

SUBSTRATE PROCESSING APPARATUS AND SUBSTRATE PROCESSING METHOD USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

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[0001] A claim for priority under 35 U.S.C. § 119 is made to Korean Patent Application No. 10-2018-0020607 filed on February 21, 2018, in the Korean Intellectual Property Office, the entire contents of which are hereby incorporated by reference.

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BACKGROUND

[0002] Embodiments of the inventive concept described herein relate to a substrate processing apparatus and a substrate processing method using the same.

15 **[0003]** In general, various processes, such as etching, ashing, deposition, cleaning, and the like, which process a substrate using plasma are required to manufacture semiconductor devices, display panels, and the like.

[0004] A substrate may be bent or twisted in general processes. The phenomenon in which the substrate is bent or twisted is referred to as substrate warpage. The substrate warpage may happen in the case where the substrate is non-
20 uniformly shrunk after expanded in response to high-temperature heating in a process or the substrate is thin.

[0005] If the warped substrate is processed in the bent or twisted state, there may be a gap between the substrate and a susceptor, and local plasma may be

generated in the gap, as illustrated in FIGS. 1 and 2, to have a bad effect on etch rate, etch uniformity, or the like.

SUMMARY

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[0006] Embodiments of the inventive concept provide a substrate processing apparatus and method for preventing a substrate from being processed in a warped state.

[0007] According to an aspect of an embodiment, a substrate processing
10 apparatus comprises an equipment front end module, a process chamber that processes a substrate, a transfer chamber having a transfer robot that transfers the substrate into or out of the process chamber, and a buffer unit located between the transfer chamber and the equipment front end module and having an edge clamp support member that supports an edge clamp that is located at an edge of the
15 substrate and moved into the process chamber together with the substrate.

[0008] The edge clamp supported by the edge clamp support member may be located at a higher position than a position where the substrate is received in the buffer unit.

[0009] The edge clamp received in the buffer unit may be selectively moved
20 upward or downward from a reference position set in advance.

[0010] According to another aspect of an embodiment, an apparatus for processing a substrate comprises an equipment front end module and a processing module that processes the substrate. The equipment front end module comprises a load port on which a container having the substrate inside is placed and a transfer
25 frame having an index robot that transfers the substrate between the load port and the

processing module. The processing module comprises a clamping buffer disposed adjacent to the equipment front end module, a process chamber that processes the substrate, and a transfer chamber having a transfer robot that transfers the substrate between the process chamber and the clamping buffer. The clamping buffer
5 comprises a substrate support member that supports the substrate and an edge clamp support member having a support end that supports an edge clamp that is located at an edge of a top side of the substrate and transferred to the process chamber together with the substrate.

[0011] The support end may be located at a second position higher than a
10 first position at which the substrate is supported on the substrate support member.

[0012] The support end may move between the second position and a third position higher than the second position.

[0013] The clamping buffer may further include a detection sensor that detects a presence or absence of the substrate on the substrate support member.

15 **[0014]** The clamping buffer may further include an actuator that moves the support end of the clamping buffer between the second position, which is higher than the first position at which the substrate is supported on the substrate support member, and the third position higher than the second position.

[0015] The apparatus may further include a controller, and the controller may
20 control the actuator to locate the support end at the third position, based on information about an absence of the substrate on the substrate support member, which is detected by the detection sensor and may control the actuator to locate the support end at the second position, based on information about a presence of the substrate on the substrate support member, which is detected by the detection sensor.

- [0016]** The process chamber may include a susceptor on which the substrate is placed and a guide ring that surrounds the susceptor and has a protrusion that further protrudes upward beyond a top side of the susceptor and has an inclined side surface facing the substrate. The edge clamp may have an inclined portion that
5 corresponds to a slope of the protrusion.
- [0017]** The process chamber may further include a detection sensor that detects the edge clamp that further protrudes beyond a boundary of the guide ring by a preset value or more.
- [0018]** The apparatus may further include a controller.
- 10 **[0019]** The controller may stop operating the apparatus, or may activate an alarm, when the detection sensor detects that the edge clamp further protrudes beyond the boundary of the guide ring by the preset value or more.
- [0020]** A plurality of clamping buffers may be provided to form a clamping buffer unit.
- 15 **[0021]** The processing module may further include a pass buffer disposed in parallel to the clamping butter between the equipment front end module and the transfer chamber.
- [0022]** A plurality of pass buffers may be provided to form a pass buffer unit.
- [0023]** The clamping buffer and the pass buffer may be vertically stacked to
20 form a buffer unit.
- [0024]** According to another aspect of an embodiment, an apparatus for processing a substrate comprises an equipment front end module and a processing module that processes the substrate. The equipment front end module comprises a load port on which a container having the substrate inside is placed and a transfer
25 frame having an index robot that transfers the substrate between the load port and the

processing module. The processing module may include a clamping buffer unit disposed adjacent to the equipment front end module, a process chamber that processes the substrate, and a transfer chamber having a transfer robot that has two hands simultaneously extending and retracting and transfers the substrate between
5 the process chamber and the clamping buffer unit. The clamping buffer unit may include two clamping buffers arranged side by side. Each of the clamping buffers may include a substrate support member that supports the substrate and an edge clamp support member including a support end that supports an edge clamp that is located at an edge of a top side of the substrate and transferred to the process
10 chamber together with the substrate.

[0025] The clamping buffer may further include an actuator that moves the support end of the clamping buffer between a second position higher than a first position at which the substrate is supported on the substrate support member and a third position higher than the second position.

15 **[0026]** The clamping buffer may further include a detection sensor that detects a presence or absence of the substrate on the substrate support member, and the apparatus may further include a controller. The controller may control the actuator to locate the edge clamp at the third position, based on information about an absence of the substrate on the substrate support member, which is detected by the
20 detection sensor and may control the actuator to locate the edge clamp at the second position, based on information about a presence of the substrate on the substrate support member, which is detected by the detection sensor.

[0027] The processing module may further include a pass buffer unit vertically stacked on the clamping buffer unit between the equipment front end
25 module and the transfer chamber and including a plurality of pass buffers.

[0028] According to another aspect of an embodiment, a method for processing a substrate by using the substrate processing apparatus comprises locating the edge clamp on the support end of the clamping buffer, transferring, into the clamping buffer, the substrate to be processed, and transferring the edge clamp and
5 the substrate from the clamping buffer to the process chamber.

[0029] The clamping buffer may further include a detection sensor that detects a presence or absence of the substrate on the substrate support member, and the method may further include detecting a presence or absence of the substrate on the substrate support member of the clamping buffer, controlling the actuator to
10 locate the edge clamp at a specific position, based on information detected by the detection sensor, simultaneously making an entrance into the clamping buffer by two hands of the transfer robot, and picking up the substrate in the clamping buffer and transferring the substrate into the process chamber by the transfer robot.

[0030] According to another aspect of an embodiment, a method for
15 processing a substrate by using the substrate processing apparatus comprises locating the edge clamp on the support end of the clamping buffer, controlling the index robot by the controller to selectively transfer the substrate into the pass buffer or the clamping buffer, based on information about the substrate that is transferred to the load port and is to be processed, detecting a presence or absence of the substrate on
20 the substrate support member of the clamping buffer, controlling the actuator by the controller, based on information detected by the detection sensor, simultaneously making an entrance into the selected pass buffer or the selected clamping buffer by the two hands of the transfer robot, and picking up the substrate in the selected pass buffer or the selected clamping buffer and transferring the substrate into the process
25 chamber by the transfer robot.

[0031] According to embodiments of the inventive concept, it is possible to reduce a loss caused by a warped substrate and to efficiently process a substrate. In addition, it is possible to prevent damage to a substrate processing apparatus.

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BRIEF DESCRIPTION OF THE FIGURES

[0032] The above and other objects and features will become apparent from the following description with reference to the following figures, wherein like reference numerals refer to like parts throughout the various figures unless otherwise specified, and wherein:

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[0033] FIGS. 1 and 2 are views for explaining problems in the related art;

[0034] FIG. 3 is a plan view of a substrate processing apparatus according to an embodiment of the inventive concept;

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[0035] FIG. 4 is a plan view of a transfer robot according to an embodiment of the inventive concept;

[0036] FIG. 5 is a schematic plan view of a buffer unit according to an embodiment of the inventive concept;

[0037] FIG. 6 is a schematic side view illustrating the interior of a housing of the buffer unit according to an embodiment of the inventive concept;

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[0038] FIG. 7 is a side view illustrating an operating state of a clamping buffer according to an embodiment of the inventive concept;

[0039] FIG.8 illustrates a state in which a substrate is transferred into the clamping buffer from an equipment front end module;

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[0040] FIG. 9 illustrates a state in which pushers correct the position of a substrate and the transfer robot enters the clamping buffer;

- [0041]** FIG. 10 illustrates a state in which a substrate is picked up by the transfer robot and an edge clamp is located on the substrate;
- [0042]** FIG. 11 illustrates a state in which a substrate is transferred out of the buffer unit of FIG. 6;
- 5 **[0043]** FIG. 12 is a schematic side view of a process chamber in which a substrate is located on a susceptor;
- [0044]** FIG. 13 is a blowup of detail A in FIG. 12;
- [0045]** FIG. 14 is a blowup of detail A in FIG. 12 according to another embodiment;
- 10 **[0046]** FIG. 15 illustrates a state in which a substrate and an edge clamp are mounted on the susceptor;
- [0047]** FIG. 16 is a schematic side view of a buffer unit having a clamping buffer unit and a pass buffer unit vertically stacked, where the clamping buffer unit comprises clamping buffers horizontally arranged and the pass buffer unit comprises
- 15 pass buffers horizontally arranged;
- [0048]** FIG. 17 is a view for explaining a problem with a double-hand type transfer robot;
- [0049]** FIG. 18 is a flowchart illustrating a substrate processing method according to an embodiment of the inventive concept;
- 20 **[0050]** FIG. 19 illustrates a state in which a substrate is transferred into one of the horizontally-arranged clamping buffers according to an embodiment of the inventive concept;
- [0051]** FIG. 20 illustrates a state in which a support end of the clamping buffer where no substrate is detected is moved upward and a support end of the
- 25 clamping buffer where the substrate is detected is maintained at the same position;

[0052] FIG. 21 illustrates a state in which the transfer robot enters the clamping buffer unit of FIG. 19;

[0053] FIG. 22 illustrates a state in which an edge clamp is located on the substrate picked up by the transfer robot in the clamping buffer unit of FIG. 20;

5 **[0054]** FIG. 23 illustrates an edge clamp support member according to another embodiment of the inventive concept; and

[0055] FIG. 24 illustrates a substrate support member according to another embodiment of the inventive concept.

10 **DETAILED DESCRIPTION**

[0056] Hereinafter, embodiments of the inventive concept will be described in more detail with reference the accompanying drawings. The inventive concept may, however, be embodied in different forms and should not be constructed as limited to the embodiments set forth herein. Rather, these embodiments are provided
15 so that this disclosure will be thorough and complete, and will fully convey the scope of the inventive concept to those skilled in the art. In the drawings, the dimensions of elements are exaggerated for clarity of illustration.

[0057] FIG. 3 is a schematic plan view of a substrate processing apparatus 1 according to an embodiment of the inventive concept.

20 **[0058]** Referring to FIG. 3, the substrate processing apparatus 1 may have an equipment front end module (EFEM) 20 and a processing module 30. The equipment front end module 20 and the processing module 30 may be arranged in a direction. Hereinafter, the direction which the equipment front end module 20 and the processing module 30 are arranged may be referred to as a first direction 11, and a

direction perpendicular to the first direction 11 when viewed from above may be referred to a second direction 12.

[0059] The equipment front end module 20 may have a load port 10 and a transfer frame 21. The load port 10 may be disposed in the front of the equipment front end module 20 in the first direction 11. The load port 10 may have a plurality of supports 6. The supports 6 may be arranged in a row in the second direction 12 and may have, on the top sides thereof, carriers 4 (e.g., cassettes, FOUPs, or the like) that have substrates W to be processed and processed substrates W received therein. The carriers 4 may have substrates W to be processed and processed substrates W received therein. The transfer frame 21 may be disposed between the load port 10 and the processing module 30. The transfer frame 21 may include an index robot 25 inside, which transfers substrates W between the load port 10 and the processing module 30. The index robot 25 may move along a transport rail 27 arranged in the second direction 12 to transfer substrates W between the carriers 4 and the processing module 30.

[0060] The processing module 30 may include a buffer unit 40, a transfer chamber 50, a plurality of process chambers 60, and a controller 70.

[0061] The buffer unit 40 may be disposed adjacent to the transfer frame 21. For example, the buffer unit 40 may be disposed between the transfer chamber 50 and the equipment front end module 20. The buffer unit 40 may provide a space where substrates W to be processed stand by before transferred to the process chambers 60 or a space where processed substrates W stand by before transferred to the equipment front end module 20.

[0062] The transfer chamber 50 may be disposed adjacent to the buffer unit 40. The transfer chamber 50 may have a polygonal body when viewed from above.

The buffer unit 40 and the plurality of process chambers 60 may be arranged around the body. The body may have, in side walls thereof, passages (not illustrated) through which substrates W enter or exit the transfer chamber 50, and the passages may connect the transfer chamber 50 with the buffer unit 40 or the process chambers 60. Doors (not illustrated) may be provided at the respective passages to open/close the passages and to hermetically seal the interior of the transfer chamber 50. A transfer robot 53 that transfers substrates W between the buffer unit 40 and the process chambers 60 may be disposed in an inner space of the transfer chamber 50. The transfer robot 53 may transfer unprocessed substrates W standing by in the buffer unit 40 to the process chambers 60, or may transfer processed substrates W to the buffer unit 40. Furthermore, the transfer robot 53 may transfer substrates W between the process chambers 60 to sequentially or simultaneously provide the substrates W to the plurality of process chambers 60.

[0063] The process chambers 60 may be arranged around the transfer chamber 50. The plurality of process chambers 60 may be provided. In each process chamber 60, a process may be performed on a substrate W. The process chamber 60 may process a substrate W transferred by the transfer robot 53 and may provide the processed substrate W to the transfer robot 53. Processes performed in the respective process chambers 60 may differ from one another. The processes performed in the process chambers 60 may be one of processes of manufacturing a semiconductor device or a display panel by using a substrate W.

[0064] The controller 70 may control the elements of the substrate processing apparatus 1, including the buffer unit 40.

[0065] A substrate W that is processed by the substrate processing apparatus 1 may have a comprehensive meaning including a substrate used to manufacture a

semiconductor device or a flat panel display (FPD) and other substrates used to manufacture objects having a circuit pattern formed on a thin film. Examples of the substrate W may include a silicon wafer, a glass substrate, an organic substrate, and the like.

5 **[0066]** FIG. 4 is a plan view of the transfer robot according to an embodiment of the inventive concept.

[0067] Referring to FIG. 4, the transfer robot 53 may have two hands 53a and 53b. The two hands 53a and 53b may share one actuator 54 and may be simultaneously driven. However, the scope of the inventive concept is not limited to
10 a double-hand type transfer robot with two hands that are simultaneously driven by one actuator.

[0068] FIG. 5 is a schematic plan view of the buffer unit 40 according to an embodiment of the inventive concept.

[0069] Referring to FIG. 5, the buffer unit 40 may include housings 110a and
15 110b and substrate support members 130.

[0070] The housings 110a and 110b may be frames that protect the buffer unit 40. The housings 110a and 110b may have inner spaces in which substrates W are received. The housings 110a and 110b may have passages 112a and 114a through which substrates W are transferred between the transfer frame 21 and the inner
20 spaces of the housings 110a and 110b arranged in proximity to and in parallel to the transfer frame 21 and passages 112b and 114b through which substrates W are transferred between the inner spaces of the housings 110a and 110b and the transfer chamber 50. Doors 116a, 116b, 117a, and 117b may be installed on side walls in which the passages 112a, 112b, 114a, and 114b are formed. The doors 116a, 116b,
25 117a, and 117b may open/close the passages 112a, 112b, 114a, and 114b and may

hermetically seal the inner spaces of the housings 110a and 110b. Gas supply lines 181 may be installed on sides of the housings 110a and 110b to supply a purge gas into the inner spaces of the housings 110a and 110b. The first housing 110a and the second housing 110b may be arranged side by side in the first direction 11. Each of the housings 110a and 110b may selectively include a clamping buffer 41 or a pass buffer 42.

[0071] FIG. 6 is a schematic side view illustrating the interior of the first or second housing 110a or 110b. Hereinafter, the first or second housing 110a or 110b may be referred to a housing 110.

10 **[0072]** Referring to FIG. 6, the housing 110 may include the clamping buffer 41 and the pass buffer 42 vertically stacked.

[0073] The clamping buffer 41 may form a first buffer area 41a. The first buffer area 41a may include the substrate support member 130, pushers 140, and an edge clamp support member 150.

15 **[0074]** The pass buffer 42 may form a second buffer area 42a. The second buffer area 42a may include the substrate support member 130 and the pushers 140.

[0075] The substrate support members 130 may support substrates W transferred into the buffer areas 41a and 42a. The substrate support members 130 may support the bottom sides of the substrates W. The substrate support members 130 may be located on a lower side of the buffer areas 41a and 42a. The substrate support members 130 may have a shape that does not interfere within the entrance of the index robot 25 or the transfer robot 53 when the index robot 25 or the transfer robot 53 transfers a substrate W into and out of the buffer areas 41a and 42a. For example, the substrate support members 130 may have a rod shape to support the bottom side of a substrate W.

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[0076] The pushers 140 may be located outside the substrate W supported by the substrate support member 130. The pushers 140 may align the transferred substrate W. The pushers 140 may be provided such that portions thereof facing the side surface of the substrate W are movable toward the substrate W. The pushers 140
5 may be arranged to face each other with respect to the substrate W. For example, two pushers 140 may be arranged to face each other with respect to the substrate W, or four pushers 140 may be arranged to be symmetric with respect to the substrate W.

[0077] FIG. 7 is a side view illustrating an operating state of the clamping buffer according to an embodiment of the inventive concept.

10 **[0078]** Referring to FIG. 7, the clamping buffer 41 may include the substrate support member 130 and the edge clamp support member 150.

[0079] The edge clamp support member 150 may support an edge clamp 160. The edge clamp support member 150 may be located outside the edge of the substrate W supported by the substrate support member 130.

15 **[0080]** The edge clamp support member 150 may include a support end 151 located at a second position h2 that is higher than a first position h1 at which the top side of the substrate support member 130 is located. The support end 151 may support the edge clamp 160.

[0081] The support end 151 may be connected to an actuator (not illustrated),
20 and the actuator may move the support end 151 between the second position h2 and a third position h3 higher than the second position h2.

[0082] FIG. 8 illustrates a state in which a substrate is transferred into the clamping buffer from the equipment front end module.

[0083] Referring to FIG. 8, the edge clamp 160 may be located on the edge
25 clamp support member 150 before a substrate W is transferred into the buffer unit 40

from the equipment front end module 20. The edge clamp 160 may have a circular or rectangular shape to correspond to the periphery of the substrate W and may be made of a ceramic material.

[0084] A mounting groove 162 may be formed on the edge clamp 160. The mounting groove 162 may be formed to correspond to the shape of the edge clamp support end 151. The mounting groove 162 may prevent the edge clamp 160 from being separated from the support end 151.

[0085] In the state in which the edge clamp 160 is prepared, the index robot 25 may transfer, into the clamping buffer 41, a substrate W to be processed. The controller 70 may control the index robot 25 to transfer, into the clamping buffer 41, the substrate W at a height of h_4 that is a preset distance higher than the height at which the substrate W is to be supported by the substrate support member 130. Thereafter, when the substrate W is vertically aligned with the position where the substrate W is to be supported by the substrate support member 130, the index robot 25 may move downward to place the substrate W on the substrate support member 130.

[0086] FIG. 9 illustrates a state in which the pushers correct the position of a substrate and the transfer robot enters the clamping buffer.

[0087] Referring to FIG. 9, after a substrate W is transferred into the clamping buffer 41 from the equipment front end module 20, the position of the substrate W may be corrected by the pushers 140. The index robot 25 (see FIG. 8) may be set up to locate the substrate W at a preset position. However, there may be a difference between the position of the substrate W and the preset position in the process of locating the substrate W on the substrate support member 130. The controller 70 may move the pushers 140 toward the substrate W by a preset distance

to push the substrate W to a correct position. Thereafter, the pushers 140 may move away from the substrate W to prevent interference with other elements. When the substrate W is completely aligned, the transfer robot 53 may enter the clamping buffer 41 so as to be located below the substrate W.

5 **[0088]** FIG. 10 illustrates a state in which a substrate is picked up by the transfer robot and the edge clamp is located on the substrate.

[0089] Referring to FIG. 10, the transfer robot 53 may move upward to a preset height higher than the second position h2 (see FIG. 7) to pick up a substrate W (the preset height being lower than the third position h3). The edge clamp 160 may
10 be located on the substrate W in the process in which the transfer robot 53 moves upward to pick up the substrate W. When the substrate W is completely picked up, the transfer robot 53 may move backward from the clamping buffer 41 to the transfer chamber 50.

[0090] FIG. 11 illustrates a state in which a substrate is transferred out of the
15 buffer unit of FIG. 6.

[0091] Referring to FIG. 11, the buffer unit 40 may include detection sensors 171, 172, and 173, and the edge clamp support member 150 may include the support end 151 and a cylinder 152 supporting the support end 151.

[0092] The first detection sensors 171 and 172 may detect a presence or
20 absence of a substrate W on the substrate support member 130 and may transmit the detected information to the controller 70. The first detection sensors 171 and 172 may be selected to be laser sensors emitting laser beams 171a and 172a.

[0093] The cylinder 152 constituting the edge clamp support member 150 may be selected to be a hydraulic, pneumatic, or screw cylinder and may be variable

in length. The support end 151 may be coupled to an end portion of the cylinder 152 and may be variable in height as the cylinder 152 is driven.

[0094] Since the support end 151 supports the edge clamp 160, the edge clamp 160 moves upward or downward as the support end 151 is raised or lowered.

5 A reference position of the support end 151 may be set to the second position h2 (see FIG. 7) where the edge clamp 160, together with a substrate W, is transferred out of the buffer unit 40 while making contact with the top side of the substrate W, and the support end 151 may move upward to the third position h3 (see FIG. 7), which is higher than the second position h2 by a predetermined height, so as not to make
10 contact with the index robot 25 and the transfer robot 53.

[0095] The controller 70 may receive information about an absence of a substrate W on the substrate support member 130 from the first detection sensors 171 and 172 and may drive the cylinder 152, based on the received information about the absence of the substrate W. The cylinder 152 may move the support end 151 upward
15 from the second position h2 to the third position h3.

[0096] The second detection sensor 173 may detect the height of the edge clamp 160. According to an embodiment, the second detection sensor 173 may be a laser sensor that is disposed on a side wall of the housing 110 to correspond to a reference position of the edge clamp 160 and emits a laser beam 173a in a direction
20 parallel to the ground to detect whether the edge clamp 160 is at the second position h2.

[0097] FIG. 12 is a schematic side view of a process chamber in which a substrate is located on a susceptor.

[0098] Referring to FIG. 12, the process chamber 60 may include a chamber
25 2100, a susceptor 2200, a baffle 2300, and a plasma excitation module 2400.

[0099] The chamber 2100 may have a space in which a process is performed.

[00100] The susceptor 2200 may be located inside the chamber 2100. A substrate W may be placed on the top side of the susceptor 2200. The susceptor 2200 may be made of aluminum. The susceptor 2200 may have a coolant passage (not
5 illustrated) formed therein, through which cooling fluid circulates. The cooling fluid may cool the susceptor 2200 while circulating through the coolant passage. A bias supply 2210 may apply electric power to the susceptor 2200 to adjust the extent to which the substrate W is processed by plasma. The electric power applied by the bias supply 2210 may be radio frequency (RF) power. The susceptor 2200 may form a
10 sheath by using the electric power supplied by the bias supply 2210 and may generate high-density plasma in the area to enhance process capability.

[00101] The susceptor 2200 may have a heating member 2220 inside. According to an embodiment, the heating member 2220 may be a heating wire. The heating member 2220 may heat the substrate W to a preset temperature.

[00102] The baffle 2300 may be electrically connected to an upper wall of a body 2110. The baffle 2300 may have a disk shape and may be arranged parallel to the top side of the susceptor 2200. The baffle 2300 may be made of anodized aluminum. The baffle 2300 may have distribution holes 2310 formed therein. The distribution holes 2310 may be formed on concentric circumferences at
15 predetermined intervals to uniformly supply radicals. Plasma diffused throughout a diffusion space 2121 may be introduced into the distribution holes 2310. At this time, charged particles, such as electrons or ions, may be confined in the baffle 2300, and neutral particles, such as oxygen radicals, which have no electrical charge may be
20 supplied to the substrate W through the distribution holes 2310. Furthermore, the

baffle 2300 may be grounded to form a passage through which electrons or ions move.

[00103] The plasma excitation module 2400 may generate plasma and may supply the plasma to the chamber 2100. The plasma excitation module 2400 may be provided at the top of the chamber 2100. The plasma excitation module 2400 may include an oscillator 2410, a waveguide 2420, a dielectric tube 2430, and a process gas supply unit 2440. The oscillator 2410 may generate electromagnetic waves. The waveguide 2420 may connect the oscillator 2410 and the dielectric tube 2430 and may serve to guide the electromagnetic waves generated by the oscillator 2410 into the dielectric tube 2430. The process gas supply unit 2440 may supply a process gas into the dielectric tube 2430. The process gas may be selected depending on the progress of a process. The process gas supplied into the dielectric tube 2430 may be excited into plasma by electromagnetic waves. The plasma may be introduced into the diffusion space 2121 via the dielectric tube 2430. Although the above-described plasma excitation module 2400 has been described as using electromagnetic waves, the plasma excitation module 2400 may be an inductively-coupled plasma excitation module or a capacitively-coupled plasma excitation module.

[00104] The susceptor 2200 may include lift pins (not illustrated), and the substrate W may be placed in the process chamber 60 in the state in which the lift pins of the susceptor 2200 are moved upward.

[00105] According to an embodiment of the inventive concept, the substrate W may be placed in the process chamber 60, with the edge of the substrate W covered with the edge clamp 160. Accordingly, it is possible to prevent a phenomenon caused by exposure of the edge of the substrate W to plasma during a process and to reduce the extent to which the edge of the substrate W is exposed to

plasma during the process. For example, when the substrate W is located on the susceptor 2200, there may be a gap between the bottom of the outer periphery of the substrate W and the susceptor 2200 due to a problem that the bottom of the outer periphery of the substrate W does not form a completely flat surface. The gap may generate an arc to cause damage to the substrate W while the substrate W is being processed. Also, it may be necessary to prevent the outer periphery of the substrate W from being processed by plasma. In addition, since an element for fixing the substrate W is not required inside the process chamber 60, it is possible to simplify maintenance of the process chamber 60.

10 **[00106]** A guide ring 2230 may be disposed to surround the susceptor 2200. The guide ring 2230 may be made of a ceramic material.

[00107] FIG. 13 is a blowup of detail A in FIG. 12.

[00108] Referring to FIG. 13, the guide ring 2230 may include a protrusion 2231 that further protrudes a predetermined height beyond the top side of the susceptor 2200 on which the substrate W is placed. The protrusion 2231 may be formed to be spaced apart from the edge of the substrate W by a predetermined distance in the state in which the substrate W is placed at the reference position of the susceptor 2200. The protrusion 2231 may have an inclined surface 2232 formed on a side thereof that faces the substrate W. A mounting portion 2233 on which the edge clamp 160 is mounted may be formed inward of the inclined surface 2232.

[00109] The edge clamp 160 may have the mounting groove 162 that corresponds to the protrusion 2231 of the guide ring 2230. The mounting groove 162 may have an inclined surface 162a that corresponds to the inclined surface 2232 of the protrusion 2231. The inclined surfaces 2232 and 162a may be downwardly inclined from the outside to the inside with respect to the guide ring 2230.

[00110] The inclined surface 2232 of the guide ring 2230 and the inclined surface 162a of the edge clamp 160 may slide relative to each other to move to correct positions when a teaching position is changed due to an abnormal operation of the transfer robot 53.

5 **[00111]** FIG. 14 is a blowup of detail A in FIG. 12 according to another embodiment. The edge clamp 160 may have a receiving groove 161' having a shape corresponding to the outer side surface of the substrate W. The receiving groove 161' may be more firmly coupled with the substrate W than an inclined surface 161 in the embodiment illustrated in FIG. 11 and may prevent the edge clamp 160 from being
10 separated from the substrate W when the inclined surface 2232 of the guide ring 2230 and the inclined surface 162a of the edge clamp 160 slide relative to each other due to a teaching position change caused by an abnormal operation of the transfer robot 53.

[00112] The edge clamp 160 may have the mounting groove 162 formed
15 thereon. The mounting groove 162 may be formed to correspond to the shape of an upper end of the edge clamp support member 150. When the edge clamp 160 is located on the edge clamp support member 150, the upper end of the edge clamp support member 150 may be located in the mounting groove 162 to prevent the edge clamp 160 from being separated from the edge clamp support member 150.

20 **[00113]** FIG. 15 illustrates a state in which the substrate and the edge clamp are mounted on the susceptor.

[00114] Referring to FIG. 15, the process chamber 60 may include third detection sensors 2500. The third detection sensors 2500 may detect the position of the edge clamp 160 that is placed in the process chamber 60, together with the
25 substrate W. According to an embodiment, the third detection sensors 2500 may be

laser sensors that vertically apply laser beams 2501 to positions spaced a preset distance apart from the periphery of the guide ring 2230 that surrounds the susceptor 2200. When the third detection sensors 2500 detect that the edge clamp 160 further protrudes beyond the boundary of the guide ring 2230 by the preset distance or more, the controller 70 may stop operating the apparatus and may activate an alarm (not illustrated) to inform a worker of the fact. According to another embodiment, the controller 70 may determine whether the position detected by the third detection sensors 2500 is beyond an allowable error range. Damage to the high-priced edge clamp 160, which is made of a ceramic material, may be prevented through the detection and control using the third detection sensors 2500.

[00115] FIG. 16 is a schematic side view of a buffer unit having a clamping buffer unit and a pass buffer unit vertically stacked, where the clamping buffer unit comprises clamping buffers horizontally arranged and the pass buffer unit comprises pass buffers horizontally arranged.

[00116] Referring to FIG. 16, the clamping buffer unit may include a pair of clamping buffers 41 arranged in a horizontal direction, and the pass buffer unit may include a pair of pass buffers 42 arranged in the horizontal direction. The clamping buffer unit and the pass buffer unit may be vertically stacked to form the buffer unit 40.

[00117] FIG. 17 is a view for explaining a problem with the double-hand type transfer robot.

[00118] Referring to FIG. 17, in operating the transfer robot 53 with the two hands 53a and 53b, two substrates may be transferred into the clamping buffer unit at a time by using a cassette for carrying a set of 25 substrates, and only one substrate may be left in the last transfer step. The last remaining substrate may be transferred

into only one of the first buffer areas 41a and 41b in the clamping buffer unit. When the two hands 53a and 53b enter the clamping buffer unit to pick up the substrate W, one hand 53a may have the substrate W and the edge clamp 160 placed thereon, but the other hand 53b may have only the edge clamp 160 placed thereon, as illustrated in FIG. 17. Since the edge clamp 160 has a width d of 3 mm or less, the edge clamp 160 not being combined with the substrate W may be placed on the hand 53b in an unstable state (in the drawings, the width d is slightly exaggerated to identify the edge clamp 160). The edge clamp 160 located on the hand 53b in an unstable state is more likely to fall from the hand 53b.

10 **[00119]** The edge clamp 160 made of a ceramic material may have a high risk of damage and may be expensive. Accordingly, damage to the edge clamp 160 may cause a high loss. The inventive concept may prevent the above-described situation through the control of the edge clamp support member 150.

15 **[00120]** FIG. 18 is a flowchart illustrating a substrate processing method using the substrate treating apparatus according to an embodiment of the inventive concept. FIG. 19 illustrates a state in which a substrate is transferred into one of the horizontally-arranged clamping buffers according to an embodiment of the inventive concept. FIG. 20 illustrates a state in which the support end of the clamping buffer where no substrate is detected is moved upward and the support end of the clamping 20 buffer where the substrate is detected is maintained at the same position. FIG. 21 illustrates a state in which the transfer robot enters the clamping buffer unit of FIG. 19. FIG. 22 illustrates a state in which an edge clamp is located on the substrate picked up by the transfer robot in the clamping buffer unit of FIG. 20.

[00121] Referring to FIGS. 18 to 22, the substrate processing method using the substrate processing apparatus may provide a processing method for preventing damage to the edge clamp 160.

[00122] The edge clamp 160 may be located on the support end 151 in the
5 clamping buffer 41 (Step S110).

[00123] The index robot 23 may transfer a substrate W to be processed, into the first buffer areas 41a and 41b of the clamping buffer 41 (Step S120). According to an embodiment, a substrate W may be transferred into the first buffer area 41b, whereas a substrate W may not be transferred into the first buffer area 41a.

10 **[00124]** When the substrate W is completely transferred, the detection sensors 171 and 172 may detect whether the substrate W is located on the substrate support member 130 and is present within the clamping buffer 41 (Step S140) (see FIG. 19).

[00125] When the detection sensors 171 and 172 detect an absence of the substrate W, the controller 70 may control the actuator to move the support end 151
15 upward, based on the information about the absence of the substrate W (Step S145) (see FIG. 20). In contrast, when the detection sensors 171 and 172 detect a presence of the substrate W, the lift control of the support end 151 may not be performed.

[00126] When the substrate W is aligned by the pushers 40 and the support end 151 in the clamping buffer having no substrate W therein is completely moved
20 upward, the two hands 53a and 53b of the transfer robot 53 may simultaneously enter the clamping buffer unit (Step S150) (see FIG. 21).

[00127] The two hands 53a and 53b may move to a preset position in the clamping buffer unit and then may pick up the substrate W while moving upward to a position higher than the support end 151 (Step S160) (see FIG. 22).

[00128] The transfer robot 53 having completely picked up the substrate W may transfer the substrate W out of the clamping buffer unit while moving backward from the clamping buffer unit to the transfer chamber 50 (Step S170).

[00129] The substrate W transferred into the transfer chamber 50 may be placed in the process chamber 60.

[00130] Since the edge clamp 160, together with the substrate W, is transferred out of the clamping buffer unit, the edge clamp support member 150 in the first buffer area 41b may have no edge clamp mounted thereon. The controller 70, when transferring the substrate W into the transfer chamber 50, may store information about the first buffer area 41b in which the edge clamp support member 150 has no edge clamp mounted thereon, and may instruct that the edge clamp 160 be supplied to the first buffer area 41b.

[00131] The above-described substrate processing method may prevent damage to an edge clamp in operating a double-hand type transfer robot to which the edge clamp is applied and a substrate processing apparatus with double chambers.

[00132] FIG. 23 illustrates an edge clamp support member according to another embodiment of the inventive concept.

[00133] Referring to FIG. 23, an edge clamp support member 150' according to another embodiment may be a support horizontally protruding from a side wall of the housing 110. The support 150' may be configured to move upward or downward. In the embodiment of FIG. 23, detections sensors may be provided as in the embodiment of FIG. 11.

[00134] FIG. 24 illustrates a substrate support member according to another embodiment of the inventive concept.

[00135] Referring to FIG. 24, a substrate support member 230 according to another embodiment may include a plate 232 for supporting a substrate W and lift pins 231 for lifting the substrate W to a preset height when the substrate W is exchanged with the index robot 25 or the transfer robot 53. According to an embodiment, upper ends of the lift pins 231 may be moved upward to a first position h1.

[00136] The process chamber 60 may be a process chamber other than a plasma processing chamber.

[00137] According to an embodiment, a movement reference position of the support end 151 may be set to a third position h3, and when the entrance of the substrate W to the buffer unit 40 is detected, the support end 151 may be moved downward to a second position h2 to enable the transfer robot 53 to pick up the substrate W together with the edge clamp 160.

[00138] The controller 70 may receive information about substrates W that are transferred to the load port 10 and are to be processed, and may control the index robot 25 to selectively transfer the substrates W into the clamping buffer 41 and the pass buffer 42. The edge clamp 160 may be provided for substrates with excessive warpage. Substrates with less warpage may be categorized as a first group, and substrates with excessive warpage may be categorized as a second group. When the first group of substrates is provided to the substrate processing apparatus, the controller 70 may provide the substrates to the pass buffer 42, and when the second group of substrates is provided to the substrate processing apparatus, the controller 70 may provide the substrates to the clamping buffer 41.

[00139] When the substrates W are transferred into the pass buffer 42, the controller 70 may control the transfer robot 53 to enter the second buffer areas 42a

and 42b in the pass buffer 42. The transfer robot 53 may pick up the substrates W in the pass buffer 42 and may transfer the substrates W into the process chambers 60.

[00140] The above-described substrate processing method may increase productivity by using the clamping buffer 41 along with the pass buffer 42.

5 **[00141]** The above description exemplifies the inventive concept. Furthermore, the above-mentioned contents describe exemplary embodiments of the inventive concept, and the inventive concept may be used in various other combinations, changes, and environments. That is, variations or modifications can be made to the inventive concept without departing from the scope of the inventive concept that is
10 disclosed in the specification, the equivalent scope to the written disclosures, and/or the technical or knowledge range of those skilled in the art. The written embodiments describe the best state for implementing the technical spirit of the inventive concept, and various changes required in specific applications and purposes of the inventive concept can be made. Accordingly, the detailed description of the inventive concept
15 is not intended to restrict the inventive concept in the disclosed embodiment state. In addition, it should be construed that the attached claims include other embodiments.

[00142] While the inventive concept has been described with reference to embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the
20 inventive concept. Therefore, it should be understood that the above embodiments are not limiting, but illustrative.

WHAT IS CLAIMED IS:

1. An apparatus for processing a substrate, the apparatus comprising:
 - an equipment front end module;
 - a processing module configured to process the substrate; and
 - a controller,wherein the equipment front end module comprises:
 - a load port on which a container having the substrate inside is placed; and
 - a transfer frame having an index robot configured to transfer the substrate between the load port and the processing module,wherein the processing module comprises:
 - a clamping buffer disposed adjacent to the equipment front end module;
 - a process chamber configured to process the substrate; and
 - a transfer chamber having a transfer robot configured to transfer the substrate between the process chamber and the clamping buffer, andwherein the clamping buffer comprises:
 - a substrate support member configured to support the substrate;
 - an edge clamp support member having a support end configured to support an edge clamp that is transferred to the process chamber in a state of being located at an edge of a top side of the substrate;
 - a detection sensor configured to detect a presence or absence of the substrate on the substrate support member; and
 - an actuator configured to move the support end of the clamping buffer between the second position, which is higher than the first position at which the substrate is supported on the substrate support member, and the third position higher than the second position,

wherein the controller is configured to:

control the actuator to locate the support end at the third position, based on information about an absence of the substrate on the substrate support member, wherein the detection sensor detects the information about the absence of the substrate; or

control the actuator to locate the support end at the second position, based on information about a presence of the substrate on the substrate support member, wherein the detection sensor detects the information about the presence of the substrate.

2. An apparatus for processing a substrate, the apparatus comprising:

an equipment front end module;

a processing module configured to process the substrate; and

a controller,

wherein the equipment front end module comprises:

a load port on which a container having the substrate inside is placed; and

a transfer frame having an index robot configured to transfer the substrate between the load port and the processing module,

wherein the processing module comprises:

a clamping buffer disposed adjacent to the equipment front end module;

a process chamber configured to process the substrate; and

a transfer chamber having a transfer robot configured to transfer the substrate between the process chamber and the clamping buffer,

wherein the clamping buffer comprises:

a substrate support member configured to support the substrate; and

an edge clamp support member having a support end configured to support an edge clamp that is transferred to the process chamber in a state of being located at an edge of a top side of the substrate,

wherein the support end is provided to movable between a second position and a third position which is higher than the second position,

wherein the process chamber comprises:

a susceptor on which the substrate is placed; and

a guide ring configured to surround the susceptor and having a protrusion that further protrudes upward beyond a top side of the susceptor and has an inclined side surface that faces the substrate,

wherein the edge clamp has an inclined portion that corresponds to a slope of the protrusion.

3. An apparatus for processing a substrate, the apparatus comprising:

an equipment front end module;

a processing module configured to process the substrate; and

a controller,

wherein the equipment front end module comprises:

a load port on which a container having the substrate inside is placed; and

a transfer frame having an index robot configured to transfer the substrate between the load port and the processing module,

wherein the processing module comprises:

a clamping buffer disposed adjacent to the equipment front end module;

a process chamber configured to process the substrate; and

a transfer chamber having a transfer robot configured to transfer the substrate between the process chamber and the clamping buffer,

wherein the clamping buffer comprises:

a substrate support member configured to support the substrate; and

an edge clamp support member having a support end configured to support an edge clamp that is transferred to the process chamber in a state of being located at an edge of a top side of the substrate,

wherein the support end is provided to movable between a second position and a third position which is higher than the second position,

wherein the process chamber comprises:

a susceptor on which the substrate is placed;

a guide ring configured to surround the susceptor and guide a position of the substrate;

and

a detection sensor configured to detect the edge clamp that further protrudes beyond a boundary of the guide ring by a preset value or more.

4. The apparatus of claim 3, further comprising:

a controller,

wherein the controller is configured to stop operating the apparatus or activate an alarm when the detection sensor detects that the edge clamp further protrudes beyond the boundary of the guide ring by the preset value or more.

5. The apparatus of claim 1, wherein a plurality of clamping buffers are provided to form a clamping buffer unit.

6. The apparatus of claim 1, wherein the processing module further comprises:
a pass buffer disposed in parallel to the clamping butter between the equipment front end module and the transfer chamber.

7. The apparatus of claim 6, wherein a plurality of pass buffers are provided to form a pass buffer unit.

8. The apparatus of claim 6, wherein the clamping buffer and the pass buffer are vertically stacked to form a buffer unit.

9. An apparatus for processing a substrate, the apparatus comprising:
an equipment front end module;
a processing module configured to process the substrate; and
a controller,
wherein the equipment front end module comprises:
a load port on which a container having the substrate inside is placed; and
a transfer frame having an index robot configured to transfer the substrate between the load port and the processing module,

wherein the processing module comprises:
a clamping buffer unit disposed adjacent to the equipment front end module;
a process chamber configured to process the substrate; and
a transfer chamber having a transfer robot that has two hands configured to simultaneously extend and retract and transfers the substrate between the process chamber and the clamping buffer unit,

wherein the clamping buffer unit comprises two clamping buffers arranged side by side, and

wherein each of the clamping buffers comprises:

a substrate support member configured to support the substrate;

an edge clamp support member including a support end configured to support an edge clamp that is transferred to the process chamber in a state of being located at an edge of a top side of the substrate;

a detection sensor configured to detect a presence or absence of the substrate on the substrate support member; and

an actuator configured to move the support end of the clamping buffer between the second position, which is higher than the first position at which the substrate is supported on the substrate support member, and the third position higher than the second position,

wherein the controller is configured to:

control the actuator to locate the edge clamp at the third position, based on information about an absence of the substrate on the substrate support member, wherein the detection sensor detects the information about the absence of the substrate; or

control the actuator to locate the edge clamp at the second position, based on information about a presence of the substrate on the substrate support member, wherein the detection sensor detects the information about the presence of the substrate.

10. The apparatus of claim 9, wherein the processing module further comprises:

a pass buffer unit vertically stacked on the clamping buffer unit between the equipment front end module and the transfer chamber and including a plurality of pass buffers.

11. A method for processing a substrate by using a substrate processing apparatus,
the substrate processing apparatus comprising:

an equipment front end module; and

a processing module configured to process the substrate; and

wherein the equipment front end module comprises:

a load port on which a container having the substrate inside is placed; and

a transfer frame having an index robot configured to transfer the substrate between the
load port and the processing module,

wherein the processing module comprises:

a clamping buffer disposed adjacent to the equipment front end module;

a process chamber configured to process the substrate; and

a transfer chamber having a transfer robot configured to transfer the substrate between
the process chamber and the clamping buffer,

wherein the clamping buffer comprises:

a substrate support member configured to support the substrate; and

an edge clamp support member having a support end configured to support an edge
clamp that is transferred to the process chamber in a state of being located at an edge of a top
side of the substrate; and

a detection sensor configured to detect a presence or absence of the substrate on the
substrate support member,

the method comprising:

locating the edge clamp on the support end of the clamping buffer;

transferring, into the clamping buffer, the substrate to be processed;

detecting a presence or absence of the substrate on the substrate support member of
the clamping buffer;

controlling the actuator to locate the edge clamp at a specific position, based on information detected by the detection sensor;

entering a hand of the transfer robot into the clamping buffer; and transferring the edge clamp and the substrate from the clamping buffer to the process chamber.

12. A method for processing a substrate by using a substrate processing apparatus, the substrate processing apparatus comprising:

an equipment front end module;

a processing module configured to process the substrate; and

a controller,

wherein the equipment front end module comprises:

a load port on which a container having the substrate inside is placed; and

a transfer frame having an index robot configured to transfer the substrate between the load port and the processing module,

wherein the processing module comprises:

a clamping buffer unit disposed adjacent to the equipment front end module;

a process chamber configured to process the substrate; and

a transfer chamber having a transfer robot that has two hands configured to simultaneously extend and retract and transfers the substrate between the process chamber and the clamping buffer unit,

wherein the clamping buffer unit comprises two clamping buffers arranged side by side, and

wherein each of the clamping buffers comprises:

a substrate support member configured to support the substrate;

an edge clamp support member including a support end configured to support an edge clamp that is transferred to the process chamber in a state of being located at an edge of a top side of the substrate; and

a detection sensor configured to detect a presence or absence of the substrate on the substrate support member, and

the method comprising:

locating the edge clamp on the support end of the clamping buffer;

transferring, into the clamping buffer, the substrate to be processed; detecting a presence or absence of the substrate on the substrate support member of the clamping buffer;

controlling the actuator to locate the edge clamp at a specific position, based on information detected by the detection sensor;

entering the two hands of the transfer robot into the clamping buffer simultaneously; and

picking up the substrate in the clamping buffer and transferring the substrate into the process chamber by the transfer robot.

13. A method for processing a substrate by using the apparatus of claim 10 , the method comprising:

locating the edge clamp on the support end of the clamping buffer;

controlling the index robot by the controller to selectively transfer the substrate into the pass buffer or the clamping buffer, based on information about the substrate that is transferred to the load port and is to be processed;

detecting a presence or absence of the substrate on the substrate support member of the clamping buffer;

controlling the actuator by the controller, based on information detected by the detection sensor;

entering the two hands of the transfer robot into the clamping buffer simultaneously;
and

picking up the substrate in the selected pass buffer or the selected clamping buffer and transferring the substrate into the process chamber by the transfer robot.