Ctr may execute a process of attaching a new nozzle 100 to another vacant recess 53a. Alternatively, the controller Ctr may execute a process of detaching the nozzle 100 attached to another recess 53a. Alternatively, the controller Ctr may terminate the process.

[0094] [Operation]

20 When the supply of the processing liquid from the nozzle 100 to the substrate W is repeated, it is necessary to replace it with a new nozzle 100 for maintenance. This replacement work of the nozzle 100 was usually performed manually by an operator. However, recent thin film processing apparatuses U1 have become more compact, and it may be
25 difficult for an operator to insert his/her hand into the thin film processing apparatus U1. Further, in the thin film processing apparatus U1, in

consideration of maintenance of the drive unit 54, the drive unit 54 may be arranged on the inlet side of the thin film processing apparatus U1, and the holding base 53 for holding the nozzle 100 may be arranged on the rear side of the thin film processing apparatus U1. In this case, it becomes even more difficult for an operator to put his/her hand inside the thin film processing apparatus U1.

[0095] However, according to the above example, the rotational force of the holding unit 20 by the rotating unit 40 acts on the replacement tool 200 attached to the holding unit 20 via the flange portion 220, whereby the replacement tool 200 rotates. Then, by this rotation of the replacement tool 200, the nozzle 100 is attached to and detached from the holding base 53. That is, according to the above example, the holding unit 20 and the rotating unit 40 for holding and rotating the substrate W are also used for holding and rotating the replacement tool 200. Therefore, it is possible to efficiently replace the nozzle 100 without manual labor with an extremely simple configuration of adding the replacement tool 200 to the equipment for substrate processing (the holding unit 20, the rotating unit 40, the holding base 53, and the drive unit 54).

[0096] According to the above example, the replacement tool 200 can be detachably attached to a portion substantially coinciding with the center of rotation of the holding unit 20. In this case, since the center of rotation of the replacement tool 200 and the center of rotation of the holding unit substantially coincide, the rotation of the replacement tool 200 via the holding unit 20 is likely to act on the nozzle 100. Therefore, it is possible to replace the nozzle 100 more efficiently.

[0097] According to the above example, the suction unit 30 can cause the

flange portion 220 to be suctioned to the holding unit 20 by suctioning the atmosphere in the space V2 through the suction hole 22. In this case, it is possible to more firmly attach the flange portion 220 of the replacement tool 200 to the holding unit 20.

5 [0098] According to the above example, the flange portion 220 can be suctioned to the holding unit 20 by operating the suction unit 30 in a state where the lower part 211b of the main body 210 is inserted into the suction hole 22 to generate a negative pressure in the space V2. In this case, by inserting the lower part 211b of the main body 210 into the
10 suction hole 22, it is possible to accurately position the replacement tool 200 with respect to the holding unit 20.

[0099] According to the above example, the main body 210 (lower part 211b) may include the cutout 211e extending in the extending direction of the replacement tool 200. In this case, when the suction unit 30 is
15 operated in a state where the lower part 211b is inserted into the suction hole 22, a relatively large flow path (space V1) is formed between the suction hole 22, the lower part, and the main body 210 due to the presence of the cutout 211e. Therefore, since suction by the suction unit 30 is performed through the space V1, the flange portion 220 is more likely to
20 be suctioned to the holding unit 20. Thus, it is possible to more firmly attach the flange portion 220 of the replacement tool 200 to the holding unit 20.

[0100] According to the above example, the flange portion 220 includes the ridge 221 projecting downward, and in a state where the replacement
25 tool 200 is attached to the holding unit 20, the ridge 221 may be located inside the ridge 27 of the holding unit 20. In this case, when the

replacement tool 200 is placed on the holding unit 20, a space V2 surrounded by the ridge 221, the upper surface 21 of the holding unit 20, and the flange portion 220 is formed. Therefore, by reducing the pressure in the space V2 through the suction hole 22, it is possible to more firmly attach the flange portion 220 of the replacement tool 200 to the holding unit 20. Further, in this case, the ridge 221 is located inside the ridge 27 and does not interfere with the ridge 27. Therefore, it is possible to exert the function of supporting the substrate W by the ridge 27 and also exert the function of suctioning the flange portion 220 to the holding unit 20. Furthermore, in this case, since the ridge 221 is located inside the ridge 27, the size of the flange portion 220 can be made smaller than the size of the substrate W. Therefore, it is possible to make the replacement tool 200 more compact.

[0101] According to the above example, the outer peripheral surface of the deformed shape portion 103 of the nozzle 100 may have a non-circular deformed shape. The main body 210 (upper part 212b) of the replacement tool 200 may have a tubular shape capable of housing the deformed shape portion 103 of the nozzle 100. The inner peripheral surface of the opening OP of the main body 210 of the replacement tool 200 may have a shape corresponding to the outer peripheral surface of the deformed shape portion 103 of the nozzle 100. In this case, the rotation of the replacement tool 200 is transmitted to the nozzle 100 simply by inserting the deformed shape portion 103 of the nozzle 100 into the opening OP of the main body 210 of the replacement tool 200. Therefore, it is not necessary to use other members for preventing idle rotation between the replacement tool 200 and the nozzle 100. Thus, it is

possible to simplify the configuration of the replacement tool 200 and the nozzle 100.

[0102] According to the above example, the biasing unit 214 may be configured to apply a biasing force to the outer tubular portion 212 in a direction to separate the base portion 211 and the outer tubular portion 212 from each other in the extending direction of the replacement tool 200. In this case, even if the deformed shape portion 103 of the nozzle 100 does not enter the opening OP of the main body 210 and the lowering of the nozzle 100 continues, the outer tubular portion 212 is pushed by the nozzle 100 (deformed shape portion 103), and the outer tubular portion 212 lowers together with the nozzle 100 against the bias of the biasing unit 214. Then, when the deformed shape portion 103 enters the opening OP during the rotation of the replacement tool 200, the outer tubular portion 212 returns to its original position by the biasing force of the biasing unit 214, and the deformed shape portion 103 engages with the opening OP. In this way, the lowering of the nozzle 100 can continue until the deformed shape portion 103 enters the opening OP. Therefore, it is possible to replace the nozzle 100 more efficiently.

[0103] According to the above example, in a state where the deformed shape portion 103 is inserted into the main body 210 (upper part 212b) and the deformed shape portion 103 is supported by the slide portion 213, pressure may be applied to the slide portion 213 via the nozzle 100 by the holding base 53 until the biasing unit 214 is compressed by a predetermined amount. In this case, by applying pressure to the slide portion 213 via the nozzle 100 by the holding base 53, the biasing unit 214 is compressed by a predetermined amount, so that the restoring force

of the biasing unit 214 acts on the nozzle 100 via the slide portion 213. As a result, the holding base 53 and the nozzle 100 are pressed against each other. Therefore, when the tip of the male screw 101a of the base end portion 101 reaches the entrance of the thread groove of the female screw 53f of the main portion 53c, the tip naturally enters the entrance. Thus, it is possible to fasten the fastening of the male screw 101a and the female screw 53f together extremely smoothly.

[0104] According to the above example, the outer peripheral surface of the base portion 211 (upper part 211a) may have a non-circular deformed shape. The inner peripheral surface of the outer tubular portion 212 (lower part 212a) may have a shape corresponding to the outer peripheral surface of the base portion 211 (upper part 211a). The inner peripheral surface of the upper part 212b and the outer peripheral surface of the deformed shape portion 103 may form a transmission portion that transmits a rotational force between the nozzle 100 and the replacement tool 200. In this case, it is not necessary to use other members for preventing idle rotation between the outer tubular portion 212 and the base portion 211. Therefore, it is possible to provide a simple configuration for the replacement tool 200.

[0105] According to the above example, the main body 210 may include the projection 215 projecting from the outer tubular portion 212 toward the base portion 211. The base portion 211 may include the receiving part 211c that receives the projection 215. In this case, with the simple configuration of the projection 215 and the receiving part 211c, it is possible to prevent idle rotation between the outer tubular portion 212 and the base portion 211, and to prevent the outer tubular portion 212,

which is biased by the biasing unit 214, from coming off the base portion 211.

[0106] According to the above example, the receiving part 211c may extend along the extending direction of the replacement tool 200. In this case, the movement of the outer tubular portion 212 with respect to the base portion 211 in the extending direction of the replacement tool 200 is limited according to the length of the receiving part 211c. Therefore, it is possible to adjust the stroke length of the outer tubular portion 212 according to the length of the receiving part 211c.

[0107] According to the above example, the state of the replacement tool 200 and/or the nozzle 100 may be automatically determined based on the captured image by the imaging unit 70. In this case, visual confirmation by an operator is not required when replacing the nozzle 100. Therefore, it is possible to replace the nozzle 100 more efficiently.

[0108] [Variations]

The disclosure in this specification should be considered illustrative in all respects and not restrictive. Various omissions, substitutions, changes, and the like may be made to the above examples without departing from the scope and spirit of the claims.

[0109] (1) In the above example, the male screw 101a is directly provided on the outer peripheral surface of the nozzle 100 (base end portion 101). However, as illustrated in FIG. 17, the nozzle 100A (processing tool) may not be provided with a screw, and the nozzle 100A may be attached to the holding base 53 via a nut 120 (processing tool, another fastening part, engagement part).

[0110] In the example of FIG. 17, the holding base 53 includes a

connection portion 55 projecting downward. A flow path 53e connected to the pipe 52 is provided inside the connection portion 55. The connection portion 55 includes a base end portion 55a, a tip portion 55b, and an intermediate portion 55c. The base end portion 55a may be integrally connected to the holding base 53. The tip portion 55b has a shape corresponding to the base end portion 101 of the nozzle 100A and is configured to be accommodated in a recess 101b provided in the base end portion 101. The intermediate portion 55c is located between the base end portion 55a and the tip portion 55b and connects them. A male screw 55d (fastening part) is provided on the outer peripheral surface of the intermediate portion 55c.

[0111] The nozzle 100A includes a base end portion 101 and a tip portion 102. The outer shape of the base end portion 101 is configured to be larger than the outer shape of the tip portion 102.

[0112] The nut 120 includes a tubular portion 121 (engagement portion) and a flange portion 122. The inner shape of the tubular portion 121 is configured to be substantially the same as or larger than the outer shape of the base end portion 101, and substantially the same as the outer shape of the intermediate portion 55c. A female screw 120a is provided on the inner peripheral surface of the tubular portion 121. The nut 120 is attached to the holding base 53 (connection portion 55) by the female screw 120a being fastened to the male screw 55d. On the other hand, the nut 120 is detached from the holding base 53 (connection portion 55) by the female screw 120a being loosened from the male screw 55d.

[0113] The outer peripheral surface of the tubular portion 121 has a shape corresponding to the inner peripheral surface of the upper part 212b (the

inner peripheral surface of the opening OP of the main body 210). That is, the outer peripheral surface of the tubular portion 121 has a non-circular (a shape other than a perfect circle) deformed shape. Therefore, when replacing the nozzle 100A using the replacement tool 200, the tubular portion 121 is inserted into the upper part 212b, and the outer tubular portion 212 (replacement tool 200) and the nut 120 enter a fitted (engaged) state.

[0114] The flange portion 122 extends radially inward of the nut 120 from the vicinity of the lower end of the tubular portion 121. The flange portion 122 may be a plate-like body having an annular shape. That is, a through-hole 122a may be provided in the central portion of the flange portion 122. The inner shape of the through-hole 122a is configured to be larger than the outer shape of the tip portion 102 and smaller than the outer shape of the base end portion 101. Therefore, the tip portion 102 can pass through the through-hole 122a, but the base end portion 101 cannot pass through the through-hole 122a. Thus, the flange portion 122 is configured to sandwich the base end portion 101 with the tip portion 55b in a state where the nut 120 is attached to the intermediate portion 55c. Accordingly, in a state where the nut 120 is attached to the intermediate portion 55c, the nozzle 100A is prevented from coming out of the nut 120. The flange portion 122 may be integrally formed with the tubular portion 121.

[0115] In the example shown in FIG. 17, the same operational effects as in the above example can be obtained.

[0116] (2) In the above example, the nozzle 100 is replaced by the replacement tool 200, but as illustrated in FIG. 18(a), a brush 100B

(processing tool) may be replaced by the replacement tool 200. In the example of FIG. 18(a), the holding base 53 includes a recess 56 (fastening part) that is depressed inward. A female screw is provided on the inner peripheral surface of the recess 56.

5 [0117] The brush 100B may be configured, for example, to scrub clean the surface Wa of the substrate W. The brush 100B may include a base portion 131, a brush portion 132 provided on the lower surface of the base portion 131, and a connection portion 133 provided on the upper surface of the base portion 131.

10 [0118] The outer peripheral surface of the base portion 131 has a shape corresponding to the inner peripheral surface of the upper part 212b (the inner peripheral surface of the opening OP of the main body 210). That is, the outer peripheral surface of the base portion 131 has a non-circular (a shape other than a perfect circle) deformed shape. Therefore, when
15 replacing the brush 100B using the replacement tool 200, the base portion 131 is inserted into the upper part 212b, and the outer tubular portion 212 (replacement tool 200) and the base portion 131 enter a fitted (engaged) state.

[0119] A male screw is provided on the outer peripheral surface of the
20 connection portion 133. The brush 100B is attached to the holding base 53 by fastening the male screw of the connection portion 133 to the female screw of the recess 56. On the other hand, the brush 100B is detached from the holding base 53 by loosening the male screw of the connection portion 133 from the female screw of the recess 56.

25 [0120] In the example shown in FIG. 18(a), the same operational effects as in the above example can be obtained.

[0121] (3) As illustrated in FIG. 18(b), the nozzle 100 may be attached to the holding base 53 by screws 140 instead of the male screw 101a of the base end portion 101 of the nozzle 100. In the example of FIG. 18(b), the holding base 53 includes a plurality of recesses 57 (fastening parts) that are recessed inward. A female screw is provided on the inner peripheral surface of the recess 57.

[0122] The nozzle 100 may be provided with a flange portion 105 (another flange portion). The flange portion 105 extends (projects) radially outward of the nozzle 100 from the outer peripheral surface of the nozzle 100. The flange portion 105 may be a plate-like body having an annular shape. The flange portion 105 may be integrally formed with the nozzle 100. The flange portion 105 is provided with a plurality of through-holes 105a. The number of the plurality of through-holes 105a may be the same as the number of the plurality of recesses 57. The positions of the plurality of through-holes 105a correspond to the positions of the plurality of recesses 57, respectively. A female screw may be provided on each of the inner peripheral surfaces of the plurality of through-holes 105a.

[0123] The screw 140 includes a main body 141 (another fastening part) and a head 142 (engagement part). A male screw is provided on the outer peripheral surface of the main body 141. The outer shape of the main body 141 may be substantially the same as the inner shape of the recess 57 and the inner shape of the through-hole 105a. The head 142 is integrally connected to the base end of the main body 141. The outer shape of the head 142 is configured to be larger than the outer shape of the main body 141. The outer peripheral surface of the head 142 has a

non-circular (a shape other than a perfect circle) deformed shape. Therefore, when replacing the brush 100B using the replacement tool 200, the head 142 is inserted into the upper part 212b, and the outer tubular portion 212 (replacement tool 200) and the head 142 enter a fitted (engaged) state.

[0124] The nozzle 100 is attached to the holding base 53 by fastening the male screw of the main body 141 to the female screws of the recess 57 and the through-hole 105a. On the other hand, the brush 100B is detached from the holding base 53 by loosening the male screw of the main body 141 from the female screws of the recess 57 and the through-hole 105a. That is, when replacing the nozzle 100, the position of the holding base 53 may be adjusted by the drive unit 54 so that the recess 57 is located directly above the replacement tool 200.

[0125] In the example shown in FIG. 18(b), the same operational effects as in the above example can be obtained.

[0126] (4) As illustrated in FIG. 19, the outer shape of the flange portion 220 may be configured to be substantially the same size as the outer shape of the substrate W. In this case, the flange portion 220 is suctioned to the holding unit 20 in a state where the lower surface of the flange portion 220 is supported by the ridges 23 to 27. The replacement tool 200 illustrated in FIG. 19 may not include the elastic member 230.

[0127] (5) In the above example, the replacement tool 200 is attached to the holding unit 20 by suctioning the flange portion 220 to the holding unit 20 by the suction unit 30. However, with a holding unit 20A illustrated in FIGS. 20 and 21, the replacement tool 200 may be attached to the holding unit 20A by physically gripping the outer peripheral edge

of the flange portion 220. The holding unit 20A may be applied to holding the replacement tool 200 illustrated in FIG. 19, whose the flange portion 220 is enlarged.

[0128] As illustrated in FIG. 20, the holding unit 20A includes a rotating plate 28 and a plurality of support portions 29. The rotating plate 28 has a substantially disk shape and is connected to the rotating unit 40. The plurality of support portions 29 are provided on the outer peripheral edge of the rotating plate 28 so as to be arranged at substantially equal intervals along the outer peripheral edge of the rotating plate 28.

[0129] The support portion 29 includes a gripping portion 29a and support bars 29b arranged on both sides of the gripping portion 29a. As illustrated in FIG. 21, the gripping portion 29a includes a gripping piece 29c, a lever member 29d, and a biasing unit 29e. The gripping piece 29c is configured to physically grip the substrate W or the flange portion 220 by contacting the outer peripheral edge of the substrate W or the outer peripheral edge of the flange portion 220. The lower end of the gripping piece 29c is connected to one end of the lever member 29d. The lever member 29d is connected to the gripping piece 29c so as to form a predetermined angle (e.g., approximately 120°) with respect to the gripping piece 29c. The gripping piece 29c and the lever member 29d are attached to the rotating plate 28 via a rotating shaft 29f. Therefore, the gripping piece 29c is configured to be pivotable between a first position (see FIG. 21(a)) away from the outer peripheral edge of the substrate W or the outer peripheral edge of the flange portion 220, and a second position (see FIG. 21(b)) in contact with the outer peripheral edge of the substrate W or the outer peripheral edge of the flange portion 220.

[0130] The biasing unit 29e is provided so as to connect the lower surface of the rotating plate 28 and the lever member 29d, and is configured to apply a biasing force to the lever member 29d. The biasing unit 29e may be, for example, a compression coil spring. Therefore, when a rod ARa provided on an arm AR moves up together with the arm AR, the lever member 29d is also moved up by the rod ARa, and the biasing unit 29e is compressed. Thus, the gripping piece 29c rotates around the rotating shaft 29f and moves to the first position (see FIG. 21(a)). On the other hand, when the rod ARa provided on the arm AR moves down together with the arm AR, the lever member 29d is pushed downward by the restoring force of the biasing unit 29e. Therefore, the gripping piece 29c rotates around the rotating shaft 29f and moves to the second position (see FIG. 21(b)). At this time, the biasing force of the biasing unit 29e acts on the gripping piece 29c via the lever member 29d. Thus, the gripping piece 29c presses the outer peripheral edge of the substrate W or the outer peripheral edge of the flange portion 220. As a result, the gripping piece 29c grips the substrate W or the flange portion 220. The arm AR may be configured to move up and down by a drive unit (not shown).

[0131] As illustrated in FIG. 20, the support bar 29b includes an inclined surface S. The inclined surface S is provided on the inner peripheral edge part of the support bar 29b. The inclined surface S is inclined downward as it extends radially inward. Therefore, when the outer peripheral edge of the substrate W or the outer peripheral edge of the flange portion 220 comes into contact with the inclined surface S, the substrate W or the flange portion 220 is guided while sliding along the inclined surface S, and is positioned with respect to the holding unit 20A.

[0132] (6) As illustrated in FIGS. 22 and 23, the upper part 212b of the replacement tool 200 (the opening OP of the main body 210) may be provided with at least two replacement tool protrusions 240. The replacement tool protrusions 240 may project inward in the radial direction of the opening OP. That is, the replacement tool protrusions 240 may project so as to extend toward the central axis Ax2. The replacement tool protrusions 240 may be ridges extending in the extending direction of the main body 210 (central axis Ax2).

[0133] In the example of FIGS. 22 and 23, two replacement tool protrusions 240 (241, 242) are provided in the opening OP. The replacement tool protrusion 241 (first replacement tool protrusion) and the replacement tool protrusion 242 (second replacement tool protrusion) may be positioned to face each other with the center of the opening OP (central axis Ax2) therebetween. Here, "facing each other" means that when the position of one replacement tool protrusion 241 on the inner peripheral surface of the opening OP is taken as a base point (0°), the other replacement tool protrusion 242 is located within a range of 90° to 270° on the inner peripheral surface of the opening OP. That is, the replacement tool protrusions 241 and 242 may be separated by a range of 90° to 270° in the radial direction of the opening OP, may be separated by a range of 120° to 240° , may be separated by a range of 150° to 210° , or may be positioned to be 180° opposite each other. Similarly, when three or more replacement tool protrusions 240 are provided in the opening OP, at least two of the three or more replacement tool protrusions 240 may be positioned to face each other with the center of the opening OP (central axis Ax2) therebetween. The three or more replacement tool

protrusions 240 may be arranged at substantially equal intervals in the radial direction of the opening OP, or may be arranged at different intervals.

[0134] As illustrated by the one-dot chain line in FIG. 23, the deformed shape portion 103 of the nozzle 100 may include a plurality of processing tool protrusions 106 projecting outward in the radial direction of the nozzle 100 (deformed shape portion 103). Although the deformed shape portion 103 includes six processing tool protrusions 106 in the example of FIG. 23, it may include two or more processing tool protrusions 106.

A processing tool recess 107 is formed between two of the plurality of processing tool protrusions 106 adjacent in the circumferential direction of the deformed shape portion 103.

[0135] The outer peripheral surface of the replacement tool protrusion 240 may have a shape corresponding to the outer peripheral surface of the processing tool recess 107. As illustrated in FIG. 23, when viewed from the extending direction of the main body 210 (central axis Ax2), the outer peripheral surface of the replacement tool protrusion 240 may be a convex curved surface having a circular arc shape, and the outer peripheral surface of the processing tool recess 107 may be a concave curved surface having a circular arc shape corresponding to the convex curved surface. However, the shapes of the outer peripheral surfaces of the replacement tool protrusion 240 and the processing tool recess 107 are not particularly limited as long as the replacement tool protrusion 240 and the processing tool recess 107 can contact each other when the replacement tool 200 rotates in a state where the deformed shape portion 103 of the nozzle 100 is accommodated in the opening OP. That is, the

replacement tool protrusion 240 and the processing tool protrusion 106 each only need to be configured to be engageable with each other in a state where the deformed shape portion 103 of the nozzle 100 is accommodated in the opening OP. Therefore, the deformed shape portion 103 may have a polygonal shape (e.g., a triangular shape, a quadrangular shape, a hexagonal shape, an octagonal shape, etc.) as a whole. The replacement tool protrusion 240 and the processing tool protrusion 106 may each have a plate shape, a semi-cylindrical shape, or a polygonal prism shape (e.g., a triangular prism shape, a quadrangular prism shape, a hexagonal prism shape, an octagonal prism shape, etc.).

[0136] Incidentally, when the deformed shape portion 103 (processing tool protrusion 106) of the nozzle 100 is inserted into the opening OP of the main body 210 of the replacement tool 200, the processing tool protrusion 106 may ride on the replacement tool protrusion 240, or a misalignment may occur between the center of the replacement tool 200 (central axis Ax2) and the center of the nozzle 100 (see FIG. 24(a)). However, in the case of the replacement tool 200 illustrated in FIGS. 22 and 23, the number of replacement tool protrusions 240 is the same as or less than the number of processing tool protrusions 106. Therefore, as the replacement tool 200 rotates, the replacement tool protrusion 240 is smoothly inserted into the processing tool recess 107 (see FIGS. 24(b) to 24(d)). Further, in the case of the replacement tool 200 illustrated in FIGS. 22 and 23, the replacement tool protrusions 241 and 242 are positioned to face each other with the center (central axis Ax2) of the opening OP therebetween. Therefore, even if there is a misalignment between the center of the replacement tool 200 and the center of the nozzle 100, after

the deformed shape portion 103 of the nozzle 100 is inserted into the opening OP, the replacement tool protrusion 240 remains in the processing tool recess 107 (see FIG. 24(d)). Thus, the replacement tool protrusion 240 and the processing tool protrusion 106 is more reliably engaged when the replacement tool 200 rotates. As a result, it is possible to more reliably insert the deformed shape portion 103 of the nozzle 100 into the opening OP, and to more reliably transmit the rotation of the replacement tool 200 to the nozzle 100.

[0137] In the case of the replacement tool 200 illustrated in FIGS. 22 and 23, the opening OP may have a substantially circular shape. Therefore, since the processing tool protrusion 106 does not engage with anything other than the replacement tool protrusion 240 in the opening OP, it is possible to more reliably transmit the rotation of the replacement tool 200 to the nozzle 100.

[0138] In the case of the replacement tool 200 illustrated in FIGS. 22 and 23, the outer peripheral surface of the replacement tool protrusion 240 may have a shape corresponding to the outer peripheral surface of the processing tool recess 107. Therefore, after the deformed shape portion 103 of the nozzle 100 is inserted into the opening OP, the replacement tool protrusion 240 and the processing tool protrusion 106 can more easily engage more closely. Thus, it is possible to more reliably transmit the rotation of the replacement tool 200 to the nozzle 100.

[0139] In the case of the replacement tool 200 illustrated in FIGS. 22 and 23, the replacement tool protrusion 240 may be a ridge extending in the extending direction of the main body 210 (central axis Ax2). Therefore, when the deformed shape portion 103 of the nozzle 100 is inserted into

the opening OP, the nozzle 100 moves smoothly along the replacement tool protrusion 240. Thus, it is possible to more reliably insert the deformed shape portion 103 of the nozzle 100 into the opening OP.

[0140] (7) When there are two replacement tool protrusions 240 and two processing tool protrusions 106, as illustrated in FIG. 25, the two replacement tool protrusions 241 and 242 may be positioned 180° opposite each other, and the two processing tool protrusions 106 may be positioned 180° opposite each other. In the example of FIG. 25(a), the width of the processing tool protrusion 106 is approximately the same as the width of the replacement tool protrusions 241 and 242, and the processing tool protrusions 106 are separated from each other by approximately 170° in the circumferential direction of the deformed shape portion 103. That is, since the two processing tool protrusions 106 occupy a part of the opening OP, it may take a predetermined time until the replacement tool protrusions 240 contacts the processing tool protrusion 106 when the replacement tool 200 rotates. On the other hand, in the example of FIG. 25(b), the width of the processing tool protrusion 106 is approximately the same as the separation between the replacement tool protrusions 241 and 242 in the circumferential direction of the deformed shape portion 103, and is approximately the same as the width of the processing tool recess 107. That is, since the two processing tool protrusions 106 occupy almost the entire opening OP, the replacement tool protrusion 240 can immediately contact the processing tool protrusions 106 when the replacement tool 200 rotates.

[0141] (8) As illustrated in FIGS. 22 and 26, the flange portion 220 of the replacement tool 200 may be enlarged in the radial direction of the

central axis Ax2. Specifically, the flange portion 220 may have a substantially circular shape when viewed from the extending direction of the central axis Ax2, and may have an area larger than the area of the upper surface 21 of the holding unit 20. In a state where the replacement tool 200 is attached to the holding unit 20 via the flange portion 220, the flange portion 220 may be configured to cover the entire upper surface 21 of the holding unit 20.

[0142] In this case, when replacing the nozzle 100, even if objects (e.g., droplets of processing liquid (chemical liquid, resist liquid, etc.)) falls from the nozzle 100 as the nozzle 100 moves above the holding unit 20, the objects fall onto the flange portion 220. Therefore, the presence of the flange portion 220 prevents the falling objects from adhering to the upper surface 21 of the holding unit 20. Therefore, when the substrate W is held by the holding unit 20 after the replacement of the nozzle 100, it is possible to prevent contamination of the substrate W due to the transfer of fallen objects present on the upper surface 21 of the holding unit 20 to the substrate W.

[0143] In the examples of FIGS. 22 and 26, the flange portion 220 may include a plurality of ridges 222 to 227 projecting downward from the lower surface S1 of the flange portion 220. The ridges 222 to 227 may have an annular shape (e.g., a circular ring shape) and may be arranged concentrically around the central axis Ax2. The ridge 222 may be higher than the other ridges 223 to 227. Therefore, in a state where the replacement tool 200 is attached to the holding unit 20 via the flange portion 220, the tip of the ridge 222 is in contact with the upper surface 21 of the holding unit 20, while the other ridges 223 to 227 may not be in

contact with the upper surface 21 of the holding unit 20 and the ridges 23 to 26. In this case, when the suction unit 30 operates in a state where the replacement tool 200 is attached to the holding unit 20 via the flange portion 220, the atmosphere in the space surrounded by the lower surface S1 of the flange portion 220, the upper surface 21 of the holding unit 20, and the ridge 222 is suctioned through the suction hole 22, and the space is depressurized. In this way, by causing the ridge 222, which is closer to the central axis Ax2 among the plurality of ridges 222 to 227, to come into contact with the upper surface 21 of the holding unit 20, when the space is depressurized and the flange portion 220 is suctioned to the holding unit 20, downward sagging of the flange portion 220 is suppressed. Therefore, since the flange portion 220 is less likely to come into contact with the ridges 23 to 26, it is possible to suppress contamination of the ridges 23 to 26 that the substrate W contacts when the holding unit 20 holds the substrate W.

[0144] [Other Examples]

Example 1. An example of a substrate processing apparatus includes a holding unit configured to hold a substrate; a rotating unit configured to rotate the holding unit; a processing tool configured to process a surface of the substrate held by the holding unit; a replacement tool configured to be detachably attached to the holding unit; a holding and transport unit configured to hold and transport the processing tool; and a control unit. The replacement tool includes a main body configured to be engageable with an engagement part of the processing tool, and a flange portion projecting from a peripheral surface of the main body for attachment to and detachment from the holding unit. The processing tool

includes another fastening part configured to be fastenable to a fastening part provided on the holding and transport unit. The control unit is configured to execute a first process of attaching and detaching the processing tool to and from the holding and transport unit by controlling the rotating unit to rotate the holding unit in a state where the replacement tool is attached to the holding unit via the flange portion and the engagement part of the processing tool is engaged with the main body of the replacement tool. In this case, the rotational force of the holding unit by the rotating unit acts on the replacement tool attached to the holding unit via the flange portion, whereby the replacement tool rotates. Then, by this rotation of the replacement tool, the processing tool is attached to and detached from the holding and transport unit. That is, according to the apparatus of Example 1, the holding unit and the rotating unit for holding and rotating the substrate are also used for holding and rotating the replacement tool. Therefore, it is possible to efficiently replace the processing tool with an extremely simple configuration of adding the replacement tool to the equipment for substrate processing (the holding unit, the rotating unit, and the holding and transport unit).

[0145] Example 2. In the apparatus of Example 1, the replacement tool may be detachably attached to a portion substantially coinciding with a center of rotation of the holding unit. In this case, since the center of rotation of the replacement tool and the center of rotation of the holding unit substantially coincide, the rotation of the replacement tool via the holding unit is likely to act on the processing tool. Therefore, it is possible to replace the processing tool more efficiently.

[0146] Example 3. The apparatus of Example 1 or 2 may further include

a suction unit configured to cause the substrate to be suctioned to the holding unit, the holding unit may include a suction hole that is open upward and is connected to the suction unit, and the control unit may be further configured to execute a second process of operating the suction unit to cause the flange portion to be suctioned to the holding unit before the first process. In this case, it is possible to more firmly attach the flange portion of the replacement tool to the holding unit.

[0147] Example 4. In the apparatus of Example 3, the second process may include causing the flange portion to be suctioned to the holding unit by operating the suction unit in a state where a lower part of the main body is inserted into the suction hole to generate a negative pressure between the flange portion and an upper surface of the holding unit before the first process. In this case, since the lower part of the main body is inserted into the suction hole, it is possible to accurately position the replacement tool with respect to the holding unit.

[0148] Example 5. In the apparatus of Example 4, the main body may include a cutout in which an outer peripheral surface of the lower part of the main body is partially cut out such that the cutout extends in an extending direction of the replacement tool. In this case, when the suction unit is operated in a state where the lower part of the main body is inserted into the suction hole, a relatively large flow path is formed between the suction hole and the lower part of the main body due to the presence of the cutout. Therefore, since suction by the suction unit is performed through the flow path, the flange portion is more likely to be suctioned to the holding unit. Therefore, it is possible to more firmly attach the flange portion of the replacement tool to the holding unit.

[0149] Example 6. In the apparatus of any one of Examples 3 to 5, the holding unit may include a first ridge which has an annular shape and is provided on an upper surface of the holding unit to support the substrate, the first ridge has an annular shape, the flange portion includes a second annular ridge projecting toward a lower side of the main body, and the second ridge may be located inside the first ridge in a state where the replacement tool is attached to the holding unit. In this case, when the replacement tool is placed on the holding unit, a space surrounded by the second ridge, the upper surface of the holding unit, and the flange portion is formed. Therefore, by reducing the pressure in the space through the suction hole, it is possible to more firmly attach the flange portion of the replacement tool to the holding unit. Further, in Example 5, the second ridge is located inside the first ridge and does not interfere with the first ridge. Therefore, it is possible to exert the function of supporting the substrate by the first ridge and also exert the function of suctioning the flange portion to the holding unit. Furthermore, in Example 5, since the second ridge is located inside the first ridge, the size of the flange portion can be made smaller than the size of the substrate. Therefore, it is possible to make the replacement tool more compact.

[0150] Example 7. In the apparatus of any one of Examples 1 to 6, an outer peripheral surface of the engagement part of the processing tool may have a non-circular deformed shape, the main body of the replacement tool may have a tubular shape capable of housing the engagement part of the processing tool, and an inner peripheral surface of an opening of the main body of the replacement tool may have a shape corresponding to the outer peripheral surface of the engagement part of

the processing tool. In this case, the rotation of the replacement tool is transmitted to the processing tool simply by inserting the engagement part of the processing tool into the opening of the main body of the replacement tool. Therefore, it is not necessary to use other members for preventing idle rotation between the replacement tool and the processing tool. Thus, it is possible to have a simple configuration for the replacement tool and the processing tool.

[0151] Example 8. In the apparatus of any one of Examples 1 to 7, the main body of the replacement tool may include: a base portion having a tubular shape; an outer tubular portion having a tubular shape and disposed outside the base portion; a transmission portion configured to transmit a rotational force from the holding unit between the base portion and the outer tubular portion; and a biasing unit, the outer tubular portion may be configured to be slidable relative to the base portion in an extending direction of the replacement tool, and the biasing unit may be configured to apply a biasing force to the outer tubular portion in a direction to separate the base portion and the outer tubular portion from each other in the extending direction of the replacement tool. By the way, when detaching the processing tool from the holding and transport unit, if the processing tool is lowered toward the replacement tool while rotating the replacement tool, the engagement part of the processing tool may be blocked by the edge of the opening of the main body when it reaches the replacement tool, and the engagement part may not enter the opening. However, according to Example 7, even if the engagement part does not enter the opening and the lowering of the processing tool continues, the outer tubular portion is pushed by the processing tool, and

the outer tubular portion is lowered together with the processing tool against the bias of the biasing unit. Then, when the engagement part enters the opening during the rotation of the replacement tool, the outer tubular portion returns to its original position by the biasing force of the biasing unit, and the engagement part engages with the opening. In this way, according to Example 7, the lowering of the processing tool can be continued until the engagement part enters the opening. Therefore, it is possible to replace the processing tool more efficiently.

[0152] Example 9. In the apparatus of Example 8, the main body of the replacement tool may further include a slide portion configured to be slidable in the extending direction of the replacement tool inside the outer tubular portion between the base portion and the outer tubular portion, the biasing unit may be configured to apply the biasing force to the outer tubular portion via the slide portion, and the control unit may further configured to execute a third process of controlling the holding and transport unit to apply pressure to the slide portion via the processing tool by the holding and transport unit until the biasing unit is compressed by a predetermined amount, in a state where the engagement part of the processing tool is inserted into the outer tubular portion of the replacement tool attached to the holding unit via the flange portion, and in a state where the processing tool is supported by the slide portion, before the first process. By the way, when attaching the processing tool to the holding and transport unit, if the holding and transport unit is lowered toward the processing tool while rotating the replacement tool, the thread grooves of the another fastening part of the processing tool and the fastening part of the holding and transport unit may not mesh with

each other when they reach each other. That is, the processing tool may slip with respect to the holding and transport unit without the fastening part and the another fastening part being fastened. However, according to Example 12, by applying pressure to the slide portion via the processing tool by the holding and transport unit, the biasing unit is compressed by a predetermined amount, and thus the restoring force of the biasing unit acts on the processing tool via the slide portion. As a result, since the holding and transport unit and the processing tool are pressed against each other, when the tip of the thread of one of the fastening part and the another fastening part reaches the entrance of the thread groove of the other, the tip naturally enters the entrance. Therefore, it is possible to perform the fastening of the fastening part and the another fastening part extremely smoothly.

[0153] Example 10. In the apparatus of Example 8 or 9, an outer peripheral surface of the base portion may have a non-circular deformed shape, an inner peripheral surface of the outer tubular portion may have a shape corresponding to the outer peripheral surface of the base portion, and the transmission portion may be constituted by the outer peripheral surface of the base portion and the inner peripheral surface of the outer tubular portion. In this case, it is not necessary to use other members for preventing idle rotation between the outer tubular portion and the base portion. Therefore, it is possible to have a simple configuration for the replacement tool.

[0154] Example 11. In the apparatus of any one of Examples 8 to 10, the main body may include a projection projecting from the outer tubular portion toward the base portion, and the base portion may include a

receiving part that receives the projection. In this case, with the simple configuration of the projection and the receiving part, it is possible to prevent idle rotation between the outer tubular portion and the base portion, and to prevent the outer tubular portion, which is biased by the
5 biasing unit, from coming off the base portion.

[0155] Example 12. In the apparatus of Example 11, the receiving part may extend along the extending direction of the replacement tool. In this case, the movement of the outer tubular portion with respect to the base portion in the extending direction of the replacement tool is limited
10 according to the length of the receiving part. Therefore, it is possible to adjust the stroke length of the outer tubular portion by the length of the receiving part.

[0156] Example 13. In the apparatus of any one of Examples 1 to 12, the processing tool may include a nozzle for supplying a processing liquid to
15 the surface of the substrate.

[0157] Example 14. In the apparatus of any one of Examples 1 to 12, the processing tool may include a plurality of nozzles for supplying a processing liquid to the surface of the substrate, and the control unit may execute the first process for a designated one of the plurality of nozzles.

20 [0158] Example 15. In the apparatus of any one of Examples 1 to 12, the processing tool may include a brush for scrub cleaning the surface of the substrate.

[0159] Example 16. In the apparatus of any one of Examples 1 to 12, the processing tool may include another flange portion projecting from a
25 peripheral surface of the processing tool, and the another fastening part may be configured to be fastenable to the fastening part of the holding

and transport unit via the another flange portion.

[0160] Example 17. In the apparatus of Example 1 or 2, the holding unit may be configured to be capable of physically gripping a peripheral edge of the substrate, and the replacement tool may be attached to the holding unit by the peripheral edge of the flange portion being gripped by the holding unit. In this case, it is possible to more firmly attach the flange portion of the replacement tool to the holding unit.

[0161] Example 18. The apparatus of any one of Examples 1 to 17 may further include an imaging unit configured to capture an image of the holding unit, and the control unit may be configured to execute a fourth process of determining a state of the replacement tool and/or the processing tool based on a captured image from the imaging unit. In this case, it is automatically determined based on the captured image whether the replacement tool is present or not on the holding unit and whether the processing tool is present or not on the replacement tool, visual confirmation by an operator is not required when replacing the processing tool. Therefore, it is possible to replace the processing tool more efficiently.

[0162] Example 19. In the apparatus of any one of Examples 1 to 18, the engagement part of the processing tool may be provided with a plurality of processing tool protrusions projecting outward in a radial direction of the engagement part, the main body of the replacement tool may have a tubular shape capable of housing the engagement part of the processing tool, an opening of the main body of the replacement tool may be provided with a first replacement tool protrusion and a second replacement tool protrusion that project inward in a radial direction of the

opening and are configured to be engageable with any of the plurality of processing tool protrusions in a state where the engagement part of the processing tool is housed in the opening, and the first replacement tool protrusion and the second replacement tool protrusion may be positioned to face each other with a center of the opening therebetween. Incidentally when the engagement part of the processing tool is inserted into the opening of the main body of the replacement tool, the processing tool protrusion may ride on the replacement tool protrusion, or a misalignment may occur between the center of the replacement tool and the center of the processing tool. However, in the case of Example 19, the number of replacement tool protrusions is the same as or less than the number of processing tool protrusions. Therefore, by the rotation of the replacement tool, the first and second replacement tool protrusions are respectively smoothly inserted into a processing tool recess formed between two of processing tool protrusions adjacent that are adjacent to each other in a circumferential direction of the engagement part. Further, in the case of Example 19, the first replacement tool protrusion and the second replacement tool protrusion are positioned to face each other with the center of the opening therebetween. Therefore, even if there is a misalignment between the center of the replacement tool and the center of the processing tool, after the engagement part of the processing tool is inserted into the opening of the main body of the replacement tool, the first and second replacement tool protrusions respectively remain in the processing tool recesses. Therefore, the engagement between the replacement tool protrusion and the processing tool protrusion more reliably occurs when the replacement tool rotates. As a result, it is

possible to more reliably insert the engagement part of the processing tool into the opening of the main body of the replacement tool, and to more reliably transmit the rotation of the replacement tool to the processing tool.

5 [0163] Example 19a. In the apparatus of Example 19, the opening may have a substantially circular shape. In this case, since the processing tool protrusion does not engage with anything other than the replacement tool protrusion in the opening of the main body of the replacement tool, it is possible to more reliably transmit the rotation of the replacement tool to
10 the processing tool.

[0164] Example 19b. In the apparatus of Example 19 or 19a, an outer peripheral surface of the first and second replacement tool protrusions may have a shape corresponding to an outer peripheral surface of a processing tool recess formed between two of the plurality of processing
15 tool protrusions that are adjacent each other in a circumferential direction of the engagement part. In this case, after the engagement part of the processing tool is inserted into the opening of the main body of the replacement tool, the replacement tool protrusion and the processing tool protrusion are more likely to engage more closely. Therefore, it is
20 possible to more reliably transmit the rotation of the replacement tool to the processing tool.

[0165] Example 19c. In the apparatus of any one of Examples 19, 19a, and 19b, the first and second replacement tool protrusions may be ridges extending in an extending direction of the main body. In this case, when
25 the engagement part of the processing tool is inserted into the opening of the main body of the replacement tool, the processing tool moves

smoothly along the replacement tool protrusion. Therefore, it is possible to more reliably insert the engagement part of the processing tool into the opening of the main body of the replacement tool.

[0166] Example 20. In the apparatus of any one of Examples 1 to 19 and 19a to 19c, the flange portion of the replacement tool may have an area larger than an area of a surface of the holding unit, and may be configured to cover the entire surface of the holding unit in a state where the replacement tool is attached to the holding unit via the flange portion. In this case, when replacing the processing tool, even if objects (e.g., droplets) fall from the processing tool as it moves above the holding unit, the objects fall onto the flange portion. Therefore, the presence of the flange portion prevents the falling objects from adhering to the surface of the holding unit. Thus, when the substrate is held by the holding unit after the replacement of the processing tool, it is possible to prevent contamination of the substrate due to the transfer of the objects present on the surface of the holding unit to the substrate.

[0167] Example 21. An example of a method of replacing a processing tool includes: a first step of attaching a replacement tool to a holding unit configured to hold a substrate, the replacement tool including a main body and a flange portion projecting from a peripheral surface of the main body for attachment to and detachment from the holding unit; a second step of causing an engagement part of a processing tool to engage with the main body, the processing tool being configured to process a surface of the substrate held by the holding unit, and the processing tool being configured to be transportable while being held by a holding and transport unit; and a third step of attaching and detaching the processing tool to and

from the holding and transport unit by rotating the holding unit. In this case, the same operational effects as in the apparatus of Example 1 can be obtained.

[0168] Example 22. An example of a replacement tool is a replacement tool for replacing a processing tool configured to process a surface of a substrate held by a holding unit. The example of the replacement tool includes: a main body configured to be engageable with an engagement part of the processing tool; and a flange portion projecting from a peripheral surface of the main body for attachment to and detachment from the holding unit. In this case, the same operational effects as in the apparatus of Example 1 can be obtained.

[0169] Example 23. In the replacement tool of Example 22, the main body may have a tubular shape capable of housing the engagement part of the processing tool, an opening of the main body may be provided with a first replacement tool protrusion and a second replacement tool protrusion projecting inward in a radial direction of the opening, and the first replacement tool protrusion and the second replacement tool protrusion may be positioned to face each other with a center of the opening therebetween, and configured to be engageable with any of a plurality of processing tool protrusions in a state where the engagement part of the processing tool is housed in the opening, the plurality of processing tool protrusions being provided on the engagement part of the processing tool and projecting outward in a radial direction of the engagement part. In this case, the same operational effects as in the apparatus of Example 19 can be obtained.

[0170] Example 24. In the replacement tool of Example 23, the opening

may have a substantially circular shape. In this case, the same operational effects as in the apparatus of Example 19a can be obtained.

[0171] Example 25. In the replacement tool of Example 23 or 24, an outer peripheral surface of the first and second replacement tool protrusions may have a shape corresponding to an outer peripheral surface of a processing tool recess formed between two of the plurality of processing tool protrusions that are adjacent each other in a circumferential direction of the engagement part. In this case, the same operational effects as in the apparatus of Example 19b can be obtained.

[0172] Example 26. In the replacement tool of any one of Examples 23 to 25, the first and second replacement tool protrusions may be ridges extending in an extending direction of the main body. In this case, the same operational effects as in the apparatus of Example 19c can be obtained.

[0173] Example 27. In the replacement tool of any one of Examples 22 to 26, the flange portion may have an area larger than an area of a surface of the holding unit, and may be configured to cover the entire surface of the holding unit in a state where the replacement tool is attached to the holding unit via the flange portion. In this case, the same operational effects as in the apparatus of Example 20 can be obtained.

Reference Signs List

[0174] 1 ... Substrate processing system (Substrate processing apparatus),

20, 20A ... Holding unit,

22 ... Suction hole,

27 ... Ridge (First ridge),

30 ... Suction unit,

	40 ... Rotating unit,
	50 ... Supply unit,
	53 ... Holding base (Holding and transport unit),
	53f ... Female screw (Fastening part),
5	54 ... Drive unit (Holding and transport unit),
	56 ... Recess (Fastening part),
	57 ... Recess (Fastening part),
	55 ... Connection portion,
	55d ... Male screw (Fastening part),
10	70 ... Imaging unit,
	100, 100A ... Nozzle (Processing tool),
	100B ... Brush (Processing tool),
	101a ... Male screw (Another fastening part),
	103 ... Deformed shape portion (Engagement part),
15	105 ... Flange portion (Another flange portion),
	106 ... Processing tool protrusion,
	107 ... Processing tool recess,
	120 ... Nut (Processing tool, Another fastening part, Engagement
	part),
20	121 ... Tubular portion (Engagement part),
	140 ... Screw,
	141 ... Main body (Another fastening part),
	142 ... Head (Engagement part),
	200 ... Replacement tool,
25	210 ... Main body,
	211 ... Base portion (Transmission portion),

211b ... Lower part,
 211c ... Receiving part (Transmission portion),
 211e ... Cutout,
 212 ... Outer tubular portion (Transmission portion),
 5 213 ... Slide portion,
 214 ... Biasing unit,
 215 ... Projection (Transmission portion),
 220 ... Flange portion,
 221 ... Ridge (Second ridge),
 10 240 ... Replacement tool protrusion,
 241 ... Replacement tool protrusion (First replacement tool
 protrusion),
 242 ... Replacement tool protrusion (Second replacement tool
 protrusion),
 15 Ctr ... Controller (Control unit),
 OP ... Opening,
 U1 ... Thin film processing apparatus,
 W ... Substrate,
 Wa ... Surface.

20

CLAIMS

[Claim 1]

A substrate processing apparatus comprising:

a holding unit configured to hold a substrate;

5 a rotating unit configured to rotate the holding unit;

a processing tool configured to process a surface of the substrate held by the holding unit;

a replacement tool configured to be detachably attached to the holding unit;

10 a holding and transport unit configured to hold and transport the processing tool; and

a control unit,

wherein the processing tool includes another fastening part configured to be fastenable to a fastening part provided on the holding and transport unit,

15

wherein the replacement tool includes:

a main body configured to be engageable with an engagement part of the processing tool; and

a flange portion projecting from a peripheral surface of the main body for attachment to and detachment from the holding unit, and

20

wherein the control unit is configured to execute a first process of attaching and detaching the processing tool to and from the holding and transport unit by controlling the rotating unit to rotate the holding unit in a state where the replacement tool is attached to the holding unit via the flange portion and the engagement part of the processing tool is engaged

25

with the main body of the replacement tool.

[Claim 2]

5 The apparatus according to claim 1, wherein the replacement tool
is detachably attached to a portion substantially coinciding with a center
of rotation of the holding unit.

[Claim 3]

10 The apparatus according to claim 1, further comprising a suction
unit configured to cause the substrate to be suctioned to the holding unit,
wherein the holding unit includes a suction hole that is open
upward and is connected to the suction unit, and

15 wherein the control unit is further configured to execute a second
process of operating the suction unit to cause the flange portion to be
suctioned to the holding unit before the first process.

[Claim 4]

20 The apparatus according to claim 3, wherein the second process
includes causing the flange portion to be suctioned to the holding unit by
operating the suction unit in a state where a lower part of the main body
is inserted into the suction hole to generate a negative pressure between
the flange portion and an upper surface of the holding unit before the first
process.

25 [Claim 5]

The apparatus according to claim 4, wherein the main body

includes a cutout in which an outer peripheral surface of the lower part of the main body is partially cut out such that the cutout extends in an extending direction of the replacement tool.

5 [Claim 6]

The apparatus according to claim 3,

wherein the holding unit includes a first ridge which has an annular shape and is provided on an upper surface of the holding unit to support the substrate,

10 wherein the first ridge has an annular shape;

wherein the flange portion includes a second annular ridge projecting toward a lower side of the main body, and

wherein the second ridge is located inside the first ridge in a state where the replacement tool is attached to the holding unit.

15

[Claim 7]

The apparatus according to claim 1,

wherein an outer peripheral surface of the engagement part of the processing tool has a non-circular deformed shape,

20 wherein the main body of the replacement tool has a tubular shape capable of housing the engagement part of the processing tool, and

wherein an inner peripheral surface of an opening of the main body of the replacement tool has a shape corresponding to the outer peripheral surface of the engagement part of the processing tool.

25

[Claim 8]

The apparatus according to any one of claims 1 to 7,
wherein the main body of the replacement tool includes:

a base portion having a tubular shape;

an outer tubular portion having a tubular shape and
5 disposed outside the base portion;

a transmission portion configured to transmit a rotational
force from the holding unit between the base portion and the outer tubular
portion; and

a biasing unit,

10 wherein the outer tubular portion is configured to be slidable
relative to the base portion in an extending direction of the replacement
tool, and

wherein the biasing unit is configured to apply a biasing force to
the outer tubular portion in a direction to separate the base portion and
15 the outer tubular portion from each other in the extending direction of the
replacement tool.

[Claim 9]

The apparatus according to claim 8,

20 wherein the main body of the replacement tool further includes a
slide portion configured to be slidable in the extending direction of the
replacement tool inside the outer tubular portion between the base portion
and the outer tubular portion,

wherein the biasing unit is configured to apply the biasing force
25 to the outer tubular portion via the slide portion, and

wherein the control unit is further configured to execute a third

process of controlling the holding and transport unit to apply pressure to the slide portion via the processing tool by the holding and transport unit until the biasing unit is compressed by a predetermined amount, in a state where the engagement part of the processing tool is inserted into the outer tubular portion of the replacement tool attached to the holding unit via the flange portion, and in a state where the processing tool is supported by the slide portion, before the first process.

[Claim 10]

The apparatus according to claim 8,
wherein an outer peripheral surface of the base portion has a non-circular deformed shape,
wherein an inner peripheral surface of the outer tubular portion has a shape corresponding to the outer peripheral surface of the base portion, and
wherein the transmission portion is constituted by the outer peripheral surface of the base portion and the inner peripheral surface of the outer tubular portion.

[Claim 11]

The apparatus according to claim 8,
wherein the main body includes a projection projecting from the outer tubular portion toward the base portion, and
wherein the base portion includes a receiving part that receives the projection.

[Claim 12]

The apparatus according to claim 11, wherein the receiving part extends along the extending direction of the replacement tool.

5 [Claim 13]

The apparatus according to claim 1, wherein the processing tool includes a nozzle for supplying a processing liquid to the surface of the substrate.

10 [Claim 14]

The apparatus according to claim 1,
wherein the processing tool includes a plurality of nozzles for supplying a processing liquid to the surface of the substrate, and
wherein the control unit executes the first process for a designated
15 one of the plurality of nozzles.

[Claim 15]

The apparatus according to claim 1, wherein the processing tool includes a brush for scrub cleaning the surface of the substrate.

20

[Claim 16]

The apparatus according to claim 1,
wherein the processing tool includes another flange portion projecting from a peripheral surface of the processing tool, and
25 wherein the another fastening part is configured to be fastenable to the fastening part of the holding and transport unit via the another

flange portion.

[Claim 17]

The apparatus according to claim 1,

5 wherein the holding unit is configured to be capable of physically gripping a peripheral edge of the substrate, and

 wherein the replacement tool is attached to the holding unit by the peripheral edge of the flange portion being gripped by the holding unit.

10 [Claim 18]

 The apparatus according to claim 1, further comprising an imaging unit configured to capture an image of the holding unit,

 wherein the control unit is configured to execute a fourth process of determining a state of the replacement tool and/or the processing tool
15 based on a captured image from the imaging unit.

[Claim 19]

The apparatus according to claim 1,

 wherein the engagement part of the processing tool is provided
20 with a plurality of processing tool protrusions projecting outward in a radial direction of the engagement part,

 wherein the main body of the replacement tool has a tubular shape capable of housing the engagement part of the processing tool,

 wherein an opening of the main body of the replacement tool is
25 provided with a first replacement tool protrusion and a second replacement tool protrusion that project inward in a radial direction of the

opening and are configured to be engageable with any of the plurality of processing tool protrusions in a state where the engagement part of the processing tool is housed in the opening, and

wherein the first replacement tool protrusion and the second replacement tool protrusion are positioned to face each other with a center of the opening therebetween.

[Claim 20]

The apparatus according to claim 1, wherein the flange portion of the replacement tool has an area larger than an area of a surface of the holding unit, and is configured to cover the entire surface of the holding unit in a state where the replacement tool is attached to the holding unit via the flange portion.

[Claim 21]

A method of replacing a processing tool, comprising:

a first step of attaching a replacement tool to a holding unit configured to hold a substrate, the replacement tool including a main body and a flange portion projecting from a peripheral surface of the main body for attachment to and detachment from the holding unit;

a second step of causing an engagement part of a processing tool to engage with the main body, the processing tool being configured to process a surface of the substrate held by the holding unit, and the processing tool being configured to be transportable while being held by a holding and transport unit; and

a third step of attaching and detaching the processing tool to and

from the holding and transport unit by rotating the holding unit.

[Claim 22]

A replacement tool for replacing a processing tool configured to
5 process a surface of a substrate held by a holding unit, the replacement
tool comprising:

a main body configured to be engageable with an engagement
part of the processing tool; and

a flange portion projecting from a peripheral surface of the main
10 body for attachment to and detachment from the holding unit.

[Claim 23]

The replacement tool according to claim 22,

wherein the main body has a tubular shape capable of housing the
15 engagement part of the processing tool,

wherein an opening of the main body is provided with a first
replacement tool protrusion and a second replacement tool protrusion
projecting inward in a radial direction of the opening, and

wherein the first replacement tool protrusion and the second
20 replacement tool protrusion are

positioned to face each other with a center of the opening
therebetween, and

configured to be engageable with any of a plurality of
processing tool protrusions in a state where the engagement part of the
25 processing tool is housed in the opening, the plurality of processing tool
protrusions being provided on the engagement part of the processing tool

and projecting outward in a radial direction of the engagement part.

[Claim 24]

5 The replacement tool according to claim 23, wherein the opening
has a substantially circular shape.

[Claim 25]

10 The replacement tool according to claim 23, wherein an outer
peripheral surface of the first and second replacement tool protrusions has
a shape corresponding to an outer peripheral surface of a processing tool
recess formed between two of the plurality of processing tool protrusions
that are adjacent each other in a circumferential direction of the
engagement part.

15 [Claim 26]

 The replacement tool according to claim 23, wherein the first and
second replacement tool protrusions are ridges extending in an extending
direction of the main body.

20 [Claim 27]

 The replacement tool according to any one of claims 22 to 26,
wherein the flange portion has an area larger than an area of a surface of
the holding unit, and is configured to cover the entire surface of the
holding unit in a state where the replacement tool is attached to the
25 holding unit via the flange portion.