

WAFER CARRIER CLEANING SYSTEM

RELATED APPLICATION

The present application claims the benefit of U.S. Provisional Application No. 60/462,428 filed April 10, 2003, which is incorporated herein in its entirety by reference.

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FIELD OF THE INVENTION

The present invention relates to a system for automatically washing substrate carriers that are used for containing, transporting and storing a plurality of substrates, such as semiconductor wafers, glass substrates, metallic substrates and the like (hereinafter generically referred to as "substrates").

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BACKGROUND OF THE INVENTION

In manufacturing wafers, the wafers are often stored in wafer carriers as the wafers are transported for carrying out sequential processes. The type of wafer carrier utilized in fabrication facilities has evolved from an open cassette type to a sealable enclosure or pod, which separates the wafers from the outside atmosphere. One currently favored pod design is known as a front opening unified pod (FOUP).

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It is necessary to clean the pods at appropriate intervals to minimize contamination of the wafers and wafer processing apparatus. The cleaning operation typically requires a human operator to place and remove the pods in a specialized pod washing apparatus. There is therefore a desire to provide an automated pod washing system in order to lower manufacturing costs and minimize contamination from human operators. It is further desired to provide a system adaptable to a variety of pod shapes and styles, as well as various wafer washing apparatus.

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U.S. Patent No. 5,621,982, to Yamashita et al., discloses the use of a robot to manipulate bottom opening pods in a wafer washing apparatus. The robot, however, is not adaptable to various washing devices. Moreover, Yamashita is only able to grasp the pod and cannot manipulate any other carrier component, thereby being unable to individually place a door and a container in cleaning equipment, which necessitates manual intervention. There is therefore a continuing need to provide a wafer carrier

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washing system and apparatus to address the aforementioned automation and adaptability needs.

SUMMARY OF THE INVENTION

Disclosed is a system and method for automating the handling of wafer carriers for
5 a washing procedure. The system according to one embodiment comprises disposing a
robot between a loading and unloading section, and the washing apparatus. The robot
preferably includes a hand that may comprise a first engaging component for operably
grasping the carrier body and a second engaging component for operably engaging the
carrier door. In one embodiment, the robot removes the carrier door from the carrier
10 body and grasps the body while maintaining possession of the door. The carrier door and
carrier body are then placed in respective positions within the washing apparatus. This
procedure is reversed for retrieval of the clean wafer container components.

It is an object and advantage of particular embodiments of the present invention to
enable faster handling to carry out unmanned washing for wafer containers.

15 It is an object and advantage of particular embodiments of the present invention to
improve the efficiency of washing in automating the washing of the wafer containers.

It is an object and advantage of particular embodiments of the present invention to
reduce the cost of washing wafer containers.

20 It is an object and advantage of particular embodiments of the present invention to
minimize the time required for handling in the washing process.

It is an object and advantage of particular embodiments of the present invention to
provide a device that can separate the door from the container while simultaneously
transferring both to a washing apparatus.

25 It is an object and advantage of particular embodiments of the present invention to
simultaneously transport the doors and the containers to the loading and unloading section
where the doors are installed to the containers.

It is an object and advantage of particular embodiments of the present invention to
address the disadvantages present in the prior art.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1(a) is a top plan view of an automated wafer carrier washing system according to an embodiment of the present invention.

FIG. 1(b) is a side view of an automated wafer carrier washing system according to
5 an embodiment of the present invention.

FIG. 2(a) is a side view of a robot hand for an automated wafer carrier washing system according to an embodiment of the present invention.

FIG. 2(b) is a first side view of a robot hand for an automated wafer carrier washing system according to an embodiment of the present invention.

10 FIG. 2(c) is a second side view of a robot hand for an automated wafer carrier washing system according to an embodiment of the present invention.

FIG. 3(a) is a side view of the robot hand engaging a carrier door and a carrier body according to an embodiment of the present invention.

15 FIG. 3(b) is a top plan view of the carrier engaging member of a robot hand engaging a carrier body according to an embodiment of the present invention.

FIG. 4(a) is a front view of the carrier door engaging member of a robot hand according to an embodiment of the present invention.

FIG. 4(b) is a front view of the carrier door engaging member of a robot hand according to an embodiment of the present invention.

20 FIG. 4(c) is schematic for a carrier door engaging member actuator for a robot hand according to an embodiment of the present invention.

FIG. 4(d) is a schematic for a door engaging member actuator for a robot hand according to an embodiment of the present invention.

25 FIGS. 5(a), 5(b), 5(c) and 5(d) are plan view diagrams of the rotation of a wafer carrier upon a loading and unloading station for operable engagement by a robot arm according to an embodiment of the present invention.

FIG. 5(e) is a side view of a robot hand simultaneously grasping a carrier door and a carrier body according to an embodiment of the present invention.

FIG. 5(f) is a plan view of a robot hand presenting a carrier door and a carrier body to automated washing equipment according to an embodiment of the present invention.

5 FIGS. 6(a), 6(b), 6(c) and 6(d) are plan view diagrams of the rotation of a wafer carrier upon a loading and unloading station for operable engagement by a robot arm according to an embodiment of the present invention.

FIG. 6(e) is a side view of a robot hand simultaneously grasping a carrier door and a carrier body according to an embodiment of the present invention.

10 FIG. 6(f) is a plan view of a robot hand presenting a carrier door and a carrier body to automated washing equipment according to an embodiment of the present invention.

FIG. 7(a) is a front view of an automated wafer container washing device with wafer carrier doors and bodies placed therein.

15 FIG. 7(b) is a side view showing the respective placement of a carrier body and carrier door within an automated wafer container washing device.

While the present invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the invention to the particular embodiments described. On the contrary, the intention is to
20 cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 7(b), a FOUP and washing device are illustrated. The FOUP 1 may comprise a container or carrier body 2 for storing a plurality of wafers, and a carrier
25 door 3 detachably mounted to the opening of the front side of the container 2 via a latching system. The carrier body 2 has a holding portion 4 mounted above the carrier 2, and can be automatically transported by grasping the holding portion 4 with the door 3 sealed in place. The carrier door 3 has latch holes 5 and latch bars 3a which constitute the latch system. The carrier door 3 is latched and unlatched via the latch bars 3a by inserting

keys into the latch holes 5 and rotating the keys. U.S. Patent No. 5,915,562, which is hereby incorporated by reference as part of this specification, discloses one type of FOUP contemplated by the present invention. Those having skill in the art will recognize that other types of wafer carrier or pod designs may be used without departing from the spirit or scope of the present invention.

A carrier washing device 6 is used to wash the wafer carrier 1. The washing operation is set in a clean room where the door 3 is separated from the wafer container 2 prior to engagement with the washing device 6. One suitable washing device is disclosed in co-pending U.S. Patent Application Serial No. 10/282,924, which is hereby incorporated by reference as part of this specification. Those having skill in the art will recognize that other types of washing devices may be used without departing from the spirit or scope of the present invention.

As shown in FIGS. 7(a) and 7(b), after separating the carrier body 2 and door 3, the wafer carrier components are placed in the washing apparatus at predetermined positions. In this example, left and right sides of the inside of washer 6 include two container washing portions 8a and 8b, and door washing portions 9a and 9b. The carrier portions are then washed. After the washing process is complete, the body 2 and doors 3, respectively, are taken out of the washing device 6 after lifting the upper cover 7. The doors 3 are securably attached to their respective carrier bodies 2. Then the clean sealed wafer containers are transported to a use or storage location.

An automated wafer carrier washing system according to an embodiment of the present invention is disposed within a clean room C-R, as shown in FIGS. 1(a) and 1(b). A loading and unloading section 10 and a washer 6 are positioned to oppose each other, and the robot 20 is positioned between the loading and unloading section 10 and the washer 6. The loading and unloading section 10 has three holding tables 11A, 1B and 11C disposed on the lower side and a holding table 11D disposed on the upper side. The loading and unloading section 10 may serve to appropriately position and hold wafer carriers 1 at suitably located holding tables when the wafer carriers 1 are fed to the unloading and loading section 10 by an automatic feeding machine (not shown). In addition, the loading and unloading section 10 may serve to hold the wafer carriers 1 (each having the container 2 and the respective door 3 attached thereto) and to feed them to the outside of the clean room via a loading port (not shown).

The holding tables 11A, 11B and 11C are capable of positioning and holding the containers 2, and are rotatable through a suitable angle by a rotating system. In this embodiment, the holding table 11D is positioned at a level higher than the holding tables 11A, 11B and 11C in order to minimize the square footage of the footprint for the automated washing system. Reference numeral 13 designates an air conditioning device mounted at a ceiling 14 in the clean room.

The washer 6 in the illustrated embodiment is capable of washing two wafer carriers 1 (specifically, two carrier bodies 2 and two carrier doors 3) simultaneously. The inside of washing apparatus 6 is divided into washing parts 6a and 6b disposed at the left side and the right side, respectively. In the washing parts 6a and 6b respectively, container holding parts 8a and 8b position and hold the bodies 2, and door holding parts 9a and 9b position and hold the doors 3. In addition, the door holding parts 9a and 9b are configured to mount and remove the doors 3 via latch systems that are similar to latch systems for mounting and removing the doors 3 with respect to the carrier bodies 2. The washer 6 may be constructed to automatically wash a single or a plurality of wafer carriers 1.

The robot 20 is set in the middle of the clean room C-R, wherein a container component grasping portion or a robot hand 21 has a first hand engaging component 23 and a second hand engaging component 30. A suitable robotic body for use with the present invention is model YR-CR20-A00 from Yasukawa Electric Corporation. However, those having skill in the art will recognize that other robots suitable for use in a clean room may be used without departing from the spirit or scope of the present invention. In the illustrated embodiment, six robotic segments T, B, R, U, L and S are used to minimize the consumption of space.

The articulation of the six segments for the illustrated embodiment is as follows: S shaft rotates (at plus and minus 180 degrees), L shaft rotates (at +120 degrees and -90 degrees), U shaft rotates (at +90 degrees and -80 degrees), R shaft rotates (at +165 degrees and -165 degrees), B shaft swings (at +230 degrees and -50 degrees), and T shaft rotates (at +360 degrees and -360 degrees). The first engaging component 23 and second engaging component 30 of robot hand 21 are operably provided to shaft T on robot 20.

The first engaging component 23 comprises a clamp system where the holding portion 4, termed a robotic flange, mounted on the upper side of the carrier body 2 is

clamped and unclamped, as is shown in FIGS. 2(a), 2(b), 2(c), 3(a) and 3(b). More specifically, in this configuration, a pair of grasping members 24 are operably coupled to base 22, which is connected to shaft T by pivot pin 25. Grasping members 24 are controllably movable by actuation of a linear actuator 26.1, for example a pneumatic or hydraulic cylinder comprising a piston 26 in a cylinder housing 27. The grasping members 24 oppose each other and present grasping portions 24a. The piston 26 is positioned at or near the pivot pins and on the grasping members 24 so that cylinder housing 27 is pivotally fastened to a first grasping member 24 via pivot member 29a and rod 28 is pivotally fastened to a second grasping member 24 via a pivot member 29b. The first engaging component 23 is positioned opposite the second engaging component 30, as shown in FIG. 2(a).

In operation, both grasping members 24 are brought down toward the carrier body 2 in an open condition, as shown by the full line in FIG. 3(b). The container engaging portion 4 is engaged by the grasping portions 24a at both sides by moving horizontally via retraction of the rod 28 into piston housing 27. The carrier body 2 is releasably held by the first engaging component 23.

The second engaging component 30 is shown in FIGS. 2(a), 2(b), 2(c), 4(a), 4(b), 4(c) and 4(d). The second engaging component 30 engages and disengages the door with the carrier body 2 (and with door holding parts 9a and 9b of the washing device). The second engaging component 30 is provided with a door holding system for holding the door 3 via a holding board 31. The holding board 31 is connected to the shaft T of the robot 20 via base member 32.

The holding board 31, according to one embodiment, is in the form of a hollow, flat board and is somewhat smaller than the door 3. Four suction cups 33 are provided to the board 31 for enabling the holding of the door 3. Two key members 35 are provided to the board relative to the locus of the latch holes 5 of the container 1. The suction cups are provided with a central suction and discharge port 34 to which a gas suction and discharge hose is coupled for selectively retaining the door.

In this configuration, the door 3, separated from the carrier body 2, together with the next system of opening and closing the door, is attracted and held by two suction cups 33 on a diagonal line. The suction cups 33 are disposed on the board 31 in one

configuration so that two cups are always engaging the door even if the carrier 1 is positioned a different direction.

Key members 35 function to latch and unlatch the door from the carrier body 2. The key members 35 are actuated by the linkage shown in FIGS. 4(a), 4(b), 4(c) and 4(d).

5 The linkage, according to the illustrated embodiment, comprises a pivotally mounted actuator 36 and crank member 40. The cylinder housing 37 is pivotally fastened to the board 31 via pin member 39. Jig 38a is connected to the top end of the expandable and retractable rod 38, and one end of the crank member 40 is rotatably connected to jig 38a via connection pin 41.

10 The key member 35 extends through hole 31b formed in holding board 31 and supplementary base 31a. As the expandable and retractable rod 38, shown in FIG. 4(c), is switched from a retracted position to an extended position, shown in FIG. 4(d), cylinder 37 moves crank member 40 by rotating so that the key member 35 is switched from the unlatch position shown in FIG. 4(c) to the latch position shown in FIG. 4(d). When the
15 expandable and retractable rod 38 of cylinder 37 is selectively retracted, key member 35 is switched from the latch position to the unlatch position by the movement of the expandable and retractable rod 38 and crank member 40.

A method of operating the automated wafer carrier washing system according to an embodiment of the present invention will be described in reference to FIGS. 5(a) thru 5(f)
20 and FIGS. 6(a) thru 6(f). The wafer carriers 1 are placed on the holding table 11 at two locations by an automatic carrier transporting machine (not shown in the drawings). FIGS. 5(a) to 5(f) illustrate a first handling operation. The holding table 11 is rotated from the initial position shown in FIG. 5(a) to a position shown in FIG. 5(b) at 90 degrees in a clockwise direction. At the same time, the robot 20 is driven so that the second
25 engaging component 30 of the robot hand 21 is positioned adjacent to the door 3. When the robot hand 21 engages the door 3, each key member 35 is inserted into the corresponding key hole 5. After that, the door 3 is attracted and held by the holding board 31 via the above-mentioned suction cups 34 and the piston 36 is actuated to cause the switching of the key member 35 from the latch position to the unlatch position. After
30 the door 3 is moved away from the carrier body 2, the robot hand 21 is rotated in the direction of the arrow shown in FIG. 5(b) by 90 degrees to be horizontal with the door 3 on top of the hand.

Now the first and second engaging components 23 and 30 are positioned horizontally, and the holding table 11 is rotated by 180 degrees from the position shown in FIG. 5(b) to the position shown in FIG. 5(c). Next, the first engaging component 23 is moved towards the engaging portion 4 of the container 2 until both grasping members 24
5 are in position to grasp the engaging portion 4 via actuation of the cylinder 26, as shown in FIG. 5(d). In this condition, as shown in FIG. 3(a), the door 3 is held by the second engaging component 30 and the carrier body 2 is held by the first engaging component 23.

Next, the robot hand 21 is rotated by 90 degrees in the direction of the arrow in FIG. 5(d), causing the orientation of the components to be switched to the position shown
10 in FIG. 5(e). Then, the robot hand 21 is turned to move to the door 3 and carrier body 2 into alignment with respective container holding part 8a and door holding part 9a. The container is disposed by placing it on the container holding portion 8a. The door 3 is disposed in the door holding part 9a by switching the above mentioned key members 35 to the latch position. Upon latching, holding by the suction cups 33 of the door holding
15 system is released, and the key member 35 is pulled out from the key hole 5 by the movement of the robot hand 21.

The handling operation shown in FIGS. 6(a) to 6(f) is similar to that described for FIGS. 5(a) to 5(f). Here, the holding table 11 is rotated by 90 degrees from the initial position shown in FIG. 6(a) to a position shown in FIG. 6(b), which is opposite to the
20 direction in the above handling operation (rotation in the counterclockwise direction). At the same time, the robot 20 is driven, so that the second engaging component 30 of the robot hand 21 is positioned to oppose to the door 3. When the robot hand 21 is adjacent to the door 3, the key member 35 is inserted into each key hole 5 of the door 3 and switched from the latch position to the unlatch position, similar to the above mentioned
25 example. After grasping the door, the second engaging component 30 is rotated by 90 degrees in the direction of arrow shown in FIG. 6(b). Then, the first engaging component 23 is brought engagement position with the engaging portion 4 of the carrier body 2 for engagement as described previously. Next, the robot hand 21 is rotated by 90 degrees in the direction of the arrow shown in FIG. 6(d) (in the counterclockwise
30 direction), so that the situation is switched to the position shown in FIG. 6(e) where the front opening of the carrier body 2 is oriented downward and the side surface of the door 3 is oriented upward. The robot hand 21 is turned to move toward the washing apparatus 6 wherein the carrier body 2 is disposed on the holding part 8b, and the door 3 is disposed in

the door holding part 9b. In this way, after the carrier body 2 and door 3 are set at the washing parts 6a and 6b respectively, upper cover 7 of the washer 6 is closed and a washing operation is performed on the carrier components.

After the washing process, the door 3 is held by the second engaging component 30 and the carrier body 2 is held by the first engaging component 23 in the order that is reverse to the order for the previously described handling operation. After the door 3 and carrier body 2 are transported to the empty holding table 11 by rotation of the robot hand 21, the carrier body 2 is held on the holding table 11, and then the door 3 is latched in the carrier body 2. Then, each wafer container 1 is transported from the loading and unloading section 10 to a desired position by the automatic transporting machine.

Although the present invention has been described with reference to particular embodiments, one skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and the scope of the invention. Therefore, the illustrated embodiments should be considered in all respects as illustrative and not restrictive.

CLAIMS

1. An automated wafer carrier washing system for wafer carriers comprising a carrier body and a carrier door securably disposed in the carrier body, the automated washing system comprising:

a washing apparatus including one or more wash bays, each wash bay including a carrier body washing portion and a carrier door washing portion; and

a robot operably disposed adjacent to the washing apparatus, the robot comprising a multi-segmented body and hand joined to the body, the hand being configured to separate the carrier door from the carrier body.

2. The automated wafer carrier washing system of claim 1, further comprising:

a loading and unloading station operably disposed adjacent the robot.

3. The automated wafer carrier washing system of claim 2, wherein the loading and unloading station includes a holding table.

4. The automated wafer carrier washing system of claim 1, wherein the robot body comprises six segments.

5. The automated wafer carrier washing system of claim 1, wherein the hand comprises:

a first engaging component configured to grasp the container body; and

a second engaging component configured to grasp the carrier door.

6. The automated wafer carrier washing system of claim 5, wherein the first engaging component comprises:

a pair of opposed grasping members pivotally coupled to a base; and

an actuator fastened to each of the opposed grasping members.

7. The automated wafer carrier washing system of claim 5, wherein the second engaging component comprises a holding board comprising:

a plurality of suction cups disposed thereon; and

at least two key members disposed thereon and aligned relative to a respective at least two latches provided in the carrier door.

8. The automated wafer carrier washing system of claim 1, wherein the hand comprises:

means for grasping the container body and means for grasping the carrier door.

9. A robot for an automated wafer carrier washing system, the wafer carrier to be washed comprising a carrier body and a carrier door securably sealable within the carrier body, the robot comprising:

a multi-segmented body; and

a hand joined to the body, the hand including a first engaging component configured to grasp the container body; and a second engaging component configured to grasp the carrier door.

10. The automated wafer carrier washing system of claim 9, wherein the robot body comprises six segments.

11. The automated wafer carrier washing system of claim 5, wherein the first engaging component comprises:

a pair of opposed grasping members pivotally coupled to a base; and

a linear actuator pivotally fastened to each of the opposed grasping members.

12. The automated wafer carrier washing system of claim 5, wherein the second engaging component comprises a holding board comprising:

a plurality of suction cups disposed thereon; and

at least two key members disposed thereon and aligned relative to a respective at least two latch key holes provided in the carrier door.

13. A robot for an automated wafer carrier washing system, the wafer carrier to be washed comprising a carrier body and a carrier door securably sealable within the carrier body, the robot comprising:

a multi-segmented body; and

a hand joined to the body, the hand including means for grasping the container body and means for grasping the carrier door.

14. A robot hand for manipulating wafer carrier components in an automated cleaning system, the robot hand comprising a first engaging component and a second engaging component, the first engaging component comprising:

a pair of opposed grasping members pivotally coupled to a base; and

a linear actuator pivotally fastened to at least one of the opposed grasping members; and

the second engaging component comprising a holding board including:

a plurality of suction cups disposed thereon; and

at least two key members disposed thereon and aligned relative to a respective at least two latches key holes provided in the carrier door.

15. The robot hand of claim 14, wherein the second engaging portion further comprises

a linkage operably connected to a first end of each of the key members;

a crank member having a first end and a second end, the first end of the crank member operably connected to the linkage; and

an actuator operably connected to the crank member and pivotally connected to the holding board.

16. A method of automated washing of wafer carriers, the wafer carriers to be washed comprising a carrier body and a carrier door securably sealable within the carrier body, the method comprising the steps of:

removing the carrier door from the carrier body with a first engaging component of a robotic hand, the robotic hand operably connected to a robot body;

grasping the carrier body with a second engaging component of the robotic hand;

placing the carrier door into a portion of a carrier washing apparatus with the robotic hand, wherein the carrier washing apparatus is configured to wash both the carrier door and the carrier body;

placing the carrier body into a portion of the carrier washing apparatus with the robotic hand;

removing the washed carrier body from the washing apparatus using the second engaging component of the robotic hand;

removing the carrier door from the washing apparatus using the first engaging component of the robotic hand; and

securing the carrier door to the carrier body.

17. The method of claim 16, further comprising the step of placing the carrier body on a loading and unloading station.

18. The method of claim 16, further comprising the step of rotating the robot body.

19. A method of automated washing of wafer carriers, the wafer carriers to be washed comprising a carrier body and a carrier door securably sealable within the carrier body, the method comprising the steps of:

grasping the carrier door secured to the carrier body with a robotic hand, the robotic hand operably connected to a robot body;

unsecuring the carrier door from the carrier body using the robotic hand;

removing the carrier door with the robotic hand;

rotating the robotic hand into position to grasp the carrier body while maintaining grasp on the carrier door;

placing the carrier door into a portion of a carrier washing apparatus with the robotic hand, wherein the carrier washing apparatus is configured to wash both the carrier door and the carrier body; and

placing the carrier body into a portion of the carrier washing apparatus with the robotic hand.

20. The method of claim 19, further comprising the steps of:
- grasping the washed carrier body in the washing apparatus using the robotic hand;
 - placing the washed carrier body on a loading and unloading station;
 - grasping the washed carrier door in the washing apparatus using the robotic hand;
 - and
 - securing the carrier door to the carrier body.