In a wafer transfer apparatus for transferring a semiconductor wafer, a wafer gripper is composed of a pair of gripper arms, and a gripper guide is attached to each of the gripper arms. A driving unit operates the gripper arms such that the semiconductor wafer is releasably gripped with the gripper guides of the gripper arms. Each of the gripper guides is formed with a groove for receiving a peripheral edge of the semiconductor wafer, and the groove is configured as a generally V-shaped groove featuring a ridge element protruded from an outer side edge thereof.
Fig. 8A

Fig. 8B
Fig. 10
WAFER TRANSFER APPARATUS, WAFER GRIPPER, AND WAFER GRIPPER GUIDE USED IN SUCH WAFER TRANSFER APPARATUS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a wafer transfer apparatus which may be used to transfer a semiconductor wafer from one apparatus to another apparatus in a semiconductor device manufacturing field, and more particularly relates to a wafer transfer apparatus which may be incorporated in an ion implantation equipment to load and unload semiconductor wafers into and from the ion implantation equipment.

[0003] Also, the present invention relates to a wafer gripper and a wafer gripper guide which are used in such a wafer transfer apparatus to grip the semiconductor wafer.

[0004] 2. Description of the Related Art

[0005] In a manufacturing for producing semiconductor devices, an ion implantation equipment is used to implant ions into semiconductor wafers. The ion implantation equipment includes a processing chamber housing in which a vacuum state is created, an ion beam generator provided in the processing chamber housing, a rotary disk rotatably provided in the processing chamber housing, and a plurality of circular pedestals arranged at regular intervals along a periphery of the rotary disk. Each of the circular pedestals is formed as a metal (e.g. aluminum) plate coated with silicone rubber, and a semiconductor wafer to be processed is placed and clamped on each of the circular pedestals.

[0006] In an ion implantation operation, an ion beam is emitted from the ion beam generator, while the rotary disk is rotated at a high rotational speed, e.g. 1200 rpm, and is swung at a speed, e.g. 46 mm/sec, in a direction perpendicular to the rotational axis of the rotary disk, so that all the wafers can be uniformly and completely scanned with the ion beam.

[0007] In the ion implantation equipment, the processing chamber housing is provided with a wafer loading/unloading chamber housing which is integrally and outwardly extended therefrom, and the wafer loading/unloading chamber housing is associated with a wafer loading/unloading unit. A wafer transfer apparatus is incorporated in the wafer loading/unloading chamber housing such that semiconductor wafers are transferred one by one from the wafer loading/unloading unit to the processing chamber housing, and the transferred wafer is placed and clamped on one of the circular pedestals.

[0008] When the wafers are placed and clamped on all circular pedestals, i.e., when the loading of the wafers in the processing chamber housing is completed, the wafers are processed with the ion beam in the above-mentioned manner, the processed wafers are transferred one by one from the processing chamber housing to the wafer loading/unloading unit by the wafer transfer apparatus. Namely, the unloading of the wafers from the processing chamber housing to the wafer loading/unloading unit is carried out by the wafer transfer apparatus.

[0009] The wafer transfer apparatus includes a wafer gripper composed of first and second gripper arms which are pivotally joined to each other by a pivot joint. The first gripper arm terminates with a curved end portion having a gripper guide securely attached thereto, and the second gripper arm terminates with a semi-circularly curved end portion having two gripper guides. Each of the gripper guides is formed with a generally V-shaped groove for receiving a peripheral edge of the wafer, and the first and second gripper arms are operated so that the peripheral edge of the wafer is engaged in and disengaged from the generally V-shaped grooves of the gripper guides. Namely, by operating the gripper arms, it is possible to releasably grip the wafer with the gripper guides.

[0010] When the processed wafer is removed from the pedestal, first, the wafer is gripped with the gripper guides by operating the gripper arms, and the processed wafer is unclamped on the pedestal. Thereafter, the gripper arms are moved so that the gripper guides carrying the processed wafer are moved from the pedestal.

[0011] Incidentally, while the wafers are processed in the processing chamber housing, some of the wafers may be stuck on the silicone rubber surfaces of the pedestals. As causes of the sticking of the wafer on the pedestal, there are a centrifugal force to which the wafers are subjected, moisture contents included in the processing chamber housing, a formation of a silicon dioxide layer on a surface of the wafer, (in this case, the wafer is made of silicon), and so on.

[0012] When the wafer is strongly stuck on the silicone rubber surface of the pedestal, the gripper arms may fail in the removal of the processed wafer from the pedestal, because the peripheral edge of the processed wafer is disengaged from the generally V-shaped grooves of the gripper guides without removing the wafer from the pedestal.

[0013] Also, when the processed wafers are relatively weakly stuck on the silicone rubber surface of the pedestal, it is possible to remove the processed wafers from the pedestal, but one or two of the gripper guides may be disengaged from the processed wafers, so that the processed wafers may fall off from the gripper arms.

[0014] Although the silicone rubber surface of the pedestal is treated as a rough surface in order to prevent the sticking of the wafer on the pedestal, although the silicone rubber surface of the pedestal is treated as a rough surface, the rough surface easily deteriorates to become a smooth surface. The pedestals carrying no semiconductor wafers are periodically irradiated with an argon ion beam by using the ion beam generator, to thereby improve the deterioration of the silicone rubber surface, but it is very costly to periodically repeat this process.

SUMMARY OF THE INVENTION

[0015] Therefore, an object of the present invention is to provide a wafer transfer apparatus including a wafer gripper composed of a pair of gripper arms which are constituted such that a safe removal of a processed semiconductor wafer from a pedestal can be ensured when the processed semiconductor wafer is stuck on the pedestal.

[0016] Another object of the present invention is to provide a wafer gripper and a wafer gripper guide which are used in such a wafer transfer apparatus.
In accordance with a first aspect of the present invention, there is provided a wafer transfer apparatus for transferring a semiconductor wafer, which comprises a wafer gripper composed of first and second gripper arms which are pivotally joined to each other, a first gripper guide attached to the first gripper arms, a second gripper guide attached to the second gripper arms, and a driving unit that operates the first and second grippers such that the semiconductor wafer is releasably gripped with the first and second gripper guides of the first and second gripper arms. Each of the first and second gripper guides is formed with a groove for receiving a peripheral edge of the semiconductor wafer, and the groove is configured as a generally V-shaped groove featuring a ridge element protruded from an outer side edge thereof.

Preferably, an end portion of the first gripper arm is formed as a curved end portion to which the first gripper guide is attached, and an end portion of the second gripper arm is formed as a semi-circularly curved end portion to which the second gripper guide is attached. More preferably, the semi-circularly curved end portion terminates with an arch extension which is detachably connected thereto, and the second gripper guide is attached to the arch extension. The arch extension may have a third gripper guide attached thereto.

In accordance with a third aspect of the present invention, there is provided a wafer gripping guide comprising a body portion which is formed with a groove for receiving a peripheral edge of a semiconductor wafer, with the groove being configured as a generally V-shaped groove featuring a ridge element protruded from an outer side edge thereof, and an attachment portion extended from the body portion.

Preferably, the generally V-shaped groove is defined by a bottom wall face, and a pair of tapered side wall faces extending from the lateral sides of the bottom wall face, and the ridge element is protruded from an outer side edge defining one of the tapered side wall faces. More preferably, the bottom wall face is configured as an arch bottom wall face having substantially the same curvature as that of a peripheral edge of the semiconductor wafer. The arch bottom wall face may have a width which is substantially equivalent to a thickness of the semiconductor wafer. The ridge element may have a height of at most 0.5 mm.

BRIEF DESCRIPTION OF THE DRAWINGS

The above object and other objects will be more clearly understood from the description set forth below, with reference to the accompanying drawings, wherein:

FIG. 1 is an elevational view of an ion implantation equipment, in which an embodiment of the wafer transfer apparatus according to the present invention is included;

FIG. 2 is a partial cross-sectional view taken along the line II-II of FIG. 1;

FIGS. 3A, 3B and 3C are elevational views of the wafer loading/unloading unit of FIG. 1, for explaining the movement of the movable wafer cassette included therein;

FIG. 4 is an enlarged elevational view of the wafer gripper of FIG. 1;

FIG. 5A is a partially-enlarged front view of the two gripper arms of FIG. 4;

FIG. 5B is a partially-enlarged side view of one of the gripper arms of FIG. 5A;

FIG. 5C is a partially-enlarged side view of the other gripper arm of FIG. 5A;

FIG. 6A is a plan view of the wafer gripper guide of FIG. 5B; FIG. 6B is a side view of the wafer gripper guide of FIG. 6A;

FIG. 7A is a plan view of one of the wafer gripper guide of FIG. 5C;

FIG. 7B is a side view of the wafer gripper guide of FIG. 7A;

FIG. 8A is a plan view of another of the wafer gripper guides of FIG. 5C;

FIG. 8B is a side view of the wafer gripper guide of FIG. 8A;

FIG. 9 is a detailed elevational view of the driving unit of FIG. 1;

FIG. 10 is a cross-sectional view taken along the X-X line of FIG. 2;

FIG. 11A is a cross-sectional view taken along the XI-XI line of FIG. 10, in which the pair of wafer catchers are in a closed state;

FIG. 11B is a cross-sectional view taken along the XI-XI line of FIG. 10, in which the pair of wafer catchers are in an opened state;

FIGS. 12A and 12B are explanatory views for explaining the operation of a cam mechanism included in the casing of FIG. 10;

FIGS. 13A, 13B and 13C are explanatory views for explaining the movement of the pair of wafer catchers of FIG. 10;

FIGS. 14A, 14B, 14C and 14D are explanatory views for explaining the operation of the wafer transfer apparatus of FIG. 1;

FIG. 15 is an explanatory view for explaining the operation of the wafer transfer apparatus of FIG. 1;

FIGS. 16A and 16B are explanatory views for explaining the operation of the wafer transfer apparatus of FIG. 1;
FIGS. 17A and 17B are explanatory views for explaining the operation of the wafer transfer apparatus of FIG. 1.

[0045] FIGS. 18A to 18C are explanatory views for explaining the operation of the wafer transfer apparatus of FIG. 1.

[0046] FIGS. 19A and 19B are explanatory views for explaining the operation of the wafer transfer apparatus of FIG. 1.

[0047] FIGS. 20A to 20C are explanatory views for explaining the operation of the wafer transfer apparatus of FIG. 1.

[0048] FIGS. 21A to 21C are explanatory views for explaining the removal operation of a processed wafer from a pedestal when the processed wafer is stuck on the pedestal by the wafer transfer apparatus of FIG. 1; and

[0049] FIGS. 22A to 22C are explanatory views for explaining the removal operation of a processed wafer from a pedestal when the processed wafer is stuck on the pedestal by the prior art wafer transfer apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0050] First, referring to FIG. 1 illustrating an ion implantation equipment in which the embodiment of the wafer transfer apparatus according to the present invention is included, the ion implantation equipment, generally indicated by reference 10, includes a processing chamber housing 12. Although not shown in FIG. 1, the processing chamber housing 12 is movably supported by a movable support unit. In FIG. 1, the processing chamber housing 12 is illustrated at a slant position, but it may be positioned at a vertical position or a horizontal position by operating the movable support unit (not shown), if necessary.

[0051] Referring to FIG. 2, which is a cross-sectional view taken along the line II-II of FIG. 1, the housing 12 defines a vacuum chamber 14 as a processing chamber in which semiconductor wafers to be processed are contained. The processing chamber 14 is in communication with a vacuum exhaust unit (not shown) to create a vacuum state therein.

[0052] The processing chamber housing 12 includes a rotary disk 16 for carrying semiconductor wafers to be processed. Namely, the rotary disk 16 has a plurality of circular pedestals 18 arranged at regular intervals along a periphery thereof, and the wafers to be processed are placed and clamped on the respective circular pedestals 18. Although each of the circular pedestals 18 is securely attached to the rotary disk 16, they can be removed from the rotary disk 16, for example, when being exchanged with a fresh pedestal. Note, each of the circular pedestals 18 is formed as a metal (e.g. aluminum) plate coated with silicone rubber, and has a diameter which is somewhat smaller than that of the wafer to be processed. Note, the rotary disk 16 may have a diameter of 1,200 mm.

[0053] In order to clamp the wafers to be processed on the respective circular pedestals 18, each of the circular pedestals 18 is provided with a clamp unit including a centering stopper 20, a pair of wafer pusher pins 22, and a hydraulic cylinder (not shown) associated with the wafer pusher pins 22. After the wafer to be processed is placed on the circular pedestal 18, when the wafer pusher pins 22 are moved toward the centering stopper 20 by actuating the hydraulic cylinder, the wafer to be processed is centered with respect to the circular pedestal 18, and is clamped thereon by the wafer pusher pins 22 in conjunction with the centering stopper 20. When the wafer pusher pins 22 are moved apart from the centering stopper 20 by actuating the hydraulic cylinder, the wafer is released from the clamped state based on the conjunction of the wafer pusher pins 22 with the centering stopper 20.

[0054] Returning to FIG. 1, the processing chamber housing 12 is provided with a wafer loading/unloading chamber housing 24 which is integrally and outwardly extended therefrom, and the wafer loading/unloading chamber housing 24 is associated with a wafer loading/unloading unit 26.

[0055] The wafer loading/unloading unit 26 includes a base stand 28 securely installed on a floor F, a gutter-like frame 30 rotatably attached to a top of the base stand 28 at a pivot shaft 32, and a movable wafer cassette 34 movably received in the gutter-like frame 30. Note, although not shown in FIG. 1, the wafer loading/unloading unit 26 is provided with a suitable driving unit for properly controlling the rotational movement of the gutter-like frame 30 and the movement of the wafer cassette 34.

[0056] In FIG. 1, the movable wafer cassette 34, containing the wafers to be processed in the ion implantation equipment 10, is air-tightly engaged with a side wall of the wafer loading/unloading chamber housing 24.

[0057] Returning to FIG. 2, an opening 36 is formed at the side wall of the wafer loading/unloading chamber housing 24, and the movable wafer cassette 34 is engaged with the side wall so as to air-tightly close the opening 36. In FIG. 2, one of the wafers to be processed, contained in the wafer cassette 34, is visible, and is representatively indicated by reference W. Although not shown in FIG. 2, the opening 36 is closed by an air-tight valve until the wafer cassette 34 is air-tightly engaged with the aforesaid side wall.

[0058] Note, as stated in detail hereinafter, the wafers W are loaded one by one from the wafer cassette 34 in the ion implantation equipment 10 so that each of the wafers W is placed and clamped on a corresponding pedestal 18 by the wafer pusher pins 22 in conjunction with the centering stopper 20, and are unloaded from the ion implantation equipment 10 in the wafer cassette 34 after the wafers W are processed in the ion implantation equipment 10.

[0059] In FIG. 1, as stated above, although the processing chamber housing 12 may be positioned at any one of the various positions, i.e. the slant position, the vertical position, the vertical position and so on, it is possible to ensure the air-tight engagement of the wafer cassette 34 with the side wall of the wafer loading/unloading chamber housing 24 by suitably rotating the gutter-like frame 30.

[0060] With reference to FIGS. 3A, 3B and 3C, the movement of the wafer cassette 34 of FIG. 1 is explained below.

[0061] In FIGS. 3A, 3B and 3C, the wafer cassette 34 is provided with a movable carriage 38, which is also shown in FIG. 2. The movable carriage 38 is moved between a projected position as shown in FIG. 3A, at which the
movable carriage 38 is projected from a top opening of the wafer cassette 34, and a retracted position as shown in FIG. 3B, at which the movable carriage 38 is retracted in the wafer cassette 34. Of course, although not shown, the wafer cassette 34 includes a driving unit for controlling the movement of the carriage 38 between the projected position and the retracted position.

[0062] As shown in FIG. 3A, first, the movable carriage 38 is positioned at the projected position, and the wafers W are loaded in the movable carriage 38. Note, for example, the number of loaded wafers W is thirteen.

[0063] Then, as shown in FIG. 3B, the carriage 38 at the projected position is moved to the retracted position.

[0064] Next, as shown in FIG. 3C, the wafer cassette 38 is turned in a counterclockwise direction so that the top opening of the wafer cassette 24 is directed to the aforesaid air-tight valve of the opening 36.

[0065] Thereafter, the wafer cassette 34 is moved to the position shown in FIG. 1.

[0066] Returning to FIG. 1, the wafer loading/unloading chamber housing 24 has an additional housing 40 integrally extended from a side wall of the chamber housing 24.

[0067] Referring to FIG. 2, the additional housing 40 is opposed to the side wall at which the opening 36 is formed. The additional housing 40 provides a space for receiving the movable carriage 38 of the wafer cassette 34. In particular, while the wafers W are loaded one by one from the wafer cassette 34 into the ion implantation equipment 10, the movable carriage 38 is moved step by step from the aforesaid retracted position toward the aforesaid projected position. At this time, the projected portion of the movable carriage 38 is received in the space defined by the additional housing 40.

[0068] Again referring to FIG. 1, the wafer transfer apparatus according to the present invention is generally indicated by reference 41, and carries out a loading of the wafers W from the movable carriage 38 into the processing chamber housing 12 and an unloading of the wafers W from the processing chamber housing 12 into the movable carriage 38. The wafer transfer apparatus 41 includes a wafer gripper 42 which is provided in the wafer loading/unloading chamber housing 24, and a driving unit 44 which is provided on the wafer loading/unloading chamber housing 24 at an outside of the chamber housing 24 to operate the wafer gripper 42.

[0069] As shown in FIG. 4, which is an enlarged elevational view of the wafer gripper 42 of FIG. 1, the wafer gripper 42 is composed of gripper arms 42A and 42B which are pivotally joined to each other by a pivot joint 46 with bearings. Namely, the gripper arms 42A and 42B are pivotally joined to each other by a pivot joint 46 in a scissors-like manner. The gripper arms 42A and 42B are intersected with each other at a location, indicated by reference LC, situated above the pivot joint 46.

[0070] Note, the gripper arms 42A and 42B may be formed of a suitable metal material, such as aluminum, stainless steel or the like.

[0071] Note, in FIG. 2, only an upper end portion of the gripper arm 42B is visible; an upper end portion of the gripper arm 42A is not visible because it is hidden by the upper portion of the gripper arm 42B.

[0072] In FIG. 5A which shows the upper end portions of the gripper arms 42A and 42B of FIG. 4 at an enlarged scale, the gripper arm 42A is hidden by the gripper arm 42B, the gripper arm 42A being illustrated by a broken line. Thus, when the gripper arm 42B is omitted from FIG. 5A, the upper end portion of the gripper arm 42A is obtained as shown in FIG. 5B. On the other hand, when the gripper arm 42A is omitted from FIG. 5A, the upper end portion of the gripper arm 42B is obtained as shown in FIG. 5C.

[0073] As shown in FIG. 5B, the upper end portion of the gripper arm 42A is shaped as a curved end portion 48A, which has a wafer gripper guide 50A securely attached to a side of a free tip end thereof.

[0074] As shown in FIG. 5C, the upper end portion of the gripper arm 42B is shaped as a semi-circularly curved end portion 48B, which terminates with an arch extension 51 which is detachably connected thereto. The arch extension 51 has two wafer gripper guides 50B and 50C securely attached to respective sides of the tip ends thereof.

[0075] The arch extension 51 is fine or thin, and thus is susceptible to damage. This is the reason why the arch extension 51 is detachably connected to the semi-circularly curved end portion 48B. Namely, when the arch extension 51 is damaged, only the damaged arch extension 51 can be exchanged with a fresh arch extension without exchanging the entirety of the gripper arm 42B. Nevertheless, the arch extension 51 may be integrally formed as a part of the semi-circularly curved end portion 48B, if necessary.

[0076] In FIGS. 6A and 6B, which are a plan view and a side view, respectively, of the gripper guide 50A of FIG. 5B, the gripper guide 50A includes an elongated rectangular head 50A1, defined as a body portion, which is formed with a groove 50A2 for receiving a peripheral edge of the wafer W (not shown). The groove 50A2 is configured as a generally V-shaped groove which is defined by an arch bottom wall face 50A3 having substantially the same curvature as that of the peripheral edge of the wafer W, and a pair of tapered side wall faces 50A4 and 50A5 extending from the lateral sides of the arch bottom wall face 50A3. Preferably, the arch bottom wall face 50A3 has a width which is substantially equivalent to a thickness of the wafer W so that the peripheral edge of the wafer W is fittedly abutted against the arch bottom wall face 50A3 when the wafer W is received in the generally V-shaped groove 50A2.

[0077] According to the present invention, the gripper guide 50A features a ridge element 50A6 protruded from an outer side edge defining the tapered side wall face 50A5.

[0078] Also, the gripper guide 50A includes a plate element 50A7, defined as an attachment portion, which is integrally extended from the elongated rectangular head 50A1, and which has a pair of screw holes 50A8 for attaching the plate element 50A7 to the curved end portion 48A of the gripper arm 42A by screws, as shown in FIG. 5B. Note, the attachment of the plate element 50A7 to the curved end portion 48A of FIG. 5B is carried out such that the ridge element 50A6 is farthest apart from the curved end portion 48A of FIG. 5B.

[0079] In FIGS. 7A and 7B, which are a plan view and a side view, respectively, of the gripper guide 50B of FIG. 5C,
the gripper guide 50B includes a generally trapezoid head 50B, defined as a body portion, which is formed with a groove 50B, for receiving the peripheral edge of the wafer W (not shown). Similar to the generally V-shaped groove 50A, of the gripper guide 50A of FIGS. 6A and 6B, the groove 50B is configured as a generally V-shaped groove which is defined by an arch bottom wall face 50B, having substantially the same curvature as that of the peripheral edge of the wafer W, and a pair of tapered side wall faces 50B and 50B, extending from the lateral sides of the arch bottom wall face 50B. Preferably, the arch bottom wall face 50B has a width which is substantially equivalent to the thickness of the wafer W so that the peripheral edge of the wafer W is suitably abutted against the arch bottom wall face 50B when the wafer W is received in the generally V-shaped groove 50B.

[0080] According to the present invention, the gripper guide 50B features a ridge element 50B, protruded from an outer side edge defining the tapered side face 50B.

[0081] Also, the gripper guide 50B includes a block element 50B, defined as an attachment portion, which is integrally extended from the trapezoid head 50B, and which has a pair of screw bores 50B, for attaching the block element 50B to the arch extension 51 of the gripper arm 42B by screws, as shown in FIG. 5C. Note, the attachment of the block element 50B to the arch extension 51 is carried out such that the ridge element 50B is farthest apart from the arch extension 51.

[0082] In FIGS. 8A and 8B, which are a plan view and a side view, respectively, of the gripper guide 50C of FIG. 5C, the gripper guide 50C includes a generally triangle head 50C, defined as a body portion, which is formed with a groove 50C for receiving a peripheral edge of the wafer W (not shown). Similar to the generally V-shaped groove 50A, of the gripper guide 50A of FIGS. 6A and 6B, the groove 50C is configured as a generally V-shaped groove which is defined by an arch bottom wall face 50C, having substantially the same curvature as that of the peripheral edge of the wafer W, and a pair of tapered side wall faces 50C and 50C, extending from the lateral sides of the arch bottom wall face 50C. Preferably, the arch bottom wall face 50C has a width which is substantially equivalent to the thickness of the wafer W so that the peripheral edge of the wafer W is suitably abutted against the arch bottom wall face 50C when the wafer W is received in the generally V-shaped groove 50C.

[0083] According to the present invention, the gripper guide 50C features a ridge element 50C, protruded from an outer side edge defining the tapered side face 50C.

[0084] Also, the gripper guide 50C includes a plate element 50C, defined as an attachment portion, which is integrally extended from the trapezoid head 50C, and which has a pair of screw bores 50C, for attaching the plate element 50C, to the arch extension 51 of the gripper arm 42B by screws as shown in FIG. 5C. Note, the attachment of the block element 50C to the arch extension 51 is carried out such that the ridge element 50C is farthest apart from the arch extension 51.

[0085] Note, a function of the ridge elements 50A, 50B, 50A, and 50C, of the gripper guides 50A, 50B, and 50C is stated in detail hereinafter.

[0086] Preferably, each of the gripper guides 50A, 50B, and 50C is formed as a block piece composed of a suitable synthetic resin material. For example, each of the gripper guides 50A, 50B, and 50C may be formed as molded product. Otherwise, each of the gripper guides 50A, 50B, and 50C may be shaped from a resin blank by a numerical control (NC) lathe machine.

[0087] In FIG. 9, which is a diagram of the driving unit 44 of FIG. 1, the driving unit 44 includes a base plate member 52 securely attached to the side wall of the wafer loading/unloading chamber housing 24, and the base plate 52 has a guide rail 52A integrally formed therewith, and a bracket 52B securely attached thereto.

[0088] The driving unit 44 also includes a hydraulic cylinder 54 securely supported by the bracket 52B, and a support plate member 56 securely suspended from a plunger 65A of the hydraulic cylinder 54. The support plate member 56 has a shoe portion 56A slidably engaged with the guide rail 52A, and thus the support plate 56 can be moved along the guide rail 52A by actuating the hydraulic cylinder 54. The support plate member 56 also has a pair of guide rails (only one of which is visible and indicated by reference 56B in FIG. 9) securely attached to the bottom side edges thereof.

[0089] The driving unit 44 further includes a hydraulic cylinder 58 securely attached to a side wall of the support plate member 56, and a bearing drum 60 suspended from the guide rails 56B of the support plate member 56 through a pair of suspension arm members, only one of which is visible and indicated by reference 60A in FIG. 9. The bearing drum 60 has a bracket member 60B, one end of which is securely attached to the bearing drum 58, and the other end of the bracket member 60B is securely connected to a plunger 58A of the hydraulic cylinder 58. The suspension arm members 60A are slidably engaged with the guide rails 56B of the support plate member, and thus the bearing drum 58 can be moved along the guide rails 56B by actuating the hydraulic cylinder 58.

[0090] As shown in FIG. 9, the bearing drum 60 has an opened end face wall 60F, which is near to the side wall of the wafer loading/unloading chamber housing 24, and a closed end face wall, which is far from the side wall of the side wall of the chamber housing 24. The opened end face wall 60F of the bearing drum 60 has an opening formed therein, and the closed end face wall 60G of the bearing drum 60 is air-tightly closed. On the other hand, the side wall of the chamber housing 24 has an opening 62, which is formed therein so as to be opposed to the opened end face wall 60F of the bearing drum 60.

[0091] In order to maintain a vacuum state created in the wafer loading/unloading chamber housing 24, a flexible bellows 60C is provided between the opened end face wall of the bearing drum 60 and the side wall of the chamber housing 24. Namely, an end of the flexible bellows 60C is air-tightly attached to the opened end face wall 60F of the bearing drum 60, and the other end of the flexible bellows 60C is air-tightly attached to the side wall of the chamber housing 24 so as to surround the opening 62.

[0092] The bearing drum 60 has a shaft 60D rotatably supported therein, and the shaft 60D outwardly extends from the opened end face wall 60F of the bearing drum 60, and passes through the flexible bellows 60C and the opening 62. Then, the shaft 60S is securely connected to the lower end of the gripper arm 42A.
[0093] The driving unit 44 further includes a hydraulic cylinder 64 which is supported by a bracket member 60E securely attached to a side of the bearing drum 60 at the closed end face wall 60G thereof. The hydraulic cylinder 64 is used to slightly rotate the gripper arm 42B at the pivot joint 46 of FIG. 4 with respect to the gripper arm 42A.

[0094] To this end, the bearing drum 60 contains a linkage acting between an lower end of the gripper arm 42B and a plunger of the hydraulic cylinder 64. Although not shown in FIG. 9, one end of the linkage is operationally connected to the lower end of the gripper arm 42B, and the other end of the linkage, which air-tightly passes through the closed end face wall 60G of the bearing drum 60, is operationally connected to the plunger of the hydraulic cylinder 64, such that the gripper arm 42B is slightly rotated at the pivot joint 46 of FIG. 4 with respect to the gripper arm 42A.

[0095] The driving unit 44 further includes a reduction gear drum 66 supported by a bracket member 60F suspended from the bearing drum 60, and an electric motor 68 operatively connected to the reduction gear drum 66. The reduction gear drum 66 contains a reduction gear train, an input shaft of which is connected to the electric motor 68. An output shaft of the reduction gear train is covered with an air-tight housing 66A, which is in communication with an interior of the bearing drum 60. Although not shown in FIG. 9, the output shaft of the reduction gear drum 66 has a gear wheel mounted thereon, the shaft 60D of the bearing drum 60 has a gear wheel mounted thereon, and a toothed drive belt is entrained between the gear wheels. Namely, a rotational drive force of the electric motor 68 is transmitted to the shaft 60D of the bearing drum 60 through the reduction gear train and the toothed drive belt.

[0096] With the above-mentioned arrangement of the driving unit 44, when the hydraulic cylinder 54 is actuated, the pair of gripper arms 42A and 42B are moved together upward and downward along the length of the guide rail 52A. When the hydraulic cylinder 58 is actuated, the pair of gripper arms 42A and 42B are moved together upward and downward along the length of the guide rail 56B. When the electric motor 68 is driven, the pair of gripper arms 42A and 42B are rotated together around an axis of the shaft 60D of the bearing drum 60. When the hydraulic cylinder 64 is actuated, only the gripper arm 42B is slightly rotated at the pivot joint 46 with respect to the gripper arm 42A.

[0097] In the above-mentioned ion implantation equipment of FIG. 2, after the wafers W are placed and clamped on the respective pedestals 18 by the wafer pusher pins 22 in conjunction with the centering stopper 20, the wafers W are processed with an ion beam in the processing chamber housing 12. Thereafter, the processed wafers are unloaded from the processing chamber housing 12 into the wafer cassette 34, while the unloading of the processed wafers from the processing chamber housing 12 is carried out, the wafer cassette 38, which is loaded with not processed wafers W, is at the position shown in FIG. 1. Namely, the ion implantation equipment is constituted so that the unloading of the processed wafers from the processing chamber housing 12 is carried out, the wafer cassette 38, which is loaded with not processed wafers W, is at the position shown in FIG. 1.

[0098] As shown in FIG. 10, which is a cross-sectional View taken along the line X-X of FIG. 2, a wafer catcher 70 is incorporated in the processing chamber housing 12 so as to cooperate with the wafer transfer apparatus 41 according to the present invention, whereby the unloading of the processed wafers from the processing chamber housing 12 into the wafer to cassette 34 and the loading of the not processed wafers W from the wafer cassette 34 into the processing chamber housing 12 can be simultaneously carried out. Note, in FIG. 10, reference 12A indicates an opening formed in the processing chamber housing 12, the opening 12A is air-tightly closed by a lid member 12B detachably attached to the processing chamber housing 12A, and the lid member 12B has a hole 12C formed therein.

[0099] The wafer catcher unit 70 includes a hydraulic cylinder (not shown) securely attached to the processing chamber housing 12, and a movable casing 72 connected to a plunger of the hydraulic cylinder. By actuating the hydraulic cylinder, the movable casing 72 is moved in one of two directions indicated by a double-headed arrow AR.

[0100] In FIGS. 11A and 11B, which are cross-sectional views taken along the lines XI-XI of FIG. 10, the wafer catcher unit 70 is in a closed state and in an open state, respectively. The wafer catcher unit 70 also includes a pair of wafer receivers 74, which are symmetrical with each other, and each of which features a generally V-shaped configuration. In particular, each of the wafer receivers 74 has a base portion 74A, a pair of arms 74B integrally extended from the base portion 74A, and a pair of claw elements 74C each attached to a free end of one of the arms 74B. The not processed wafer W, shown by a phantom line, is placed on the base portions 74A and the arms 74B, and can be securely caught by engaging the claw elements 74C with the peripheral edges of the not processed wafer W.

[0101] Also, each of the wafer receivers 74 has a L-shaped rod element 74D integrally extended from the base portion 74A, and the L-shaped rod element 74D passes through the hole 12C of the lid member 12B of FIG. 10, and a lower end portion of the L-shaped rod element 74D is received in the movable casing 72 of FIG. 10.

[0102] In FIG. 12A and 12B, which show a cam mechanism contained in the movable casing 72, the cam mechanism includes a pair of cam followers 76A and 76B which are suitably guided by a guide structure (not shown), and a wedge-shaped cam 78 which is slideably engaged with the cam followers 76A and 76B.

[0103] The respective lower end portions of the L-shaped rod elements 74D of FIG. 10 are connected to extensions (not shown) of the cam followers 76A and 76B, which extensions are resiliently biased by a resilient element (not shown), such as a coil spring or the like, so that the cam followers 76A and 76B are moved toward each other.

[0104] The wedge-shaped cam 78 has a pair of cam faces 78A and 78B which cooperate with the respective cam followers 76A and 76B. Also, the wedge-shaped cam 78 is connected to a plunger of a hydraulic cylinder, indicated by reference 80.

[0105] Usually, as shown in FIG. 12A, the wedge-shaped cam 78 is at a retracted position, and thus the wafer catchers 74 approach each other. At this time, the wafer catchers 74 are in a closed state in which the not processed wafer W can be caught by the claw elements 74C of the wafer catchers 74, as shown in FIG. 11A.
[0106] As shown in FIG. 12B, when the wedge-shaped cam 78 is thrust from the retracted position into a space between the cam followers 76A and 76B, the cam followers 76A and 76B are separated from each other. At this time, the wafer catchers 74 are in an opened state in which the claw elements 74C of the wafer catchers 74 are disengaged from the not processed wafer W, as shown in FIG. 11B.

[0107] Again, referring to FIG. 10, the wafer catcher unit 70 includes a flexible bellows 82 for maintaining the vacuum state created in the wafer loading/unloading chamber housing 24. Namely, the flexible bellows 82 is provided between the lid member 12B and the casing 72 such that the L-shaped rod element 74D is air-tight surrounded by the flexible bellows 82.

[0108] The operation of the wafer catcher unit 70 of FIG. 10 is explained with reference to FIG. 13A, 13B and 13C. The wafer catchers 74 are moved between an initial position at which the wafer catchers 74 are farthest apart from the pedestal 18 (FIG. 13A), an intermediate position at which the wafer catchers 74 are partially advanced from the initial position toward the pedestal 18 (FIG. 13B), and a fully-advanced position at which the wafer catchers 74 are closest to the pedestal 18 (FIG. 13C).

[0109] Note, during the unloading of the processed wafer W from the processing chamber housing 12 into the wafer cassette 34 and the loading of the not processed wafer W from the wafer cassette 34 into the processing chamber housing 12, the rotary disk 16 is intermittently rotated by a driving unit (not shown) such that the pedestals 18 are aligned with the wafer catchers 74 one after another.

[0110] With reference to FIGS. 14A to 14D, FIG. 15, FIGS. 16A and 16B, FIGS. 17A and 17B, FIGS. 18A to 18C, FIGS. 19A and 19B, and FIGS. 20A to 20C, the operation of the wafer transfer apparatus 41 of FIG. 1 is explained below.

[0111] First, referring to FIG. 14A, the gripper arms 42A and 42B of the wafer gripper 42 are at the initial position. Driving the electric motor 68, both the upper end portions 48A and 48B of the gripper arms 42A and 42B are rotated from the initial position in a clockwise direction until the gripper guide 50A is engaged with a not processed wafer W loaded in the movable carriage 38, as shown in FIG. 14B. Namely, the peripheral edge of the not processed wafer W is received in the generally V-shaped groove 50A of the gripper guide 50A (see: FIGS. 6A and 6B).

[0112] Then, by actuating the hydraulic cylinder 64 (see: FIG. 9), only the upper end portion 48B of the gripper arm 42B is slightly rotated in a counterclockwise direction at the pivot joint 46 with respect to the gripper arm 42A until the gripper guides 50B and 50C are engaged with the not processed wafer W, as shown in FIG. 14C. Namely, the peripheral edge of the not processed wafer W is received in both the generally V-shaped groove 50B, and 50C, of the gripper guides 50B and 50C (see: FIGS. 7A and 7B and FIGS. 8A and 8B). Thus, the not processed wafer W is gripped by the gripper guides 50A, 50B and 50C of the gripper arms 42A and 42B.

[0113] Subsequently, by actuating the hydraulic cylinder 54 (see: FIG. 9), both the upper end portions 48A and 48B of the gripper arms 42A and 42B are moved upward so that the not processed wafer W is lifted up from the movable carriage 38 of the wafer cassette 34, as shown in FIG. 14D. Namely, the not processed wafer W is unloaded from the movable carriage 38.

[0114] Next, by driving the electric motor 68 (see: FIG. 9), both the upper end portions 48A and 48B of the gripper arms 42A and 42B are rotated in the counterclockwise direction so that the not processed wafer W is transferred from the wafer loading/unloading chamber housing 24 into the processing chamber housing 12, as shown in FIG. 15. Namely, the not processed wafer W concerned is moved to a pedestal-aligned position at which the not processed wafer W is aligned with a corresponding pedestal 18, with the pedestal-aligned position corresponding to the intermediate position (see: FIG. 13B) of the pair of wafer catchers 74.

[0115] Note, referring to FIG. 15, the pedestals 18 are not visible, because the pedestals 18 are hidden by processed wafers, indicated by reference W, which are placed and clamped on the pedestals 18 by the centering stopper 20 and the wafer pusher pins 22.

[0116] After the movement of the not processed W to the pedestal-aligned position is completed, the wafer catchers 74, which are in the opened state (see: FIG 11B), are moved from the initial position (see: FIG. 13A) to the intermediate position (see: FIG. 13B), so that the not processed wafer W is contacted with the wafer catchers 74, as shown in FIG. 16A. Then, the wedge-shaped cam 78 is moved from the thrust position (see: FIG. 12B) to the retracted position (see: FIG. 12A), so that wafer catchers 74 are in the closed state, as shown in FIG. 16B, so that the not processed wafer W is securely caught by the claw elements 74C of the wafer catchers 74.

[0117] After the not processed wafer W has been securely caught by the claw elements 74C of the wafer catchers 74, by actuating the hydraulic cylinder 64 (see: FIG. 9), only the upper end portion 48B of the gripper arm 42B is slightly rotated in a clockwise direction at the pivot joint 46 with respect to the gripper arm 42A until the gripper guides 50B and 50C are disengaged from the not processed wafer W, as shown in FIG. 17A. Then, by driving the electric motor 68 (see: FIG. 9), both the upper end portions 48A and 48B of the gripper arms 42A and 42B are rotated in a counterclockwise direction until the gripper guide 50A is disengaged from the not processed wafer W, as shown in FIG. 17B.

[0118] After the disengagement of the gripper guides 50A, 50B and 50C from the not processed wafer W is completed, the wafer receivers 74 are once returned from the intermediate position (see: FIG. 13B) to the initial position (see: FIG. 13A). On the other hand, by actuating the hydraulic cylinder 58 (see: FIG. 9), both the upper end portions 48A and 48B of the gripper arms 42A and 42B are advanced from the aforesaid pedestal-aligned position toward the corresponding pedestal 18 until the upper end portions 48A and 48B reach a wafer-gripping position at which the processed wafer W, clamped on the pedestal 18 by the centering stopper 20 and the wafer pusher pins 22, can be gripped by the gripper guides 50A, 50B and 50C.

[0119] Referring to FIG. 18A, both the upper end portions 48A and 48B of the gripper arms 42A and 42B are shown at the aforesaid wafer-gripping position. At this wafer-gripping position, both the upper end portions 48A and 48B of the gripper arms 42A and 42B are rotated in the clockwise
direction by driving the electric motor 68 until the gripper guide 50A is engaged with the processed wafer W, as shown in FIG. 18B. Namely, the peripheral edge of the processed wafer W is received in the generally V-shaped groove 50A of the gripper guide 50A (see: FIGS. 6A and 6B). Then, by actuating the hydraulic cylinder 64, only the upper end portion 48B of the gripper arm 42B is slightly rotated in the counterclockwise direction at the pivot joint 46 with respect to the gripper arm 42A until the gripper guides 50B and 50C are engaged with the processed wafer W, as shown in FIG. 18C. Namely, the peripheral edge of the processed wafer W is received in both the generally V-shaped groove 50B, and 50C, of the gripper guides 50B and 50C (see: FIGS. 7A and 7B and FIGS. 8A and 8B). Thus, the peripheral edge of the processed wafer W is gripped by the gripper guides 50A, 50B and 50C of the gripper arms 42A and 42B.

[0120] After the processed wafer W is gripped by the gripper guides 50A, 50B and 50C of the gripper arms 42A and 42B at the aforesaid wafer-gripping position, as shown in FIGS. 18A, 18B and 18C, the wafer pusher pins 22 are moved apart from the centering stopper 20, and thus the processed wafer W is unclamped from the corresponding pedestal 18.

[0121] Next, by actuating the hydraulic cylinder 58 (see: FIG. 9), both the upper end portions 48A and 48B of the gripper arms 42A and 42B are returned from the aforesaid wafer-gripping position as shown in FIGS. 18A, 18B and 18C to the pedestal-aligned position as shown in FIG. 15 corresponding to the intermediate position (see: FIG. 13B) of the wafer catchers 74.

[0122] Then, by driving the electric motor 68 (see: FIG. 9), both the upper end portions 48A and 48B of the gripper arms 42A and 42B are rotated in the clockwise direction to transfer the processed wafer W from the processing chamber housing 12 to the wafer loading/unloading chamber housing 24, and the processed wafer W is positioned above the movable carriage 38, as shown in FIG. 19A.

[0123] Subsequently, by actuating the hydraulic cylinder 54 (see: FIG. 9), both the upper end portions 48A and 48B of the gripper arms 42A and 42B are moved downward so that the processed wafer W is loaded in the movable carriage 38 of the wafer cassette 34 at the location from which the not processed wafer W, caught by the wafer catchers 74 at this stage, has been removed, as shown in FIG. 19B.

[0124] Thereafter, the upper end portions 48A and 48B of the gripper arms 42A and 42B are operated in substantially the manner as explained with reference to FIGS. 16A and 16B, and FIGS. 17A and 17B, so that the gripper guides 50A, 50B and 50C are disengaged from the processed wafer W loaded in the movable carriage 38. Then, the movable carriage 38 is moved by one step from the aforesaid retracted position toward the aforesaid projected position, so that the next wafer W to be processed is positioned at the position at which it should be gripped by the gripper guides 50A, 50B and 50C of the upper end portions 48A and 48B.

[0125] On the other hand, after both the upper end portions 48A and 48B of the gripper arms 42A and 42B are rotated in the clockwise direction to transfer the processed wafer W from the processing chamber housing 12 to the wafer loading/unloading chamber housing 24, the wafer catchers 74, by which the not processed wafer W is caught, are moved from the initial position (see: FIG. 13A) to the fully-advanced position (see: FIG. 13C), so that the not processed wafer W is contacted with the corresponding pedestal 18, as shown in FIG. 20A. Note, in this drawing, the pedestal 18 is not visible because it is hidden by the not processed wafer W.

[0126] Then, the wafer pusher pins 22 are moved toward the centering stopper 20 by actuating the hydraulic cylinder (not shown), and thus the not processed wafer W is clamped on the pedestal 18 by the wafer pusher pins 22 in conjunction with the centering stopper 20, as shown in FIG. 20B.

[0127] After the clamping of the not processed wafer W on the pedestal 18 by the centering stopper 20 and the wafer pusher pins 22 is completed, the wedge-shaped cam 78 is thrust from the retracted position (see: FIG. 12A) into the space between the cam followers 76A and 76B, as shown in FIG. 12B, so that the wafer catchers 74 are opened in the opened state, as shown in FIG. 20C. Namely, the claw elements 74C of the wafer catchers 74 are disengaged from the not processed wafer W, as shown in FIG. 20C. Thereafter, the wafer catchers 74 are returned to the initial position (see: FIG. 13C).

[0128] After the wafer catchers 74 are returned to the initial position (see: FIG. 13C), the rotary disk 16 is rotated by the driving unit (not shown) such that a next pedestal 18 carrying the processed wafer W is aligned with the wafer catchers 74.

[0129] The above-mentioned operation is repeated until all the not processed wafers W are loaded from the wafer cassette 34 into the processing chamber housing 12, and until all the processed wafer silicon wafer W are unloaded from the processing chamber housing 12 into the wafer cassette 34.

[0130] As already stated hereinbefore, each of the processed wafers W may be stuck on the silicone rubber surface of the pedestal 18. Nevertheless, according to the present invention, it is possible to ensure a removal of the processed wafers W from the pedestals 18 when the upper end portions 48A and 48B of the gripper arms 42A and 42B, carrying the processed wafer W gripped by the gripper guides 50A, 50B and 50C, are moved from the wafer-gripping position (see: FIGS. 18A, 18B and 18C) toward the pedestal-aligned position (see: FIG. 15).

[0131] In particular, as stated above, after the peripheral edge of the processed wafer W is gripped by the generally V-shaped grooves 50A, 50B, and 50C of the gripper guides 50A, 50B and 50C, as shown in FIG. 21A, the gripper guides 50A, 50B and 50C are moved from the wafer-gripping position (see: FIGS. 18A, 18B and 18C) toward the pedestal-aligned position (see: FIG. 15). When the wafer W is strongly stuck on the silicone rubber surface of the pedestal 18, the upper end portions 48A and 48B of the gripper arms 42A and 42B (see: FIG. 4) are deformed so that the gripper guides 50A, 50B and 50C are moved such that the peripheral edge of the wafer W slides along the tapered side wall faces 50A, 50B, and 50C, but the peripheral edge of the wafer W is abutted against the ridge elements 50A, 50B and 50C, as shown in FIG. 21B. Thus, the wafer W can be safely removed from the silicone rubber surface of the pedestal 18, as shown in FIG. 21C.
In FIGS. 22A, 22B and 22C, a prior art gripper guide 50 is representatively shown. This gripper guide 50 may be configured in substantially the same manner as each of the gripper guides 50A, 50B, and 50C (see: FIGS. 6A and 6B, FIGS. 7A and 7B, FIGS. 8A and 8B), except that the gripper guide 50 features no ridge element (50Aa, 50Ba, and 50Ca). Similar to the above-mentioned case, after the peripheral edge of the processed wafer W is gripped by the generally V-shaped grooves of the gripper guides 50, as representatively shown in FIG. 22A, the gripper guides 50 are moved from the wafer-gripping position toward the pedestal-aligned position. When the wafers W are strongly stuck on the silicone rubber surface of the pedestal 18, the upper end portions 48A and 48B of the gripper arms 42A and 42B (see: FIG. 4) are deformed so that the gripper guides 50 are moved such that the peripheral edge of the processed wafers W slides along tapered side wall faces of the V-shaped grooves, as representatively shown in FIG. 22B. Eventually, the gripper guides 50 are disengaged from the wafer W, as representatively shown in FIG. 22C.

Also, when the gripper guides 50 are disengaged from the processed wafer W, it may be subjected to a reaction force so that the wafer W is removed from the pedestal 18. Further, when the wafer W is relatively weakly stuck on the silicone rubber surface of the pedestal 18, it is possible to remove the processed wafer W from the pedestal 18 by using the gripper guides 50, but one or two of the gripper guides 50 may be disengaged from the processed wafer W, so that the processed wafer W may fall off from the upper end portions 48A and 48B of the gripper arms 42A and 42B (see: FIG. 4).

JP-2000-365982A discloses a stopper member having a generally U-shaped groove for receiving a peripheral edge of a wafer to thereby hold the wafer on a pedestal. In this stopper member, the generally U-shaped groove has a width which is slightly larger than a thickness of the wafer, and thus a secure hold of the wafer on the pedestal can be ensured. Nevertheless, this stopper member should not be substituted for the gripper guides 50A, 50B, and 50C of FIG. 21A, 21B and 21C, because it is difficult to successively receive the peripheral edge of the wafer in the generally U-shaped groove having the width slightly larger than a thickness of the wafer. Also, when the peripheral edge of the wafer is received in the generally U-shaped groove of the hold member, the edges of the U-shaped groove may be chipped to thereby produce particles. Of course, the production of the particles should be avoided in the semiconductor device manufacturing field.

In the above-described embodiment, each of the gripper guides 50A, 50B and 50C (see: FIGS. 6A and 6B, FIGS. 7A and 7B, FIGS. 8A and 8B) has a gripping force of more than 3,000 g. When the wafers (W, W') have an 8-inch diameter, preferably, the respective generally U-shaped groove 50Aa, 50Ba, and 50Ca, of the gripper guides 50A, 50B and 50C should have lengths of at least 14 mm, 12 mm and 5.1 mm before the 8-inch wafer can be securely gripped by the gripper guides 50A, 50B and 50C.

Also, the ridge element 50Aa, 50Ba, and 50Ca should have a height of at least 0.2 mm before the removal of the processed wafer W from the pedestal 18 can be ensured when the wafer W is strongly stuck on the silicone rubber surface of the pedestal 18. The higher the height of the ridge element 50Aa, 50Ba, and 50Ca, the larger a damage to which the wafer W' is subjected upon the removal of the wafer W from the pedestal 18. Accordingly, the height of the ridge element 50Aa, 50Ba, and 50Ca should be at most 0.5 mm. Preferably, the height of the ridge element 50Aa, 50Ba, and 50Ca should fall within a range from 0.3 mm to 0.4 mm. Further, before the removal of the processed wafer W from the pedestal 18 can be ensured when the wafers W is strongly stuck on the silicone rubber surface of the pedestal 18, the ridge element 50Aa, 50Ba, and 50Ca should have a sufficient strength. Thus, a thickness of the ridge element 50Aa, 50Ba, and 50Ca should be at least 0.5 mm.

Finally, it will be understood by those skilled in the art that the foregoing description is of a preferred embodiment of the apparatus, and that various changes and modifications may be made to the present invention without departing from the spirit and scope thereof.

1. A wafer transfer apparatus for transferring a semiconductor wafer, which comprises:
   a wafer gripper composed of first and second gripper arms which are pivotally joined to each other;
   a first gripper guide attached to said first gripper arms;
   a second gripper guide attached to said second gripper arms; and
   a driving unit that operates said first and second grippers such that the semiconductor wafer is releasably gripped with said first and second gripper guides of said first and second gripper arms, wherein each of said first and second gripper guides is formed with a groove for receiving a peripheral edge of the semiconductor wafer, and said groove is configured as a generally V-shaped groove featuring a ridge element protruded from an outer side edge thereof.

2. The wafer transfer apparatus as set forth in claim 1, wherein an end portion of said first gripper arm is formed as a curved end portion to which said first gripper guide is attached, and an end portion of said second gripper arm is formed as a semi-circularly curved end portion to which said second gripper guide is attached.

3. The wafer transfer apparatus as set forth in claim 2, wherein said semi-circularly curved end portion terminates with an arch extension which is detachably connected thereto, and said second gripper guide is attached to said arch extension.

4. The wafer transfer apparatus as set forth in claim 3, wherein said arch extension has a third gripper guide attached thereto.

5. The wafer transfer apparatus as set forth in claim 1, wherein said generally V-shaped groove is defined by a bottom wall face, and a pair of tapered side wall faces extending from the lateral sides of the bottom wall face, and said ridge element is protruded from an outer side edge defining one of the tapered side wall faces.

6. The wafer transfer apparatus as set forth in claim 5, wherein said bottom wall face is configured as an arch bottom wall face having substantially a same curvature as that of a peripheral edge of the semiconductor wafer.
7. The wafer transfer apparatus as set forth in claim 6, wherein said arch bottom wall face has a width which is substantially equivalent to a thickness of the semiconductor wafer.

8. A wafer gripper for gripping a semiconductor wafer, which comprises:
   - first and second gripper arms which are pivotally joined to each other;
   - a first gripper guide attached to said first gripper arms; and
   - a second gripper guide attached to said second gripper arm,

   wherein each of said first and second gripper guides is formed with a groove for receiving a peripheral edge of the semiconductor wafer, and said groove is configured as a generally V-shaped groove featuring a ridge element protruded from an outer side edge thereof.

9. The wafer gripper as set forth in claim 8, wherein an end portion of said first gripper arm is formed as a curved end portion to which said first gripper guide is attached, and an end portion of said second gripper arm is formed as a semi-circularly curved end portion to which said second gripper guide is attached.

10. The wafer gripper as set forth in claim 9, wherein said semi-circularly curved end portion terminates with an arch extension which is detachably connected thereto, and said second gripper guide is attached to said arch extension.

11. The wafer gripper as set forth in claim 10, wherein said arch extension has a third gripper guide attached thereto.

12. The wafer gripper as set forth in claim 8, wherein said generally V-shaped groove is defined by a bottom wall face, and a pair of tapered side wall faces extending from the lateral sides of the bottom wall face, and said ridge element is protruded from an outer side edge defining one of the tapered side wall faces.

13. The wafer gripper as set forth in claim 12, wherein said bottom wall face is configured as an arch bottom wall face having substantially a same curvature as that of a peripheral edge of the semiconductor wafer.

14. The wafer gripper as set forth in claim 13, wherein said arch bottom wall face has a width which is substantially equivalent to a thickness of the semiconductor wafer.

15. A wafer gripper guide comprising:
   - a body portion which is formed with a groove for receiving a peripheral edge of a semiconductor wafer, said groove being configured as a generally V-shaped groove featuring a ridge element protruded from an outer side edge thereof; and
   - an attachment portion extended from said body portion.

16. The wafer gripper guide as set forth in claim 15, wherein said generally V-shaped groove is defined by a bottom wall face, and a pair of tapered side wall faces extending from the lateral sides of the bottom wall face, and said ridge element is protruded from an outer side edge defining one of the tapered side wall faces.

17. The wafer gripper guide as set forth in claim 16, wherein said bottom wall face is configured as an arch bottom wall face having substantially a same curvature as that of a peripheral edge of the semiconductor wafer.

18. The wafer gripper guide as set forth in claim 17, wherein said arch bottom wall face has a width which is substantially equivalent to a thickness of the semiconductor wafer.

19. The wafer gripper guide as set forth in claim 15, wherein said ridge element has a height of at most 0.5 mm.