

# SUBSTRATE PROCESSING APPARATUS

## BACKGROUND OF THE INVENTION

Field of the Invention:

5 [0001] The present invention relates to a substrate processing apparatus.

Description of the Related Art:

[0002] In a manufacture of semiconductor devices, many types of materials are repeatedly deposited on a wafer in a form of films, forming a layered structure. To form  
10 this layered structure, technology for flattening the wafer surface is crucial. One method for flattening the wafer surface is to use a polishing apparatus that performs chemical mechanical polishing (CMP).

[0003] The polishing apparatus generally includes a polishing table on which a polishing pad is attached, a polishing head that presses the wafer against the polishing pad on the  
15 polishing table, and a nozzle that supplies a polishing liquid onto the polishing pad. While the polishing liquid is being supplied onto the polishing pad from the nozzle, the polishing head presses the wafer against the polishing pad, and the polishing head and the polishing pad are moved relative to each other to polish the wafer.

[0004] A substrate processing apparatus includes a polishing module that performs the  
20 above-described chemical mechanical polishing (CMP), a cleaning module that cleans the polished wafer, and a drying module that dries the cleaned wafer. The wafer polished in the polishing module is transferred by a transfer robot to the cleaning module and the drying module, where it is cleaned and dried.

Citation List

25 Patent Literature

[0005]

Patent document 1: Japanese laid-open patent publication No. 2005-347568

Patent document 2: Japanese laid-open patent publication No. 2008-141186

[0006] In recent years, with an increasing productivity of the substrate processing

apparatus, optimization of each process (i.e., improving a productivity of the wafer without unnecessarily increasing a footprint size of the substrate processing apparatus) has been pursued. In particular, optimization of a measurement process using a measurement device for measuring a film thickness and cleanliness of the wafer has been required.

[0007] In order to improve the productivity of the wafer, it is desirable to install multiple measurement devices. However, even in this case, it is necessary to improve the productivity of the wafer without increasing the footprint size of the substrate processing apparatus more than necessary.

## SUMMARY OF THE INVENTION

[0008] Therefore, an object of the present invention to provide a substrate processing apparatus that can realize optimization of the measurement process.

[0009] In an embodiment, there is provided a substrate processing apparatus comprising: a polishing module configured to polish a substrate; a cleaning module configured to clean the substrate; a drying module configured to dry the cleaned substrate; a plurality of load ports configured to mount a transport container for storing the substrate; at least one transport robot disposed within a housing, and configured to transport the substrate before polishing to the polishing module and transport the substrate dried in the drying module to the transport container; a load/unload unit arranging the load ports side by side adjacent to a front outer wall of the housing; and an upper measurement module and a lower measurement module configured to measure a surface condition of the substrate, and disposed side by side vertically adjacent to a side outer wall of the housing connected to the front outer wall.

[0010] In an embodiment, at least one of the upper measurement module and the lower measurement module comprises a measurement section configured to measure the surface condition of the substrate before polishing and/or the surface condition of the substrate after polishing.

In an embodiment, when one of the upper measurement module and the lower

measurement module comprises the measurement section, the other of the upper measurement module and the lower measurement module comprises at least a control unit configured to control an operation of the measurement section and acquire data measured by the measurement section.

5           In an embodiment, when the upper measurement module comprises the measurement section and the control unit, the measurement section in the upper measurement module is located below the control unit, and when the lower measurement module comprises the measurement section and the control unit, the measurement section in the lower measurement module is located above the control unit.

10       [0011] In an embodiment, when the upper measurement module and the lower measurement module each comprises the measurement section, the measurement section in the upper measurement module and the measurement section in the lower measurement module are arranged adjacent to each other.

          In an embodiment, the substrate processing apparatus comprises a horizontal  
15       movement mechanism and a vertical movement mechanism configured to move the transport robot among a substrate transport position for transporting the substrate in the transport container to the polishing module, a substrate receiving position for receiving the substrate dried in the drying module, and the upper measurement module and the lower measurement module.

20           In an embodiment, the horizontal movement mechanism has a length corresponding to the distance between areas where the load ports are arranged, and the vertical movement mechanism has a length corresponding to the distance between the load ports and the substrate transport position and the substrate receiving position.

          [0012] In an embodiment, the substrate processing apparatus comprises an  
25       accommodation frame configured store the lower measurement module, and the accommodation frame is adjacent to the housing with a gap formed between the housing and the accommodation frame.

          In an embodiment, the upper measurement module is mounted on the accommodation frame.

In an embodiment, each of the upper measurement module and the lower measurement module is adjacent to the housing via an elastic seal disposed between the module and the lower measurement module.

[0013] The substrate processing apparatus includes an upper measurement module and a lower measurement module arranged side by side in the vertical direction, and this arrangement allows the substrate processing apparatus to improve a productivity of the substrate without unnecessarily increasing its footprint size.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a perspective view showing an embodiment of a substrate processing apparatus;

FIG. 2 is a side view of the substrate processing apparatus shown in FIG. 1;

FIG. 3 is a plan view of the substrate processing apparatus shown in FIG. 1;

FIG. 4 is a view showing one embodiment of a measurement unit;

FIG. 5 includes an accommodation frame that stores a lower measurement module;

FIG. 6 is a view showing the accommodation frame disposed with a gap formed between it and a housing;

FIG. 7 is a view showing an elastic seal disposed between a measurement unit and the housing;

FIGS. 8A to 8F are views showing an example of an arrangement of a control unit and/or the measurement unit in each of an upper measurement module and the lower measurement module;

FIG. 9 is a view showing the substrate processing apparatuses with the measurement units (i.e., upper and lower measurement modules) mounted side-by-side on the housing;

FIG. 10 is a view showing the substrate processing apparatuses with the measurement modules located on both sides of the housing;

FIG. 11 is a view showing another embodiment of the substrate processing

apparatus;

FIG. 12 is a view showing another embodiment of the substrate processing apparatus;

FIG. 13 is a view showing an example of a substrate processing flow in the substrate processing apparatus according to the embodiment described with reference to FIGS. 1 to 9, 11 and 12;

FIG. 14 is a view showing an example of a substrate processing flow in the substrate processing apparatus according to the embodiment described with reference to FIGS. 1 to 9, 11 and 12;

FIGS. 15 is a view showing an example of a substrate processing flow in the substrate processing apparatus according to the embodiment described with reference to FIGS. 1 to 9, 11 and 12;

FIGS. 16 is a view showing an example of a substrate processing flow in the substrate processing apparatus according to the embodiment described with reference to FIGS. 1 to 9, 11 and 12; and

FIG. 17 is a view showing an example of a substrate processing flow in the substrate processing apparatus according to the embodiment described with reference to FIGS. 1 to 9, 11 and 12.

## DESCRIPTION OF EMBODIMENTS

[0015] Embodiments of the present invention will be described with reference to the drawings. In the drawings described below, identical or corresponding components are designated by the same reference numerals, and duplicated descriptions will be omitted. In the multiple embodiments described below, the configuration of an embodiment that is not particularly described is the same as that of other embodiments, and therefore duplicated descriptions will be omitted.

[0016] FIG. 1 is a perspective view showing an embodiment of a substrate processing apparatus. FIG. 2 is a side view of the substrate processing apparatus shown in FIG. 1. FIG. 3 is a plan view of the substrate processing apparatus shown in FIG. 1. The

substrate processing apparatus includes a first processing unit 101 and a second processing unit 102 for processing a substrate W.

[0017] The processing of the substrate W includes a polishing, a cleaning, and a drying of the substrate W. The first processing unit 101 and the second processing unit 102 are arranged side by side. Specific examples of the substrate W include a wafer used in a semiconductor device, a circular substrate, a square substrate, a panel, etc. In the embodiment described below, a circular wafer is used as the substrate W.

[0018] Since the first processing unit 101 and the second processing unit 102 have the same components, the following description will be given of the first processing unit 101.

The following description is also applicable to the second processing unit 102.

[0019] The first processing unit 101 includes a plurality of polishing modules 1A, 1B for polishing the substrate W, a plurality of cleaning modules 7, 8, 9, 10 for cleaning the substrate W, a drying module 11 for drying the cleaned substrate W, a substrate transport device 14 extending from one side to the other side of the first processing unit 101, and an elevating transport device 5 for transporting the substrate W from the substrate transport device 14 to each polishing module 1A, 1B and from each polishing module 1A, 1B to the cleaning modules 7, 8, 9. The elevating transport device 5 is configured to transport the substrate W between the cleaning modules 7, 8, 9, 10.

[0020] The first processing unit 101 further includes an intermediary transport device 6 configured to transport the substrate W from the cleaning module 10 to the drying module 11 and from the drying module 11 to the substrate transport device 14. The intermediary transport device 6 of the first processing unit 101 is configured to transport the substrate W between the first processing unit 101 and the second processing unit 102. The substrate processing apparatus includes an operation control unit 15 that controls operations of the above-described components of the first processing unit 101 and the second processing unit 102.

[0021] As shown in FIG. 3, the polishing modules 1A, 1B, the elevating transport device 5, the intermediary transport device 6, the cleaning modules 7, 8, 9, 10 and the drying module 11 are surrounded by a wall (housing) 16, and a cleanliness is controlled so that

an atmosphere inside the wall 16 does not spread to other areas.

[0022] The substrate W is transported through an opening (having a shutter) provided in the wall (housing) 16. In particular, the polishing modules 1A, 1B and the cleaning modules 7, 8, 9, and 10 are separated from each other by an elevating transport area 17 having an elevating transport device 5 therein. The elevating transport area 17 is formed by the wall (housing) 16. Details of the wall (housing) 16 are not shown in FIGS. 1 and 2.

[0023] Each of the first processing unit 101 and the second processing unit 102 is a unitized assembly. In one embodiment, the second processing unit 102 is detachably connected to the first processing unit 101, and the entire second processing unit 102 can be separated from the first processing unit 101.

[0024] Furthermore, one or more additional processing units having a similar configuration can be connected to the second processing unit 102. That is, three or more processing units including the first processing unit 101 and the second processing unit 102 can be connected in series.

[0025] Operations of the processing units including the first processing unit 101 and the second processing unit 102 are controlled by the operation control unit 15. The operation control unit 15 includes a storage device 15a that stores a program, and an arithmetic unit 15b that executes calculations according to instructions included in the program.

[0026] The operation control unit 15 is composed of at least one computer. The storage device 15a includes a main storage device such as a random access memory (RAM) and an auxiliary storage device such as a hard disk drive (HDD) or a solid state drive (SSD). Examples of the arithmetic device 15b include a CPU (central processing unit) and a GPU (graphics processing unit). However, a specific configuration of the operation control unit 15 is not limited to these examples.

[0027] In the embodiment shown in FIGS. 1 to 3, the first processing unit 101 includes two polishing modules 1A and 1B arranged in parallel at the same height. In one embodiment, each of the processing units 101 and 102 may include a single polishing

module, while in another embodiment, each of the processing units 101 and 102 may include three or more polishing modules. The substrate transport device 14 is located at a higher position than the polishing modules 1A and 1B, the cleaning modules 7, 8, 9, and 10, and the drying module 11. In this embodiment, the substrate transport device 14 is located above the cleaning modules 7, 8, 9, and 10 and the drying module 11.

[0028] The elevating transport device 5 includes a holding hand 40 that can access the substrate transport device 14, the polishing modules 1A and 1B, and the cleaning modules 7, 8, 9, and 10. The holding hand 40 is movable up and down as shown by the arrows in FIG. 1. The intermediary transport device 6 of the first processing unit 101 includes a holding hand 60 that can access the polishing module 1B, the cleaning module 10, the drying module 11, and the substrate transport device 14 of the first processing unit 101, and the substrate transport device 14, the polishing module 1C, and the cleaning modules 7 and 8 of the second processing unit 102. The holding hand 60 is movable up and down as shown by the arrows in FIG. 1.

[0029] The substrate W to be polished is transported with its surface to be polished facing upward by the substrate transport device 14 of the first processing unit 101. The elevating transport device 5 of the first processing unit 101 rises to the substrate transport device 14 and removes the substrate W from the substrate transport device 14.

[0030] Furthermore, the elevating transport device 5 turns the substrate W over so that the surface to be polished of the substrate W faces downward, and then transfers the substrate W to one of the polishing modules 1A and 1B. The substrate W is polished by one or both of the polishing modules 1A and 1B. The elevating transport device 5 transports the substrate W between the polishing modules 1A and 1B.

[0031] Since the two polishing modules 1A and 1B have the same components, the following description will focus on the polishing module 1A. The polishing modules 1C and 1D of the second processing unit 102 also have the same components, although detailed description will be omitted.

[0032] The polishing module 1A has a polishing table 21 that supports the polishing pad 20, a table motor 22 that rotates the polishing table 21, a polishing liquid supply nozzle

24 that supplies a polishing liquid onto the polishing pad 20, two polishing heads 25, 25 that press the substrate W against the polishing pad 20 to polish the substrate W, and a polishing head motor (not shown) that rotates the polishing heads 25, 25 around their axes.

5 [0033] The two polishing heads 25, 25 are rotatably supported by a head arm 28, and the polishing head motor is disposed within the head arm 28. A center of the head arm 28 is supported by a support shaft 29.

[0034] The polishing module 1A further includes a substrate loader 33 that receives the substrate W from the elevating transport device 5 and transfers the substrate W to one of  
10 the two polishing heads 25. The substrate loader 33 is disposed outside the polishing table 21. The elevating transport device 5 is configured to invert the substrate W so that the surface to be polished of the substrate W faces downward, and transfers the substrate W to the substrate loader 33 with the surface to be polished of the substrate W facing downward.

15 [0035] The polishing module 1A further includes an arm rotation motor (not shown) that rotates the head arm 28 and the two polishing heads 25, 25 about the support shaft 29. This arm rotation motor is mounted on the head arm 28 or the support shaft 29. When the head arm 28 is rotated by an angle of 180 degrees by the arm rotation motor, one of the two polishing heads 25, 25 is moved to a position above the polishing pad 20, and the  
20 other polishing head 25 is moved to a position above the substrate loader 33.

[0036] The substrate loader 33 is configured to lift the substrate W and transfer it to the polishing head 25 located outside the polishing table 21. The polishing heads 25 are configured to hold the substrate W on their lower surfaces by vacuum suction. In one embodiment, one or both of the polishing modules 1A and 1B may have a single polishing  
25 head 25.

[0037] Polishing of the substrate W is performed as follows: When the substrate W to be polished is held by the polishing head 25, the head arm 28 rotates 180 degrees, and the polishing head 25 moves to the position above the polishing pad 20 together with the substrate W. The polishing table 21 and the polishing pad 20 are rotated by the table

motor 22, and the polishing liquid (typically a slurry) is supplied onto the polishing pad 20 from the polishing liquid supply nozzle 24.

[0038] The polishing head 25 is rotated by the polishing head motor (not shown) disposed in the head arm 28, while pressing the lower surface (surface to be polished) of the substrate W against the polishing pad 20. The lower surface of the substrate W is polished by a combination of the chemical action of the polishing liquid and the mechanical action of the abrasive grains contained in the polishing liquid and/or the polishing pad 20. The polishing modules 1A and 1B of this embodiment are chemical mechanical polishing apparatuses (CMP apparatuses) that chemically and mechanically polish the substrate W.

[0039] When polishing of the substrate W is completed, the head arm 28 rotates 180 degrees, and the polishing head 25 moves to the position above the substrate loader 33 together with the polished substrate W. The polishing head 25 releases the substrate W, and the substrate W is placed on the substrate loader 33. The holding hand 40 of the elevating transport device 5 removes the substrate W from the substrate loader 33 and carries the substrate W into any one of the cleaning modules 7 to 10.

[0040] In this embodiment, the polishing module 1A has two polishing heads 25, 25, so that while one polishing head 25 is in the position above the polishing pad 20 or is polishing the substrate W, the other polishing head 25 can release the substrate W and hold the next substrate to be polished.

[0041] The cleaning modules 7, 8, 9, and 10 in this embodiment include a cleaning module 7 used as a pre-cleaning module or a post-cleaning module, and multiple (three in FIG. 1) cleaning modules 8, 9, and 10 used as post-cleaning modules. The pre-cleaning module is a cleaning apparatus for cleaning the substrate W before it is polished by the polishing modules 1A and 1B, and the post-cleaning module is a cleaning apparatus for cleaning the substrate W after it has been polished by the polishing modules 1A and 1B.

[0042] The cleaning modules 7 and 8 are arranged in a vertical direction, and the cleaning modules 9, 10, and the drying module 11 are also arranged in the vertical

direction. A group of cleaning modules 7 and 8 is arranged apart from a group of cleaning modules 9, 10, and the drying module 11. The cleaning module 7 is arranged above the cleaning module 8. The drying module 11 is arranged above the cleaning module 10, and the cleaning module 10 is arranged above the cleaning module 9.

5 [0043] There is no particular limitation on types of the four cleaning modules 7, 8, 9, and 10. In one example, the cleaning module 7 is a buff cleaning apparatus or a sponge scrubbing cleaning apparatus, the cleaning modules 8 and 9 are sponge scrubbing cleaning apparatuses, and the cleaning module 10 is a two-fluid jet cleaning apparatus.

[0044] Known configurations can be used for the cleaning mechanisms of the cleaning  
10 modules 7, 8, 9, and 10. There is also no particular limitation on the type of the drying module 11. For example, the drying module 11 may be an IPA drying apparatus that sprays isopropyl alcohol vapor onto the substrate W to dry the substrate W, or may be a spin drying apparatus that removes a liquid from the substrate W by rotating the substrate W at high speed.

15 [0045] The operation of the elevating transport device 5 is configured to switch between a pre-cleaning mode in which the substrate W is transported to the cleaning module 7 before being transported to the polishing module 1A or 1B, and the post-cleaning mode in which the substrate W is transported to the cleaning module 7 after being removed from the polishing module 1A or 1B.

20 [0046] In the pre-cleaning mode, the cleaning module 7 operates as a pre-cleaning module. That is, the operation control unit 15 issues a command to the elevating transport device 5 to transport the substrate W from the substrate transporting device 14 to the cleaning module 7 before transporting the substrate W to the polishing module 1A or 1B. The cleaning module 7 as a pre-cleaning module cleans the substrate W before  
25 polishing.

[0047] In the post-cleaning mode, the cleaning module 7 operates as a post-cleaning module. That is, the operation control unit 15 issues a command to the elevating transport device 5 to transport the polished substrate W from the polishing module 1A or 1B to the cleaning module 7. The cleaning module 7 as a post-cleaning module cleans

the polished substrate W.

[0048] In the pre-cleaning mode, the polished substrate W is transported to the cleaning module 8, the cleaning module 9, and the cleaning module 10 in this order, and is cleaned by these cleaning modules 8, 9, and 10. In the post-cleaning mode, the polished substrate W is transported to the cleaning module 7, the cleaning module 8, the cleaning module 9, and the cleaning module 10 in this order, and is cleaned by these cleaning modules 7, 8, 9, and 10.

[0049] In this embodiment, the elevating transport device 5 is configured to be accessible to the cleaning modules 7, 8, 9, and 10, and the intermediary transport device 6 is configured to be accessible to the cleaning module 10 and the drying module 11. Therefore, the elevating transport device 5 transports the polished substrate W with low cleanliness (i.e., having polishing liquid and polishing debris attached), and the intermediary transport device 6 transports the cleaned substrate W with high cleanliness. Furthermore, by using two transport devices, i.e., the elevating transport device 5 and the intermediary transport device 6, it is possible to prevent the substrate transport from becoming rate-limiting, and to process multiple substrates continuously.

[0050] In one embodiment, the elevating transport device 5 has two holding hands arranged one above the other and operating independently of each other, and the intermediary transport device 6 has two holding hands 60 arranged one above the other and operating independently of each other.

[0051] For example, the lower holding hand 40 can transport a wet substrate, and the upper holding hand 40 can transport a dry substrate. Similarly, the lower holding hand 60 can transport a wet substrate, and the upper holding hand 60 can transport a dry substrate.

[0052] In one embodiment, the elevating transport device 5 may be configured to be accessible to all of the cleaning modules 7, 8, 9, and 10 and the drying module 11. In this case, the elevating transport device 5 transports the substrate W into and out of the cleaning modules 7, 8, 9, and 10 and the drying module 11.

[0053] The substrate transport device 14 includes a substrate stage 71 that supports the

substrate W, and a stage moving mechanism 72 that horizontally moves the substrate stage 71. The substrate stage 71 is connected to the stage moving mechanism 72. The stage moving mechanism 72 extends horizontally from one side of the first processing unit 101 to the opposite side.

5 [0054] More specifically, the stage moving mechanism 72 extends in a width direction of the first processing unit 101, and is disposed above the cleaning modules 7, 8, 9, and 10 and the drying module 11. The substrate transport device 14 of this embodiment is a linear transporter that moves the substrate W in a straight line.

[0055] The stage moving mechanism 72 is configured to stop the substrate stage 71 at a  
10 first position P1, a second position P2, and a third position P3. The first position P1 is located on one side of the first processing unit 101, and the second position P2 is located on the opposite side of the first processing unit 101. The third position P3 is located between the first position P1 and the second position P2.

[0056] More specifically, the first position P1 is located above the cleaning modules 7  
15 and 8, and the second position P2 is located above the cleaning modules 9 and 10 and the drying module 11. The third position P3 is located between the group of cleaning modules 7 and 8 and the group of cleaning modules 9 and 10 and the drying module 11.

[0057] The substrate processing apparatus includes a loading/unloading section 50  
adjacent to the first processing unit 101. As shown in FIGS. 2 and 3, the  
20 loading/unloading section 50 further includes a cassette loader (in other words, a load port) 53 on which a cassette storage (i.e., a transport container) 100 storing a plurality of substrates W is placed, and a transport robot 55 that takes out one substrate W to be polished from the cassette storage 100 and transfers it to the substrate transport device 14.

25 [0058] The transport robot 55 is disposed in a housing PL made up of multiple outer walls (see FIG. 3), and is disposed between the cassette loader 53 and the substrate transfer device 14. In this embodiment, one transport robot 55 is disposed, but the number of transfer robots 55 is not limited to this embodiment. In one embodiment, two or more transfer robots 55 may be disposed.

[0059] In this embodiment, there are provided a plurality of (more specifically, four) cassette loaders 53. These cassette loaders 53 are arranged side by side adjacent to a first outer wall (in other words, a front outer wall) PL1 of the housing PL.

[0060] The substrate processing apparatus further includes a horizontal movement mechanism 56 and a vertical movement mechanism 57 for moving the transport robot 55 horizontally and vertically. The vertical movement mechanism 57 is configured to raise and lower the transport robot 55 between the cassette storage 100 and the substrate transport device 14. That is, the transport robot 55 takes out one substrate W to be polished from the cassette storage 100, moves up to the substrate transport device 14 by the vertical movement mechanism 57, and places the substrate W on the substrate stage 71 of the substrate transport device 14 in the first processing unit 101.

[0061] Furthermore, the substrate W that has been processed (polished, cleaned, dried) by at least one of the first processing unit 101 and the second processing unit 102 is taken out by the transport robot 55 from the substrate stage 71 of the substrate transport device 14 of the first processing unit 101. The transport robot 55 is lowered by the vertical movement mechanism 57 together with the processed substrate W, and returns the processed substrate W to the cassette storage 100.

[0062] The polishing heads 25, 25 are suspended from a frame (not shown). More specifically, the support shaft 29 extends downward from the frame (not shown), and the head arm 28 is rotatably supported at a bottom of the support shaft 29. An arm rotation motor (not shown) is installed on the head arm 28 or the support shaft 29, which rotates the head arm 28 and the two polishing heads 25, 25 about the support shaft 29. The polishing module 1B has a similar configuration.

[0063] The substrate processing apparatus includes a measurement unit 200 (see FIGS. 1 and 3) for measuring a surface condition of the substrate W (e.g., the film thickness formed on the surface of the substrate W, the cleanliness of the surface of the substrate W) before polishing begins and/or after polishing is completed.

[0064] FIG. 4 is a view showing one embodiment of the measurement unit. As shown in FIG. 4, the measurement unit 200 has an upper measurement module ML and a lower

measurement module ML which have basically the same configuration. Each of the upper measurement module ML and the lower measurement module ML is configured to measure the surface condition of a substrate W.

[0065] The upper measurement module ML and the lower measurement module ML are arranged side by side in the vertical direction adjacent to a second outer wall (in other words, a side outer wall) PL2 connected to the first outer wall PL1 of the housing PL. The first outer wall PL1 and the second outer wall PL2 extend perpendicular to each other when the housing PL is viewed from above. The cassette storages 100 (or cassette loaders 53) arranged adjacent to the first outer wall PL1 and the measurement modules ML arranged adjacent to the second outer wall PL2 are arranged perpendicular to each other.

[0066] As shown in FIG. 4, the transport robot 55 is configured to be movable in the vertical and horizontal directions by the horizontal movement mechanism 56 and the vertical movement mechanism 57. More specifically, the transport robot 55 is configured to move between a substrate transport position 201 for transporting a substrate W in the cassette storage 100 to the polishing modules 1A to 1D, a substrate receiving position 202 for receiving the substrate W dried in the drying module 11, and the measurement unit 200 by operating the horizontal movement mechanism 56 and the vertical movement mechanism 57.

[0067] The horizontal movement mechanism 56 has a length equivalent to the distance of the area in which multiple cassette storages 100 (or multiple cassette loaders 53) are arranged side by side, and this distance corresponds to the distance between the two cassette storages 100 arranged at an extreme ends of the multiple cassette storages 100. The horizontal movement mechanism 56 is capable of accessing all of the multiple cassette storages 100.

[0068] The vertical movement mechanism 57 has a length equivalent to the distance between the cassette storage 100 and the substrate transport position 201 and the substrate receiving position 202, and is capable of accessing the cassette storage 100, the substrate transport position 201, and the substrate receiving position 202.

[0069] The substrate transport position 201 and the substrate receiving position 202 are located at the top of the housing PL (i.e., above the cassette storage 100) and are adjacent to each other. The substrate transport position 201 and the substrate receiving position 202 are positions accessible by the substrate transport device 14, and the transport robot 55 can transport the substrate W to and from the substrate transport device 14 via the substrate transport position 201 and the substrate receiving position 202.

[0070] In this embodiment, by arranging the measurement unit 200 to the side of the loading/unloading section 50, the transport robot 55 can quickly transport the substrate W to the measurement unit 200 before polishing begins and/or after polishing is completed.

[0071] The measurement unit 200 is arranged in an area to the side of the loading/unloading section 50, but is not arranged in areas to the side of the first processing unit 101 and the second processing unit 102 (see FIG. 3). This arrangement allows an operator to perform maintenance on the first processing unit 101 and the second processing unit 102 without being hindered by the measurement unit 200.

[0072] It is desirable to shorten a transport time of the substrate W as much as possible to prevent contamination of the substrate W. In this embodiment, the transport robot 55 can quickly access the cassette storage 100 and the measurement unit 200, which are arranged close to each other. Furthermore, by arranging the substrate transport position 201 and the substrate receiving position 202 adjacent to the measuring unit 200 and the cassette storage 100, the transport robot 55 can quickly transport the substrate W.

[0073] In the embodiment shown in FIG. 4, each of the upper measurement module ML and the lower measurement module ML includes a measurement section D2 that measures the surface condition of the substrate W before polishing and/or the surface condition of the substrate W after polishing, and a control unit D1 that controls the operation of the measurement section D2 and acquires data (measurement data) measured by the measurement section D2.

[0074] The measurement section D2 is a stand-alone measurement device that measures the surface condition of the substrate W while the substrate W is stationary. The

measurement section D2 is, for example, a film thickness measurement device (e.g., an in-line thickness monitor (ITM)) that measures the film thickness profile of the substrate W, or a measurement device (particle analyzer, particle counter) that measures the number of particles on the surface of the substrate W.

5 [0075] The control unit D1 is electrically connected to the measurement section D2. Therefore, the control unit D1 may create a profile of the surface condition of the substrate W based on the data measured by the measurement section D2.

[0076] The control unit D1 is also electrically connected to the operation control unit 15 (see FIG. 1). Therefore, the control unit D1 sends data measured by the measurement  
10 section D2 to the operation control unit 15, and the operation control unit 15 can control the operations of the first processing unit 101 and the second processing unit 102 based on the data sent from the control unit D1.

[0077] Each of the upper measurement module ML and the lower measurement module ML has an upper accommodation space UC and a lower accommodation space LC. In the  
15 lower measurement module ML, the lower accommodation space LC accommodates the control unit D1, and the upper accommodation space UC accommodates the measurement section D2. In the upper measurement module ML, the lower accommodation space LC accommodates the measurement section D2, and the upper accommodation space UC accommodates the control unit D1.

20 [0078] In the upper measurement module ML, the measurement section D2 is disposed below the control unit D1. In the lower measurement module ML, the measurement section D2 is disposed above the control unit D1. With this arrangement, the measurement section D2 in the upper measurement module ML and the measurement section D2 in the lower measurement module ML are disposed adjacent to each other.

25 [0079] Therefore, there is almost no difference between the time it takes for the transport robot 55 to access the measurement section D2 of the upper measurement module ML and the time it takes for the transport robot 55 to access the measurement section D2 of the lower measurement module ML, and as a result, a difference in transport time between the multiple substrates W being transported can be reduced.

[0080] Furthermore, in this embodiment, the measurement section D2 of the upper measurement module ML and the measurement section D2 of the lower measurement module ML are arranged in an area between the cassette storage 100 and the substrate transport position 201 and the substrate receiving position 202. Therefore, the transport robot 55 can quickly access the measurement section D2, the cassette storage 100, the substrate transport position 201, and the substrate receiving position 202. As a result, the transport time of the substrate W can be shortened as much as possible.

[0081] FIG. 5 includes an accommodation frame that stores the lower measurement module. The upper measurement module ML is disposed above the lower measurement module ML. The substrate processing apparatus includes an accommodation frame 301 that stores the lower measurement module ML. The accommodation frame 301 is installed on a floor FL on which the substrate processing apparatus is installed and which has low vibration. The upper measurement module ML is placed on the accommodation frame 301.

[0082] FIG. 6 is a view showing the accommodation frame disposed with a gap formed between it and the housing. As shown in FIG. 6, the accommodation frame 301 is adjacent to the housing PL with a gap G formed between it and the housing PL. Therefore, the gap G is formed between the measurement unit 200 and the housing PL.

[0083] The measurement unit 200 (particularly the measurement section D2) is a precision instrument, and it is desirable to measure the surface condition of the substrate W in a stationary state in order to more accurately measure the surface condition of the substrate W. In this embodiment, by forming the gap G, the measurement section D2 of the measurement unit 200 can measure the surface condition of the substrate W without being affected by vibrations caused by a device(s) inside the housing PL.

[0084] FIG. 7 is a view showing an elastic seal disposed between the measurement unit and the housing. As shown in FIG. 7, the measurement unit 200 (more specifically, the upper measurement module ML and the lower measurement module ML) is adjacent to the housing PL via an elastic seal SL disposed between the measurement unit 200 and the housing PL. Even with this configuration, the measurement section D2 of the

measurement unit 200 can measure the surface condition of the substrate W without being affected by vibrations caused by a device(s) inside the housing PL.

[0085] FIGS. 8A to 8F are views showing an example of the arrangement of the control unit and/or the measurement unit in each of the upper measurement module and the lower measurement module. In the above-described embodiment, each of the upper measurement module ML and the lower measurement module ML includes the control unit D1 and the measurement section D2, but in one embodiment, each of the upper measurement module ML and the lower measurement module ML does not need to include both the control unit D1 and the measurement section D2.

[0086] In the embodiment shown in FIGS. 8A to 8F, at least one of the upper measurement module ML and the lower measurement module ML includes a measurement section D2. When one of the upper measurement module ML and the lower measurement module ML includes the measurement section D2, the other of the upper measurement module ML and the lower measurement module ML includes at least a control unit D1.

[0087] In the embodiment shown in FIGS. 8A to 8F, the measurement sections D2 are arranged adjacent to one another. In the embodiment shown in FIG. 8A, the lower accommodation space LC of the upper measurement module ML accommodates the measurement section D2, and the upper accommodation space UC accommodates nothing. The lower accommodation space LC of the lower measurement module ML accommodates the control unit D1, and the upper accommodation space UC accommodates the measurement section D2.

[0088] In the embodiment shown in FIG. 8A, one control unit D1 is electrically connected to two measurement sections D2 and is configured to control the operations of the two measurement sections D2 and acquire measurement data. In this manner, the measurement unit 200 does not need to have the same number of control units D1 as the number of measurement sections D2.

[0089] In the embodiment shown in FIG. 8B, unlike the embodiment shown in FIG. 8A, the upper accommodation space UC of the upper measurement module ML accommodates

the measurement section D2, while the upper accommodation space UC of the lower measurement module ML accommodates nothing. This arrangement places the two measurement sections D2 in close proximity at the substrate transport position 201 and the substrate receiving position 202. Consequently, the transport robot 55 can transfer the substrate W more efficiently between the two measurement sections D2 and the substrate transport device 14.

[0090] In the embodiment shown in FIG. 8C, the upper accommodating space UC of the upper measurement module ML accommodates the control unit D1, and the lower accommodation space LC accommodates the measurement section D2. The upper accommodation space UC of the lower measurement module ML accommodates the measurement section D2, and the lower accommodation space LC accommodates nothing. This arrangement can reduce the difference in transport time between multiple transported substrates W, similar to the effect of the embodiments shown in FIGS. 4 to 7.

[0091] In the embodiment shown in FIG. 8D, the upper accommodation space UC of the upper measurement module ML accommodates the control unit D1, and the lower accommodation space LC accommodates nothing. Each of the upper accommodation space UC and the lower accommodation space LC of the lower measurement module ML accommodates the measurement section D2. This arrangement allows multiple measurement units D2 to be disposed at a center of gravity of the accommodation frame 301, and as a result, the measurement units D2 can measure the surface condition of the substrate W while minimizing the effects of vibrations acting on them.

[0092] In the embodiment shown in FIG. 8E, the upper and lower accommodation spaces UC and LC of the upper measurement module ML each accommodate the measurement section D2. The upper accommodation space UC of the lower measurement module ML accommodates the control unit D1, and the lower accommodation space LC accommodates nothing. This arrangement can achieve the same effects as the embodiment shown in FIG. 8B.

[0093] In the embodiment shown in FIG. 8F, the upper accommodation space UC of the upper measurement module ML is empty, and the lower accommodation space LC

accommodates the control unit D1. The upper accommodation space UC and the lower accommodation space LC of the lower measurement module ML each accommodate the measurement section D2. This arrangement can achieve the same effects as the embodiment shown in FIG. 8D.

5 [0094] In the embodiment shown in FIG. 8A to 8F, one control unit D1 is provided, and the upper measurement module ML and/or the lower measurement module ML have empty (nothing) accommodation spaces, but a new control unit D1 or measurement section D2 may be accommodated in the empty accommodation spaces. By accommodating the new measurement section D2 in the empty accommodation spaces,  
10 the substrate processing apparatus can further improve the productivity of substrate W.

[0095] According to this embodiment, the substrate processing apparatus includes an upper measurement module ML and a lower measurement module ML arranged side by side in the vertical direction. This arrangement allows the substrate processing apparatus to improve the productivity of substrate W without unnecessarily increasing  
15 the footprint size of the substrate processing apparatus. In other words, the substrate processing apparatus can optimize the measurement process of substrate W.

[0096] Generally, in order to improve productivity of the substrate W, a buffer device (not shown) for storing cassette storage 100 may be installed adjacent to the cassette loader 53 of the substrate processing apparatus. In this embodiment, the measurement  
20 unit 200 is disposed to the side of the loading/unloading section 50. Therefore, the buffer device can be installed adjacent to the cassette loader 53 without being obstructed by the measurement unit 200.

[0097] FIG. 9 is a view showing the substrate processing apparatuses with the measurement units (i.e., upper and lower measurement modules) mounted side-by-side  
25 on the housing. FIG. 10 is a view showing the substrate processing apparatuses with the measurement modules located on both sides of the housing.

[0098] As shown in FIGS. 9 and 10, when the substrate processing apparatuses are arranged side by side, a minimum necessary gap must be secured to prevent contact between the measurement modules ML of adjacent substrate processing apparatuses.

[0099] As clearly shown by comparing FIGS. 9 and 10, arranging the measurement modules ML on both sides of the housing PL increases the overall footprint of the substrate processing apparatus. In addition, the intervals between the substrate processing apparatuses become wider than necessary, resulting in a reduction in the number of substrate processing apparatuses that can be installed in a clean room.

[0100] On the other hand, as shown in FIG. 9, by arranging the measurement modules ML vertically on one side of the housing PL, there is no need to make the overall footprint size of the substrate processing apparatus larger than necessary, and more substrate processing apparatuses can be installed in a clean room compared to FIG. 10.

[0101] FIG. 11 is a view showing another embodiment of the substrate processing apparatus. In the embodiment shown in FIG. 11, the measurement modules ML are arranged along the longitudinal direction of the substrate processing apparatus (the direction in which the first processing units 101 and the second processing units 102 are arranged). Even with this arrangement, it is possible to install many substrate processing apparatuses in a clean room without increasing the spacing between the substrate processing apparatuses more than necessary (see FIGS. 10 and 11).

[0102] On the other hand, in the embodiment shown in FIG. 11, at least one of the measurement modules ML is not located in an installation direction of the horizontal movement mechanism 56 of the transport robot 55, so it is necessary to add a new mechanism (not shown) to allow the transport robot 55 to access each measurement module ML.

[0103] Furthermore, by arranging the measurement modules ML horizontally along the longitudinal direction of the substrate processing apparatus, the overall footprint of the substrate processing apparatus becomes larger than the overall footprint of the substrate processing apparatus according to the embodiment shown in FIG. 9. However, the configuration of the substrate processing apparatus according to the embodiment shown in FIG. 11 can also be appropriately adopted as needed.

[0104] FIG. 12 is a view showing another embodiment of the substrate processing apparatus. In the embodiment shown in FIG. 12, the measurement modules ML are

arranged in the loading/unloading section 50 along the width direction of the substrate processing apparatus (i.e., the arrangement direction of the cassette loaders 53). Even with this arrangement, it is possible to install many substrate processing apparatuses in a clean room without increasing installation intervals between the substrate processing apparatuses more than necessary (see FIGS. 10 and 12).

[0105] On the other hand, in the embodiment shown in FIG. 12, the width of the loading/unloading section 50 is larger than the width of the processing units 101 and 102, resulting in wasted space.

[0106] Furthermore, by arranging the measurement modules ML horizontally along the width direction of the substrate processing apparatus, the overall footprint of the substrate processing apparatus becomes larger than the overall footprint of the substrate processing apparatus according to the embodiment shown in FIG. 9. However, the configuration of the substrate processing apparatus according to the embodiment shown in FIG. 12 can also be adopted as needed.

[0107] FIGS. 13 to 17 are views showing an example of a substrate processing flow in the substrate processing apparatus according to the embodiment described with reference to FIGS. 1 to 9, 11 and 12. In the embodiment shown in FIGS. 13 to 17, a program for executing the processing flow is stored in the storage device 15a. The arithmetic device 15b executes the processing flow based on the program stored in the storage device 15a.

[0108] In the embodiment shown in FIG. 13, the operation control unit 15 is configured to execute a processing flow in which the surface condition of the substrate W is measured by the measurement unit 200 before the substrate W is processed (polished) in the processing unit 101 (and/or processing unit 102).

[0109] As shown in steps S101 to S104 of FIG. 13, the transport robot 55 removes one substrate W to be processed from the cassette storage 100 and transports it to either the upper measurement module ML or the lower measurement module ML. The upper measurement module ML or the lower measurement module ML measures the surface condition of the substrate W.

[0110] Thereafter, the transport robot 55 conveys the substrate W after measurement to

the processing unit 101 (and/or processing unit 102) to process the substrate W (polishing, cleaning, drying) (see steps S105, S106). After that, the transport robot 55 returns the processed substrate W to the cassette storage 100 (see steps S107, S108).

[0111] In the embodiment shown in FIG. 14, the operation control unit 15 is configured to execute a processing flow in which the surface condition of the substrate W is measured by the measurement unit 200 before and after the substrate W is processed in the processing unit 101 (and/or processing unit 102).

[0112] As shown in steps S201 to S204 of FIG. 14, the transport robot 55 removes one substrate W to be processed from the cassette storage 100 and transports it to either the upper measurement module ML or the lower measurement module ML. The upper measurement module ML or the lower measurement module ML measures the surface condition of the substrate W.

[0113] Thereafter, the transport robot 55 transports the measured substrate W to the processing unit 101 (and/or processing unit 102) and processes (polishes, cleans, dries) the substrate W (see steps S205 and S206). Thereafter, the transport robot 55 transports the processed substrate W to the upper measuring module ML or the lower measuring module ML (see steps S207 to S209), which measures the surface condition of the substrate W. Thereafter, the transport robot 55 returns the measured substrate W to the cassette storage 100 (see steps S210 and S211).

[0114] In the embodiment shown in FIG. 15, the operation control unit 15 is configured to execute a processing flow in which the surface condition of the substrate W is measured by the measurement unit 200 after the substrate W is processed (polished) in the processing unit 101 (and/or processing unit 102).

[0115] As shown in steps S301 to S303 of FIG. 15, the transport robot 55 takes out one substrate W to be processed from the cassette storage 100, transports the substrate W to the processing unit 101 (and/or processing unit 102), and processes (polishes, cleans, dries) the substrate W.

[0116] Thereafter, the transport robot 55 transports the processed substrate W to the upper measurement module ML or the lower measurement module ML (see steps S304 to

S306). The upper measurement module ML or the lower measurement module ML measures the surface condition of the substrate W. Thereafter, the transport robot 55 returns the measured substrate W to the cassette storage 100 (see steps S307 and S308).

[0117] In the embodiment shown in FIG. 16, the operation control unit 15 is configured to execute a process flow in which the surface condition of the substrate W is measured by the measuring unit 200 before and after the substrate W is processed in the processing unit 101 (and/or processing unit 102). In particular, the operation control unit 15 is configured to measure the surface condition of the substrate W by the upper measurement module ML before the substrate W is processed in the processing unit 101 (and/or processing unit 102), and to measure the surface condition of the substrate W by the lower measurement module ML after the substrate W is processed in the processing unit 101 (and/or processing unit 102).

[0118] As shown in steps S401 to S403 of FIG. 16, the transport robot 55 takes out one substrate W to be processed from the cassette storage 100 and transports it to the upper measurement module ML. The upper measurement module ML measures the surface condition of the substrate W.

[0119] Thereafter, the transport robot 55 transports the measured substrate W to the processing unit 101 (and/or processing unit 102) and processes (polishes, cleans, dries) the substrate W (see steps S404 and S405). Thereafter, the transport robot 55 transports the processed substrate W to the lower measuring module ML (see steps S406 and S407), which measures the surface condition of the substrate W. Thereafter, the transport robot 55 returns the measured substrate W to the cassette storage 100 (see steps S408 and S409).

[0120] In the embodiment shown in FIG. 17, the operation control unit 15 is configured to execute a process flow in which the surface condition of the substrate W is measured by the measuring unit 200 before and after the substrate W is processed in the processing unit 101 (and/or processing unit 102). In particular, the operation control unit 15 is configured to measure the surface condition of the substrate W by the lower measuring module ML before the substrate W is processed in the processing unit 101 (and/or processing unit 102), and to measure the surface condition of the substrate W by the upper

measuring module ML after the substrate W is processed in the processing unit 101 (and/or processing unit 102).

[0121] As shown in steps S501 to S503 of FIG. 17, the transport robot 55 retrieves one substrate W to be processed from the cassette storage 100 and transports it to the lower measurement module ML. The lower measurement module ML measures the surface condition of the substrate W.

[0122] Thereafter, the transport robot 55 transports the measured substrate W to the processing unit 101 (and/or processing unit 102) and processes (polishes, cleans, dries) the substrate W (see steps S504 and S505). Thereafter, the transport robot 55 transports the processed substrate W to the upper measuring module ML (see steps S506 and S507), which measures the surface condition of the substrate W. Thereafter, the transport robot 55 returns the measured substrate W to the cassette storage 100 (see steps S508 and S509).

[0123] The above-described embodiments have been described for the purpose of enabling a person of ordinary skill in the art to practice the present invention. Various modifications of the above-described embodiments would be obvious to a person skilled in the art, and the technical concept of the present invention may be applied to other embodiments. Therefore, the present invention is not limited to the described embodiments, but is to be interpreted in the broadest scope in accordance with the technical concept defined by the claims.

What is claimed is:

1. A substrate processing apparatus comprising:

a polishing module configured to polish a substrate;

5 a cleaning module configured to clean the substrate;

a drying module configured to dry the cleaned substrate;

a plurality of load ports configured to mount a transport container for storing the substrate;

10 at least one transport robot disposed within a housing, and configured to transport the substrate before polishing to the polishing module and transport the substrate dried in the drying module to the transport container;

a load/unload unit arranging the load ports side by side adjacent to a front outer wall of the housing; and

15 an upper measurement module and a lower measurement module configured to measure a surface condition of the substrate, and disposed side by side vertically adjacent to a side outer wall of the housing connected to the front outer wall.

20 2. The substrate processing apparatus according to claim 1, wherein at least one of the upper measurement module and the lower measurement module comprises a measurement section configured to measure the surface condition of the substrate before polishing and/or the surface condition of the substrate after polishing.

25 3. The substrate processing apparatus according to claim 2, wherein when one of the upper measurement module and the lower measurement module comprises the measurement section, the other of the upper measurement module and the lower measurement module comprises at least a control unit configured to control an operation of the measurement section and acquire data measured by the measurement section.

4. The substrate processing apparatus according to claim 3, wherein when the upper measurement module comprises the measurement section and the control unit, the measurement section in the upper measurement module is located below the control unit, and

5 wherein when the lower measurement module comprises the measurement section and the control unit, the measurement section in the lower measurement module is located above the control unit.

5. The substrate processing apparatus according to claim 2, wherein when the upper measurement module and the lower measurement module each comprises the measurement section, the measurement section in the upper measurement module and the measurement section in the lower measurement module are arranged adjacent to each other.

6. The substrate processing apparatus according to claim 1, wherein the substrate processing apparatus comprises a horizontal movement mechanism and a vertical movement mechanism configured to move the transport robot among a substrate transport position for transporting the substrate in the transport container to the polishing module, a substrate receiving position for receiving the substrate dried in the drying module, and the upper measurement module and the lower measurement module.

7. The substrate processing apparatus according to claim 6, wherein the horizontal movement mechanism has a length corresponding to the distance between areas where the load ports are arranged, and

25 wherein the vertical movement mechanism has a length corresponding to the distance between the load ports and the substrate transport position and the substrate receiving position.

8. The substrate processing apparatus according to claim 1, wherein the substrate

processing apparatus comprises an accommodation frame configured store the lower measurement module, and

wherein the accommodation frame is adjacent to the housing with a gap formed between the housing and the accommodation frame.

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9. The substrate processing apparatus according to claim 8, wherein the upper measurement module is mounted on the accommodation frame.

10. The substrate processing apparatus according to claim 1, wherein each of the upper measurement module and the lower measurement module is adjacent to the housing via an elastic seal disposed between the module and the lower measurement module.

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