APPARATUS FOR TREATING SUBSTRATE AND METHOD OF TREATING SUBSTRATE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] A claim for priority is made to Korean Patent Application No. 10-2021-0030560 filed on March 9, 2021, in the Korean Intellectual Property Office, the entire contents of which are hereby incorporated by reference.

BACKGROUND

[0002] Embodiments of the inventive concept described herein relate to an apparatus and method for treating a substrate, and more particularly, relate to a substrate treating apparatus and method for preventing warpage of a substrate.

[0003] In general, a semiconductor integrated circuit is a very small and thin silicon chip, but includes various electronic parts, and various manufacturing processes including a photolithography process, an etching process, a deposition process, a package process, and the like are performed to manufacture one semiconductor chip. Various materials are deposited on a semiconductor substrate such as a wafer, and therefore warpage of the semiconductor substrate may occur due to factors such as different coefficients of thermal expansion of the materials.

[0004] Meanwhile, warpage of wafers may be prevented by applying clamp loads to the wafers. However, the levels of warpage of the wafers differ from one another depending on the materials (e.g., silicon, glass, and the like) of the wafers, and there is a difference in properties, such as strength/rigidity, brittleness, and the like, between the wafers. Therefore, it is difficult to prevent warpage of the wafers of various materials with the same clamp load.

[0005] For example, a wafer having high rigidity may not be completely brought into close contact with a chuck even though a clamp load is applied to the wafer. When plasma processing is performed in a state in which the wafer is warped, the wafer and a part may be damaged by local plasma on the lower surface of the wafer. To prevent this problem, a heavier clamp may be used. However, in this case, a substrate formed of a brittle material such as glass may be broken when treated.

SUMMARY

[0006] Embodiments of the inventive concept provide a substrate treating apparatus and method for effectively preventing warpage of a substrate by controlling the number of clamp rings placed on the substrate, based on the substrate and a substrate treating process.

[0007] According to an exemplary embodiment, a substrate treating apparatus for treating a substrate includes a support chuck that supports the substrate and a warpage prevention device that prevents warpage of the substrate by applying a load to a peripheral area of the substrate by placing one or more clamp rings on the peripheral area of the substrate supported on the support chuck.

[0008] The warpage prevention device may adjust the load applied to the peripheral area of the substrate, by adjusting the number of clamp rings placed on the peripheral area of the substrate.

[0009] The warpage prevention device may include a plurality of pins that are disposed around the support chuck and that extend in an up/down direction, a plurality of support members that are provided on the plurality of pins along the up/down direction and that support the clamp rings in a horizontal direction, a plurality of clamp rings including through-holes through which the plurality of pins

pass and having a ring shape to press the peripheral area of the substrate, the plurality of clamp rings being supported on the plurality of support members, respectively, a lifting unit that vertically moves the plurality of pins, and a controller that controls the lifting unit to vertically move the plurality of pins such that the number of clamp rings placed on the peripheral area of the substrate is adjusted depending on a lift height of the plurality of pins.

[0010] The plurality of support members may include a plurality of first support members provided at first positions of the plurality of pins and a plurality of second support members provided at second positions higher than the first positions of the plurality of pins.

[0011] The plurality of clamp rings may include a first clamp ring that is supported on the plurality of first support members and that has first through-holes formed therein through which the plurality of pins pass and a second clamp ring that is supported on the plurality of second support members and that has second through-holes formed therein through which the plurality of pins pass.

[0012] The first through-holes and the second through-holes may have different sizes or different shapes.

[0013] The first through-holes may have a shape through which the plurality of second support members are able to pass but the plurality of first support members are unable to pass.

[0014] The second through-holes may have a shape through which the plurality of second support members are unable to pass.

[0015] The controller may determine a lift height of the plurality of pins, based on at least one of a material of the substrate or a substrate treating process and may adjust the number of clamp rings placed on the peripheral area of the substrate,

by vertically moving the plurality of pins depending on the determined lift height.

[0016] The first support members and the second support members may radially protrude from the pins. The first through-holes may have a first diameter such that the second support members are able to pass through the first through-holes but the first support members are unable to pass through the first through-holes when the pins pass through the first through-holes. The second through-holes may have a second diameter smaller than the first diameter such that the second support members are unable to pass through the second through-holes when the pins pass through the second through-holes.

[0017] The number of clamp rings placed on the peripheral area of the substrate may be increased as the plurality of pins are lowered by the controller and the lifting unit, and the number of clamp rings placed on the peripheral area of the substrate may be decreased as the plurality of pins are raised by the controller and the lifting unit.

[0018] The first support members may have a frusto-conical shape that is narrow at the top and wide at the base. Lower diameters of the first support members may be greater than diameters of the first through-holes, and upper diameters of the first support members may be equal to or smaller than the diameters of the first through-holes.

[0019] The first clamp ring and the second clamp ring may be spaced apart from each other in an up/down direction. The lifting unit may vertically move the plurality of pins by more than a separation distance between the first clamp ring and the second clamp ring.

[0020] The controller may adjust a clamp load applied to the substrate, by selecting one of a first mode for placing the first clamp ring on the peripheral area of

the substrate by lowering the plurality of pins by a first height by controlling the lifting unit and a second mode for placing the first clamp ring and the second clamp ring on the peripheral area of the substrate by lowering the plurality of pins by a second height by controlling the lifting unit.

[0021] According to an exemplary embodiment, a substrate treating method for treating a substrate includes preventing, by a warpage prevention device, warpage of the substrate by applying a load to a peripheral area of the substrate by placing one or more clamp rings on the peripheral area of the substrate supported on a support chuck.

[0022] The preventing of the warpage may include determining, by a controller, a lift height of a plurality of pins, based on at least one of a material of the substrate or a substrate treating process, the plurality of pins being disposed around the support chuck and extending in an up/down direction and adjusting, by a lifting unit, the number of clamp rings placed on the peripheral area of the substrate, by vertically moving a plurality of clamp rings by vertically moving the plurality of pins depending on the lift height, the plurality of clamp rings being supported on a plurality of support members provided on the plurality of pins along the up/down direction.

[0023] The number of clamp rings placed on the peripheral area of the substrate may be increased as the plurality of pins are lowered by the controller and the lifting unit, and the number of clamp rings placed on the peripheral area of the substrate may be decreased as the plurality of pins are raised by the controller and the lifting unit.

[0024] The preventing of the warpage may include adjusting, by the controller, a clamp load applied to the substrate, by selecting one of a first mode for

placing a first clamp ring on the peripheral area of the substrate by lowering the plurality of pins by the first height by controlling the lifting unit and a second mode for placing the first clamp ring and a second clamp ring on the peripheral area of the substrate by lowering the plurality of pins by a second height by controlling the lifting unit.

BRIEF DESCRIPTION OF THE FIGURES

[0025] 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:

[0026] FIG. 1 is a schematic sectional view illustrating a substrate treating apparatus according to an embodiment of the inventive concept;

[0027] FIG. 2 is a perspective view illustrating a warpage prevention device of the substrate treating apparatus according to an embodiment of the inventive concept;

[0028] FIG. 3 is an enlarged perspective view of portion “A” in FIG. 2;

[0029] FIG. 4 is a sectional view illustrating an operational state in which one clamp ring is placed on a peripheral area of a substrate by the substrate treating apparatus according to the embodiment of the inventive concept;

[0030] FIG. 5 is an enlarged view of portion “B” in FIG. 4;

[0031] FIG. 6 is a sectional view illustrating an operational state in which two clamp rings are placed on a peripheral area of a substrate by the substrate treating apparatus according to the embodiment of the inventive concept;

[0032] FIG. 7 is an enlarged view of portion “C” in FIG. 6;

[0033] FIG. 8 is a flowchart illustrating a substrate treating method according to an embodiment of the inventive concept;

[0034] FIG. 9 is a perspective view illustrating part of a substrate treating apparatus according to another embodiment of the inventive concept;

[0035] FIG. 10 is a sectional view illustrating part of a substrate treating apparatus according to another embodiment of the inventive concept; and

[0036] FIGS. 11 and 12 are sectional views illustrating operations of the substrate treating apparatus according to the embodiment of FIG. 10.

DETAILED DESCRIPTION

[0037] Hereinafter, embodiments of the inventive concept will be described in more detail with reference to the accompanying drawings. The inventive concept may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that the inventive concept 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 components are exaggerated for clarity of illustration.

[0038] FIG. 1 is a schematic sectional view illustrating a substrate treating apparatus according to an embodiment of the inventive concept. Referring to FIG. 1, the substrate treating apparatus 100 according to the embodiment of the inventive concept may be an apparatus for performing a process of treating a substrate 10. The substrate treating apparatus 100 may include various types of apparatuses for performing a process on the substrate 10. The substrate treating apparatus 100 may be an apparatus for performing, for example, a plasma process, a package process, a reflow process, an etching process, a deposition process, a photolithography process,

or a heat treatment process. The substrate 10 treated in the substrate treating apparatus 100 according to the embodiment of the inventive concept may be, but is not limited to, a semiconductor wafer, a mask, a glass substrate, or a liquid crystal display (LCD) panel.

[0039] The substrate treating apparatus 100 according to the embodiment of the inventive concept may include a support chuck 110, a process unit 120, and a warpage prevention device 130 provided in a chamber 100a. The chamber 100a may have a process space therein in which the substrate 10 is treated. Various parts required for treating the substrate 10 may be provided in the chamber 100a depending on the type of substrate treating process performed in the substrate treating apparatus 100.

[0040] For example, when the substrate treating apparatus 100 is an apparatus for treating the substrate 10 using plasma, a component for supplying a process gas for generation of plasma, a component (e.g., an RF generator) for converting the process gas into plasma, and a part for releasing the process gas and the plasma in the process space may be provided in the process space of the chamber 100a.

[0041] The support chuck 110 may support the substrate 10. The support chuck 110 may include a plurality of support pins supporting a lower surface of the substrate 10 and an electrostatic chuck, but is not limited thereto. A guide ring 111 for guiding the substrate 10 may be provided around the support chuck 110. The support chuck 110 may be insulated by an insulator 112. Furthermore, an exhaust ring 113 for uniformly releasing a process gas may be provided in the chamber 100a.

[0042] The process unit 120 may be a component for performing the above-described substrate treating process on the substrate 10. For example, the process

unit 120 may include an RF generator for generating and controlling plasma, an RF controller, and a heater for heating the substrate 10.

[0043] FIG. 2 is a perspective view illustrating the warpage prevention device of the substrate treating apparatus according to an embodiment of the inventive concept. FIG. 3 is an enlarged perspective view of portion "A" in FIG. 2. Referring to FIGS. 1 to 3, the warpage prevention device 130 may be configured to prevent warpage of the substrate 10 by applying a load to a peripheral area of the substrate 10 by placing one or more clamp rings 162 and 164 on the peripheral area (e.g., a circumferential portion) of the substrate 10 supported on the support chuck 10.

[0044] Warpage of the substrate 10 may mainly occur in the peripheral area (edge area) of the substrate 10 during the substrate treating process, and therefore the clamp rings 162 and 164 may be provided in a ring shape to press the peripheral area of the substrate 10. In the illustrated embodiment, the clamp rings 162 and 164 may be implemented with a circular plate having a circular ring shape. However, the clamp rings 162 and 164 may be implemented in a quadrilateral ring shape depending on the shape of the substrate 10.

[0045] The warpage prevention device 130 may include a plurality of pins 140, a plurality of support members 150, a plurality of clamp rings 160, a lifting unit 170, and a controller 180. The plurality of pins 140 may be disposed around the support chuck 110. In other words, the plurality of pins 140 may be arranged to surround the support chuck 110 and the substrate 10 supported on the support chuck 110. In the illustrated embodiment, three pins 140 may be circumferentially arranged around the support chuck 110 at an interval of 120 degrees. However, the number of pins 140 and the interval therebetween may be various modified. The plurality of pins 140 may extend in an up/down direction to vertically move the plurality of

clamp rings 160. The plurality of pins 140 may be vertically moved by the lifting unit 170.

[0046] The plurality of clamp rings 160 may include the first clamp ring 162 and the second clamp ring 164. The clamp rings 162 and 164 may have weights capable of preventing warpage of the substrate 10. The clamp rings 162 and 164 may be placed on the edge area of the substrate 10 supported on the support chuck 110. The first clamp ring 162 may include a circular plate 162b having a ring shape and a load application plate 162c having a hollow container shape, such as a hollow cylindrical or quadrilateral container shape, and extending downward from an inner diameter portion of the circular plate 162 to apply a load to the peripheral area of the substrate 10. The load application plate 162c may have the same shape as the peripheral area of the substrate 10.

[0047] In an embodiment, when the substrate 10 has a circular plate shape, the clamp rings 162 and 164 may be implemented with a plate having a circular ring shape that is open in the center. The clamp rings 162 and 164 may be designed such that inner diameter portions thereof are close to an outer diameter portion of the substrate 10 and may be formed to radially extend outward from the inner diameter portions. The plurality of clamp rings 162 and 164 may be concentric with the support chuck 110 and the substrate 10 supported on the support chuck 110. Furthermore, the plurality of clamp rings 162 and 164 may be spaced apart from each other in the up/down direction by the plurality of support members 150 provided on the plurality of pins 140.

[0048] Each of the pins 140 may include a lower pin 142, an intermediate pin 144 having a smaller diameter than the lower pin 142, and an upper pin 146 having a smaller diameter than the intermediate pin 144. The plurality of support members

150 may be provided on the plurality of pins 140 along the up/down direction and may support the clamp rings 162 and 164 in a horizontal direction. A first support member 152 may be formed between the lower pin 142 and the intermediate pin 144. A second support member 154 may be formed between the intermediate pin 144 and the upper pin 146.

[0049] The plurality of support members 150 may each include the first support member 152 and the second support member 154. The first support member 152 may be provided at a first position (a lower position) of each of the plurality of pins 140, and the second support member 154 may be provided at a second position (an upper position) of the pin 140 that is higher than the first position. The first support member 152 and the second support member 154 may radially protrude from the pin 140 to support lower surfaces of the plurality of clamp rings 162 and 164.

[0050] The plurality of clamp rings 162 and 164 may be supported in a state of being placed on the plurality of support members 152 and 154. The first clamp ring 162 may be supported on the plurality of first support members 152 formed on the plurality of pins 140. To support the first clamp ring 162 in parallel to the substrate 10, the plurality of first support members 152 may be formed on the plurality of pins 140 at the same height.

[0051] The second clamp ring 164 may be supported on the plurality of second support members 154 formed on the plurality of pins 140. To support the second clamp ring 166 in parallel to the substrate 10, the plurality of second support members 154 may be formed on the plurality of pins 140 at the same height. As described above, the plurality of clamp rings 162 and 184 including the first clamp ring 162 and the second clamp ring 164 may be supported in the state of being spaced apart from each other in the up/down direction by the plurality of support

members 152 and 154 formed on the plurality of pins 140.

[0052] The plurality of clamp rings 162 and 164 may include through-holes 162a and 164a formed therein through which the plurality of pins 140 pass. The first clamp ring 162 may include the plurality of first through-holes 162a through which the plurality of pins 140 pass. The second clamp ring 164 may include the plurality of second through-holes 164a through which the plurality of pins 140 pass. The plurality of first through-holes 162 and the plurality of second through-holes 164a may be formed in the first clamp ring 162 and the second clamp ring 164 to correspond to each other in the up/down direction.

[0053] The first through-holes 162a of the first clamp ring 162 and the second through-holes 164a of the second clamp ring 164 may have different sizes or different shapes. The first through-holes 162a may have a shape through which the plurality of first support members 152 are unable to pass, such that the first clamp ring 162 is supported by the first support members 152.

[0054] Furthermore, the first through-holes 162a may have a shape through which the plurality of second support members 154 are able to pass. In other words, the second support members 154 may have a shape capable of passing through the first through-holes 162a. The second through-holes 164a may have a shape through which the plurality of second support members 154 are unable to pass, such that the second clamp ring 164 is supported by the second support members 154.

[0055] The lifting unit 170 may be driven by the controller 180 and may vertically move the plurality of pins 140. The lifting unit 170 may be implemented with, for example, a hydraulic cylinder, a hydraulic motor, a screw shaft/guide bar, or the like that vertically moves the plurality of pins 140. However, the lifting unit 170 is not limited thereto, and various driving methods capable of vertically moving

the plurality of pins 140 may be used. The lifting unit 170 may be configured to vertically move the plurality of pins 140 by more than the separation distance between the first clamp ring 162 and the second clamp ring 164. In an embodiment, the lifting unit 170 may be provided outside the guide ring 111 to pass through the exhaust ring 113.

[0056] The controller 180 may control the lifting unit 170 to vertically move the plurality of pins 140 such that the number of clamp rings 162 and 164 placed on the peripheral area (the circumferential portion) of the substrate 10 is adjusted depending on a lift height of the plurality of pins 140. The controller 180 may adjust a clamp load applied to the substrate 10, by selecting one of a first mode for placing the first clamp ring 162 on the peripheral area of the substrate 10 by lowering the plurality of pins 140 by a first height by controlling the lifting unit 170 and a second mode for placing the first clamp ring 162 and the second clamp ring 164 on the peripheral area of the substrate 10 by lowering the plurality of pins 140 by a second height by controlling the lifting unit 170.

[0057] In an embodiment, the first support members 152 may have a frusto-conical shape that is narrow at the top and wide at the base. The first through-holes 162a formed in the first clamp ring 162 may have a first diameter D3 such that the second support members 154 are able to pass through the first through-holes 162a, but the first support members 152 are unable to pass through the first through-holes 162 when the pins 140 pass through the first through-holes 162a. The lower diameter D1 of the first support members 152 may be greater than the first diameter D3 of the first through-holes 162a, and the upper diameter of the first support members 152 may be equal to or smaller than the first diameter D3 of the first through-holes 162a.

[0058] The second support members 154 may be formed on upper areas of

the pins 140 and may have a circular ring shape surrounding the upper areas of the pins 140. The second through-holes 164a may have a second diameter D4 smaller than the first diameter D3 of the first through-holes 162a such that the second support members 154 are unable to pass through the second through-holes 164a when the pins 140 pass through the second through-holes 164a. The second diameter D4 of the second through-holes 164a may be smaller than the diameter D2 of the second support members 154 and may be equal to or slightly greater than the diameter of the upper areas of the pins 140.

[0059] The diameter D2 of the second support members 154 may be greater than the second diameter D4 of the second through-holes 164a and may be equal to or smaller than the first diameter D3 of the first through-holes 162a. When the pins 140 are lowered by the lifting unit 170, the second support members 154 may be lowered through the first through-holes 162a of the first clamp ring 162. Accordingly, the second support members 154 may be spaced apart downward from the lower surface of the second clamp ring 164, and the second clamping 164 may be placed on the first clamp ring 162.

[0060] FIG. 4 is a sectional view illustrating an operational state in which one clamp ring is placed on a peripheral area of a substrate by the substrate treating apparatus according to the embodiment of the inventive concept. FIG. 5 is an enlarged view of portion “B” in FIG. 4. FIG. 6 is a sectional view illustrating an operational state in which two clamp rings are placed on a peripheral area of a substrate by the substrate treating apparatus according to the embodiment of the inventive concept. FIG. 7 is an enlarged view of portion “C” in FIG. 6.

[0061] Referring to FIGS. 1 to 7, the controller 180 may adjust the number of clamp rings 162 and 164 placed on the peripheral area of the substrate 10 by

determining a lift height of the plurality of pins 140 depending on at least one of the material of the substrate 10 or the substrate treating process and vertically moving the plurality of pins 140 depending on the determined lift height.

[0062] As the plurality of pins 140 are lowered by the controller 180 and the lifting unit 170, the number of clamp rings 162 and 164 placed on the peripheral area of the substrate 10 may be increased one by one in a stepwise manner. In contrast, as the plurality of pins 140 are raised by the controller 180 and the lifting unit 170, the number of clamp rings 162 and 164 placed on the peripheral area of the substrate 10 may be decreased one by one in a stepwise manner. Although the two clamp rings 162 and 164 are used in the illustrated embodiment, three or more clamp rings may be used.

[0063] According to an embodiment of the inventive concept, warpage may be controlled for substrates formed of various materials and various substrate treating processes, by selectively using the number of clamp rings placed on a peripheral area of a substrate depending on a material of a substrate or a substrate treating process.

[0064] For example, in a case of a brittle substrate, a substrate treating process may be performed in a state in which a load is applied to the peripheral area of the substrate 10 by the first clamp ring 162 located in a lower position. Accordingly, warpage of the substrate 10 may be prevented with the small load of the first clamp ring 162 without fracture.

[0065] In contrast, in a case of a rigid substrate, a substrate treating process may be performed in a state in which a load is applied to the peripheral area of the substrate 10 by the two clamp rings 162 and 164 or three or more clamp rings. Accordingly, warpage of the substrate 10 may be effectively controlled with a larger load.

[0066] As described above, the number of clamp rings 162 and 162 placed on the peripheral area of the substrate 10 may be adjusted depending on the material of the substrate 10 or the substrate treating process. Accordingly, stress applied to the substrate 10 may be minimized, and local plasma damage depending on warpage in treating the substrate using plasma may be prevented.

[0067] Although the three pins 140 are formed around the support chuck 110 in the illustrated embodiment, four or more pins 140 may be provided. Furthermore, although the clamp rings 160 have a circular ring shape in the illustrated embodiment, the clamp rings 160 may have a quadrilateral ring shape depending on the shape of the substrate.

[0068] When the substrate 10 is completely treated, the clamp rings 162 and 164 may be separated from the upper surface of the substrate 10 by returning the plurality of pins 140 to upper positions by the controller 180 and the lifting unit 170. Then, the substrate 10 may be unloaded from the chamber 100a by a substrate transfer apparatus (not illustrated), and a substrate 10 to be treated may be loaded into the chamber 100a and may be supported on the support chuck 110. The controller 180 may determine the appropriate number of clamp rings 162 and 164, based on the type of the substrate 10 supported on the support chuck 110 and a substrate treating process that is to be performed on the substrate 10, and the lifting unit 170 may operate to lower the plurality of pins 140. Thereafter, a subsequent substrate treating process may be performed in a state in which the appropriate number of clamp rings 162 and 164 are placed on a peripheral area of the substrate 10.

[0069] FIG. 8 is a flowchart illustrating a substrate treating method according to an embodiment of the inventive concept. Referring to FIGS. 1 and 8, the controller

180 may determine a lift height of the plurality of pins 140, based on the material of the substrate 10, on which a substrate treating process is to be performed by the substrate treating apparatus 100, and the substrate treating process (S10).

[0070] The controller 180 may vertically move the plurality of pins 140 depending on the lift height to vertically move the plurality of clamp rings 162 and 164 supported on the plurality of support members 152 and 154 and may thus adjust the number of clamp rings 162 and 164 placed on the peripheral area of the substrate 10 (S20). When an appropriate number of clamp rings 162 and 164 are placed on the peripheral area of the substrate 10, the substrate treating process may be performed on the substrate 10 (S30).

[0071] FIG. 9 is a perspective view illustrating part of a substrate treating apparatus according to another embodiment of the inventive concept. The substrate treating apparatus according to the embodiment of FIG. 9 differs from the substrate treating apparatus according to the above-described embodiment in that first support members 152 and second support members 154 constituting a warpage prevention device 130 are coupled to pins 140 in different directions and first through-holes 162a formed in a first clamp ring 162 have a long narrow hole shape corresponding to the second support members 154.

[0072] The plurality of pins 140 may be formed to pass through end portions of the plurality of first through-holes 162a. When the pins 140 are lowered, the second support members 154 having the shape of a bar may be lowered through the first through-holes 162a of the first clamp ring 162. Accordingly, the second support members 154 may be spaced apart downward from a lower surface of a second clamp ring 164, and the second clamping 164 may be placed on the first clamp ring 162.

[0073] When the pins 140 are raised, the second support members 154 having the shape of a bar may be raised through the first through-holes 162a of the first clamp ring 162 and may be brought into contact with the lower surface of the second clamp ring 164 to raise the second clamp ring 164. Accordingly, the second clamp ring 164 may be moved to an upper position.

[0074] Furthermore, when the pins 140 are continually raised, the first support members 152 having the shape of a bar may be brought into contact with a lower surface of the first clamp ring 162 to raise the first clamp ring 162. Accordingly, the first clamp ring 162 placed on the peripheral area of the substrate 10 may be moved to an upper position.

[0075] According to the embodiment of FIG. 9, the plurality of pins 140 may be formed to pass through the end portions of the plurality of first through-holes 162a and may prevent the center of the first clamp ring 162 from being out of alignment in the radial direction when the plurality of pins 140 are vertically moved. Also, the plurality of pins 140 passing through a plurality of second through-holes 164a may prevent the center of the second clamp ring 164 from being out of alignment in the radial direction.

[0076] FIG. 10 is a sectional view illustrating part of a substrate treating apparatus according to another embodiment of the inventive concept. FIGS. 11 and 12 are sectional views illustrating operations of the substrate treating apparatus according to the embodiment of FIG. 10. The substrate treating apparatus according to the embodiment of FIGS. 10 to 12 differs from the substrate treating apparatuses according to the above-described embodiments in that a warpage prevention device 130 includes three clamp rings 162, 164, and 166 and each of a plurality of pins 140 includes three support members 152, 154, and 156. The pin 140 may include pin

members 142, 144, 146, and 148 having decreasing diameters in a stepwise manner toward the top of the pin 140.

[0077] The support members 152, and 154, and 156 may be provided in a frusto-conical shape having a decreasing diameter toward the top. Among the support members 152, 154, and 156, the first support member 152 may have the largest average diameter. The average diameter of the second support member 154 may be smaller than the average diameter of the first support member 152, and the average diameter of the third support member 156 may be smaller than the average diameter of the second support member 156.

[0078] Among the support members 152, 154, and 156, the first support member 152 may have the largest average diameter. The average diameter of the second support member 154 may be smaller than the average diameter of the first support member 152, and the average diameter of the third support member 156 may be smaller than the average diameter of the second support member 156.

[0079] The first support member 152 may be provided between the first pin member 142 and the second pin member 144. The second support member 154 may be provided between the second pin member 144 and the third pin member 146. The third support member 156 may be provided between the third pin member 146 and the fourth pin member 148.

[0080] Each of first through-holes 162a of the first clamp ring 162 may have a diameter smaller than the maximum diameter (the lower diameter) of the first support member 152 and greater than the minimum diameter (the upper diameter) of the first support member 152. Each of second through-holes 164a of the second clamp ring 164 may have a diameter smaller than the maximum diameter (the lower diameter) of the second support member 154 and greater than the minimum diameter

(the upper diameter) of the second support member 154.

[0081] Each of third through-holes 166a of the third clamp ring 166 may have a diameter smaller than the maximum diameter (the lower diameter) of the third support member 156 and greater than the minimum diameter (the upper diameter) of the third support member 156. Accordingly, the first clamp ring 162 may be supported by the first support member 152. Similarly, the second clamp ring 164 may be supported by the second support member 154, and the third clamp ring 166 may be supported by the third support member 154.

[0082] FIG. 10 illustrates a state in which the pins 140 are lowered by a first height. Only the load of the first clamp ring 162 may be applied to the peripheral area of the substrate 10. When the pins 140 are additionally lowered by a second height, not only the load of the first clamp ring 162 but also the load of the second clamp ring 164 may be applied to the peripheral area of the substrate 10, and thus a larger clamp load may be applied to the substrate 10.

[0083] Furthermore, when the pins 140 are additionally lowered by a third height, not only the loads of the first clamp ring 162 and the second clamp ring 164 but also the load of the third clamp ring 166 may be applied to the peripheral area of the substrate 10, and thus the clamp load applied to the peripheral area of the substrate 10 may be increased.

[0084] In contrast, when the pins 140 are raised, the third support member 156 may be brought into contact with a lower surface of the third clamp ring 166 to raise the third clamp ring 166. When the pins 140 are additionally raised, the second support member 154 may be brought into contact with a lower surface of the second clamp ring 164 to raise the second clamp ring 164.

[0085] Thereafter, when the pins 140 are additionally raised, the first support

member 152 may be brought into contact with a lower surface of the first clamp ring 162 to raise the first clamp ring 162. When all the clamp rings 162, 164, and 166 placed on the peripheral area of the substrate 10 are moved upward as described above, the substrate 10 may be able to be unloaded.

[0086] The substrate treating apparatus according to the embodiment of FIGS. 10 to 12 may variously adjust the clamp load, which is applied to the peripheral area of the substrate 10, in three load modes by selectively placing one clamp ring, two clamp rings, or three clamp rings on the peripheral area of the substrate 10 depending on the substrate 10 and/or a substrate treating process.

[0087] Although not illustrated, the clamp load applied to the peripheral area of the substrate 10 may be adjusted in four or more load modes by using four or more clamp rings. Furthermore, clamp rings having various weights may be applied, and the clamp load applied to the substrate 10 may be various changed through adjustment of the lift height of the pins 140.

[0088] According to the embodiments of the inventive concept, the substrate treating apparatus and method may effectively preventing warpage of a substrate by controlling the number of clamp rings placed on the substrate, based on the substrate and a substrate treating process.

[0089] 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 disclosed in the specification, the equivalent scope to the written disclosures, and/or the technical or knowledge range of those skilled in the art.

[0090] 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 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.

[0091] While the inventive concept has been described with reference to exemplary 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 inventive concept. Therefore, it should be understood that the above embodiments are not limiting, but illustrative.

WHAT IS CLAIMED IS:

1. A substrate treating apparatus for treating a substrate, the substrate treating apparatus comprising:

a support chuck configured to support the substrate; and

a warpage prevention device configured to prevent warpage of the substrate by applying a load to a peripheral area of the substrate by placing one or more clamp rings on the peripheral area of the substrate supported on the support chuck,

wherein the warpage prevention device is configured to adjust the load applied to the peripheral area of the substrate, by adjusting the number of clamp rings placed on the peripheral area of the substrate.

2. The substrate treating apparatus of claim 1, wherein the warpage prevention device includes:

a plurality of pins disposed around the support chuck, the plurality of pins extending in an up/down direction;

a plurality of support members provided on the plurality of pins along the up/down direction and configured to support the clamp rings in a horizontal direction;

a plurality of clamp rings including through-holes through which the plurality of pins pass and having a ring shape to press the peripheral area of the substrate, the plurality of clamp rings being supported on the plurality of support members, respectively;

a lifting unit configured to vertically move the plurality of pins; and

a controller configured to control the lifting unit to vertically move the

plurality of pins such that the number of clamp rings placed on the peripheral area of the substrate is adjusted depending on a lift height of the plurality of pins.

3. The substrate treating apparatus of claim 1, wherein the plurality of support members include:

a plurality of first support members provided at first positions of the plurality of pins; and

a plurality of second support members provided at second positions higher than the first positions of the plurality of pins,

wherein the plurality of clamp rings include:

a first clamp ring supported on the plurality of first support members, the first clamp ring having first through-holes formed therein through which the plurality of pins pass; and

a second clamp ring supported on the plurality of second support members, the second clamp ring having second through-holes formed therein through which the plurality of pins pass, and

wherein the first through-holes and the second through-holes have different sizes or different shapes.

4. The substrate treating apparatus of claim 3, wherein the first through-holes have a shape through which the plurality of second support members are able to pass but the plurality of first support members are unable to pass, and

wherein the second through-holes have a shape through which the plurality of second support members are unable to pass.

5. The substrate treating apparatus of claim 1, wherein the controller is configured to:

determine a lift height of the plurality of pins, based on at least one of a material of the substrate or a substrate treating process; and

adjust the number of clamp rings placed on the peripheral area of the substrate, by vertically moving the plurality of pins depending on the determined lift height.

6. The substrate treating apparatus of claim 3, wherein the first support members and the second support members radially protrude from the pins,

wherein the first through-holes have a first diameter such that the second support members are able to pass through the first through-holes but the first support members are unable to pass through the first through-holes when the pins pass through the first through-holes, and

wherein the second through-holes have a second diameter smaller than the first diameter such that the second support members are unable to pass through the second through-holes when the pins pass through the second through-holes.

7. The substrate treating apparatus of claim 3, wherein the number of clamp rings placed on the peripheral area of the substrate is increased as the plurality of pins are lowered by the controller and the lifting unit, and

wherein the number of clamp rings placed on the peripheral area of the substrate is decreased as the plurality of pins are raised by the controller and the lifting unit.

8. The substrate treating apparatus of claim 3, wherein the first support members have a frusto-conical shape that is narrow at the top and wide at the base.

9. The substrate treating apparatus of claim 8, wherein lower diameters of the first support members are greater than diameters of the first through-holes, and upper diameters of the first support members are equal to or smaller than the diameters of the first through-holes.

10. The substrate treating apparatus of claim 3, wherein the first clamp ring and the second clamp ring are spaced apart from each other in an up/down direction, and

wherein the lifting unit is configured to vertically move the plurality of pins by more than a separation distance between the first clamp ring and the second clamp ring.

11. The substrate treating apparatus of claim 3, wherein the controller is configured to adjust a clamp load applied to the substrate, by selecting one of a first mode for placing the first clamp ring on the peripheral area of the substrate by lowering the plurality of pins by a first height by controlling the lifting unit and a second mode for placing the first clamp ring and the second clamp ring on the peripheral area of the substrate by lowering the plurality of pins by a second height by controlling the lifting unit.

12. A substrate treating method for treating a substrate using the substrate treating apparatus of claim 1, the substrate treating method comprising:

preventing, by a warpage prevention device, warpage of the substrate by applying a load to a peripheral area of the substrate by placing one or more clamp rings on the peripheral area of the substrate supported on a support chuck,

wherein the preventing of the warpage includes:

determining, by a controller, a lift height of a plurality of pins, based on at least one of a material of the substrate or a substrate treating process, wherein the plurality of pins are disposed around the support chuck and extend in an up/down direction; and

adjusting, by a lifting unit, the number of clamp rings placed on the peripheral area of the substrate, by vertically moving a plurality of clamp rings by vertically moving the plurality of pins depending on the lift height, wherein the plurality of clamp rings are supported on a plurality of support members provided on the plurality of pins along the up/down direction.

13. The substrate treating method of claim 12, wherein the number of clamp rings placed on the peripheral area of the substrate is increased as the plurality of pins are lowered by the controller and the lifting unit, and

wherein the number of clamp rings placed on the peripheral area of the substrate is decreased as the plurality of pins are raised by the controller and the lifting unit.

14. The substrate treating method of claim 12, wherein the preventing of the warpage includes:

adjusting, by the controller, a clamp load applied to the substrate, by selecting one of a first mode for placing a first clamp ring on the peripheral area of the substrate by lowering the plurality of pins by the first height by controlling the lifting unit and a second mode for placing the first clamp ring and a second clamp ring on the peripheral area of the substrate by lowering the plurality of pins by a second height by controlling the lifting unit.