SUBSTRATE PROCESSING APPARATUS

FIELD OF THE INVENTION

The present invention relates to the field of equipment in semiconductor production, and in particular to a substrate processing apparatus.

BACKGROUND

In process flows such as thin film deposition, etching, and photolithography, a substrate needs to be transported in various process modules or process chambers. Some of these modules or chambers are in the atmospheric environment and some are in the vacuum environment. Typically, a pre-loading platform is used as a transition chamber for the substrate to be transported between the atmospheric environment and the vacuum environment. The pre-loading platform comprises a loading chamber. When the substrate is transported from the atmospheric environment to the vacuum environment, the substrate needs to be temporarily stored in the loading chamber, then the loading chamber is evacuated to a vacuum state. And then the manipulator in the vacuum environment takes out the substrate from the loading chamber, and then clean nitrogen is introduced into the loading chamber to restore the loading chamber to the atmospheric pressure, so as to realize the transportation of the substrate from the atmospheric environment to the vacuum environment. The pre-loading platform further comprises an unloading chamber. When the substrate is transported from the vacuum environment to the atmospheric environment, it is necessary to evacuate the unloading chamber to the vacuum state and temporarily store the substrate in the unloading chamber. Then the unloading chamber is filled with clean nitrogen to make the unloading chamber in the atmospheric environment, and then the manipulator in the atmospheric environment takes out the substrate from the unloading chamber, thereby realizing the transportation of the substrate from the vacuum environment to the atmospheric environment.

At present, the pre-loading platform comprises four chambers, two of the chambers are loading chambers, and the other two chambers are unloading chambers. The loading chambers and the unloading chambers are arranged up and down, and only one substrate can be placed in the loading chamber and the unloading chamber. The

manipulator in the vacuum environment and the manipulator in the atmospheric environment can only carry one substrate at a time. At present, this technical solution has certain defects, such as the low transportation efficiency of substrates.

SUMMARY

In view of the above-described problems, an object of the present invention is to provide a substrate processing apparatus.

According to an embodiment of the present invention, a substrate processing apparatus is proposed, comprising a vacuum chamber, a process chamber, and a controller, a vacuum manipulator mechanism being provided in the vacuum chamber, and the process chamber being provided on the outer periphery of the vacuum chamber;

the vacuum manipulator mechanism comprising at least two layers of first bearing portions stacked up and down, and the at least two layers of first bearing portions being used for taking and placing at least two substrates;

at least two process treatment devices being arranged in the process chamber, each process treatment device comprising pins, the pins being used for carrying the substrate, and the controller being used for controlling the vacuum manipulator mechanism to sequentially take and place the at least two substrates according to different distance values between the top ends of the pins in each process treatment device and the bottom of the process chamber.

Compared with the prior art, the present invention has the following beneficial effects:

In the substrate processing apparatus provided in the present invention, the first bearing portions are used for taking and placing substrates. The vacuum manipulator mechanism comprises at least two layers of first bearing portions stacked up and down. The vacuum manipulator mechanism sequentially places substrates to be processed on different process treatment devices from low to high according to the distance values between the top ends of the pins and the bottom of the process chamber. The vacuum manipulator mechanism sequentially takes out processed substrates from high to low according to the distance values between the top ends of the pins and the bottom of the

process chamber. The vacuum manipulator mechanism can take and place at least two substrates at a time, effectively improving the transportation efficiency of substrates.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to more clearly explain the embodiments of the present invention or the technical solutions in the prior art, the drawings that need to be used in the description of the embodiments or the prior art will be briefly introduced below. And it is obvious that the drawings in the following description are only some embodiments of the present invention, and for those of ordinary skill in the art, other drawings can be obtained according to these drawings without making creative efforts.

FIG. 1 is a top view of a substrate processing apparatus according to an embodiment of the present invention.

FIG. 2(a) is a schematic structural view of a pre-loading platform and an atmospheric manipulator mechanism according to an embodiment of the present invention.

FIG. 2(b) is a schematic structural view of an inflation assembly according to an embodiment of the present invention.

FIG. 2(c) is a schematic structural view of a vacuum pumping assembly according to an embodiment of the present invention.

FIG. 2(d) is a schematic view of a partial structure of a pre-loading platform according to an embodiment of the present invention.

FIG. 3(a) is a schematic structural view of a vacuum chamber according to an embodiment of the present invention.

FIG. 3(b) is a schematic structural view of a vacuum manipulator mechanism according to an embodiment of the present invention.

FIGS. 4(a)–4(c) illustrate a process of placing a plurality of substrates by a vacuum manipulator mechanism according to an embodiment of the present invention.

FIGS. 5(a)–5(d) are views of the movement path process of a vacuum manipulator mechanism placing the substrates and schematic views of a corresponding pre-loading platform according to an embodiment of the present invention.

FIGS. 6(a)–6(b) are schematic views of a vacuum manipulator mechanism placing substrates and a corresponding pre-loading platform according to another embodiment of the present invention.

FIGS. 7(a)–7(c) are schematic views of a vacuum manipulator mechanism placing substrates, a vacuum manipulator mechanism, and a corresponding pre-loading platform according to another embodiment of the present invention.

FIGS. 8(a)–8(b) are schematic views of a vacuum manipulator mechanism placing substrates and a corresponding pre-loading platform according to another embodiment of the present invention.

FIGS. 9(a)–9(c) are schematic views of a vacuum manipulator mechanism placing substrates, a vacuum manipulator mechanism, and a corresponding pre-loading platform according to another embodiment of the present invention.

FIGS. 10(a)–10(c) are schematic views of a vacuum manipulator mechanism placing substrates, a vacuum manipulator mechanism, and a corresponding pre-loading platform according to another embodiment of the present invention.

FIGS. 11(a)–11(c) are schematic views of a vacuum manipulator mechanism placing substrates, a vacuum manipulator mechanism, and a corresponding pre-loading platform according to another embodiment of the present invention.

FIG. 12 is a schematic view of a connection relationship between a controller and various components according to an embodiment of the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

In order to make the object, features, and advantages of the present invention more obvious and easier to understand, the technical solutions in the embodiments of the present invention will be clearly and completely described below with reference to the

accompanying drawings in the embodiments of the present invention. And it is obvious that the embodiments described below are only some embodiments of the present invention, but not all embodiments. Based on the embodiments in the present invention, all other embodiments obtained by those of ordinary skill in the art without making creative efforts fall within the scope of protection of the present invention.

In the description of the present invention, it is to be understood that when one component is considered to be "connected" to another component, the component may be directly connected to another component or there may be components disposed in the middle at the same time. When a component is considered to be "disposed" on another component, the component may be disposed directly on another component or there may be components disposed in the middle at the same time.

Hereinafter, the technical solutions of the present invention will be further described with reference to the accompanying drawings and specific embodiments.

As shown in FIG. 1, the present embodiment provides a substrate processing apparatus, comprising process chambers 1, a pre-loading platform 2, a front-end module 3, a vacuum chamber 4, and a controller 5. The number of the process chambers 1 is three, and the process chambers 1 are sequentially arranged on the outer periphery of the vacuum chamber 4. The pre-loading platform 2 is arranged between the front-end module 3 and the vacuum chamber 4. In other embodiments, a plurality of process chambers 1 are symmetrically arranged on both sides of the vacuum chamber 4.

The front-end module 3 comprises substrate loading ports 31 and an atmospheric manipulator mechanism 32. The substrate loading ports 31 are used for placing substrate boxes, and the substrate boxes may be front opening unified pods (FOUP). A plurality of substrates are placed in the substrate boxes. A vacuum manipulator mechanism 41 is provided in the vacuum chamber 4. Both the atmospheric manipulator mechanism 32 and the vacuum manipulator mechanism 41 are connected to the controller 5. The controller 5 controls the atmospheric manipulator mechanism 32 to transport substrates between the substrate boxes and the pre-loading platform 2, and controls the vacuum manipulator mechanism 41 to transport substrates between the pre-loading platform 2 and the process chambers 1.

As shown in FIG. 2(a), the pre-loading platform 2 comprises two chambers 21 arranged side by side along the horizontal direction. In each chamber 21, at least two substrates 6 to be processed or at least two processed substrates 6 can be stacked up and down.

As shown in FIG. 3(b), the vacuum manipulator mechanism 41 comprises a mechanical arm and a bottom device 414. The mechanical arm is disposed on the bottom device 414. The bottom device 414 comprises a housing 4141, a lifting assembly 4142 inside the housing 4141, and a rotating assembly (not shown in the figure). The lifting assembly 4142 drives the mechanical arm to elevate and lower, and the rotating assembly drives the mechanical arm to rotate. The mechanical arm comprises an end effector 411, a main arm 412, and a secondary arm 413. Wherein, the main arm 412 is rotationally disposed on the bottom device 414, the secondary arm 413 is rotationally disposed on the main arm 412, and the end effector 411 is rotationally disposed on the secondary arm 413. With reference to FIG. 4 (a), the end effector 411 comprises at least two layers of first bearing portions 4111 (three layers are schematically illustrated in the figure) stacked up and down. Generally, each first bearing portion 4111 is used to take and place one substrate 6. The distance (vertical distance) between adjacent first bearing portions 4111 is the same as the distance between two adjacent substrates 6 placed in the chamber 21. A plurality of first bearing portions 4111 simultaneously take and place the plurality of substrates 6 in the chamber 21. The vacuum manipulator mechanism 41 can take and place at least two substrates 6 at a time.

Back to FIG. 1, at least two process treatment devices 11 are provided in one process chamber 1. The process treatment devices 11 may be devices for performing photolithographic processing on substrates, for etching processing, for thin film deposition processing, or the like. The process treatment devices 11 in the embodiment of the present invention are described as thin film deposition treatment devices.

The vacuum manipulator mechanism 41 takes out processed substrates 6 from different process treatment devices 11 in the same process chamber 1 and places the substrates 6 at the pre-loading platform 2. Alternatively, the vacuum manipulator mechanism 41 takes out a plurality of substrates 6 to be processed at a time from the pre-loading platform 2 and places the substrates 6 to be processed on the different

process treatment devices 11 in the same process chamber 1, respectively. The substrates 6 complete process treatment on the respective process treatment devices 11.

Alternatively, the vacuum manipulator mechanism 41 may take out the processed substrates 6 from different process chambers 1, and place a plurality of substrates 6 to be processed on process treatment devices 11 in different process chambers 1, respectively.

As shown in FIGS. 2(a) and 2(d), the pre-loading platform 2 further comprises an upper cover 24 and a gate valve unit 23. The upper cover 24 is provided at the top of the chamber 21. The gate valve unit 23 comprises a first gate valve 231, a first chamber port 233, a second chamber port 234, and a second gate valve 232. The side of the chamber 21 facing the front-end module 3 is provided with the first chamber port 233, and the first gate valve 231 is used to open or close the first chamber port 233. The specific operation process is that the first gate valve 231 is removed from the first chamber port 233 to open the first chamber port 233, the pre-loading platform 2 and the front-end module 3 are connected through the first chamber port 233, and the atmospheric manipulator mechanism 32 takes and places substrates 6 at the position of pre-loading platform 2. The side of the chamber 21 facing the vacuum chamber 4 is provided with the second chamber port 234, and the second gate valve 232 is used to open or close the second chamber port 234. The specific operation process is that the second gate valve 232 is removed from the second chamber port 234 to open the second chamber port 234, the pre-loading platform 2 and the vacuum chamber 4 are connected through the second chamber port 234, and the vacuum manipulator mechanism 41 takes and places the substrates 6 at the position of pre-loading platform 2.

As shown in FIGS. 2(a) to 2(c), the pre-loading platform 2 comprises an inflation assembly 25 and a vacuum pumping assembly 26. The inflation assembly 25 comprises first actuators 253, each of different chambers 21 is provided with a first actuator 253 correspondingly. The first actuator 253 is installed on the chamber 21, and nitrogen, inert gas, and the like are introduced into the chamber 21 through the first actuator 253. Damage to any of the first actuators 253 does not affect the normal use of the other chamber 21. In other embodiments, all of the chambers 21 or a plurality of chambers 21 may share a first actuator 253, and all of the chambers 21 or the plurality of chambers 21 may be inflated simultaneously though the first actuator 253. The

controller 5 controls the opening and closing of the first actuator 253. After the chambers 21 are filled with sufficient amount of gas, the pressure in the chambers 21 is equivalent to the atmospheric pressure. The first gate valves 231 are opened, so that the atmospheric manipulator mechanism 32 can take the substrates 6 from and place the substrates 6 into the chambers 21.

Optionally, the inflation assembly 25 comprises a first gas branch 251 and a second gas branch 252, and a first actuator 253 is provided on the first gas branch and the second gas branch, respectively. When the chambers 21 are filled with gas, in order to avoid splashing of particulate matter in the chambers 21 caused by excessive gas flow, the controller 5 controls the inflation assembly 25 to firstly open any gas branch, that is, the first gas branch 251 or the second gas branch 252. After the chambers 21 are transited from the vacuum state to having a certain gas pressure, the controller 5 controls the first gas branch 251 and the second gas branch 252 to be in the open state at the same time.

The vacuum pumping assembly 26 comprises second actuators 261 mounted on the chambers 21, and the chambers 21 are evacuated by the second actuators 261. Each of the different chambers 21 is provided with a second actuator 261 correspondingly. Damage to any one of the second actuators 261 does not affect the normal use of the other chamber 21. In other embodiments, all chambers 21 or a plurality of chambers 21 may share a second actuator 261, and all chambers 21 or the plurality of chambers 21 may be evacuated simultaneously through the second actuator 261. The controller 5 controls the opening and closing of the second actuator 261. The vacuum pumping assembly 26 evacuates the inside of chambers 21 into the vacuum state. The second gate valves 232 are opened, so that the vacuum manipulator mechanism 41 takes and places the substrates 6 from the chambers 21.

As shown in FIG. 2 (d), substrate towers 22 are disposed in the chamber 21. Each substrate tower 22 comprises a bracket upright 221 and a multi-layer substrate tower shelf 222. The bracket upright 221 is disposed at the bottom of the chamber 21, and the substrate tower shelve 222 is disposed on the bracket upright 221. Each substrate 6 is placed on the substrate tower shelf 222 of a corresponding layer. Four substrate towers 22 are arranged in one chamber 21, and the four substrate towers 22 are arranged symmetrically with respect to the center of the substrates 6. Certainly, the

number and arrangement of the substrate towers 22 are not limited thereto, and in other embodiments, at least two substrate towers 22 are disposed within the chamber 21.

The atmospheric manipulator mechanism 32 comprises at least two layers of second bearing portions 321 stacked up and down, the distance between adjacent second bearing portions 321 is the same as the distance between adjacent substrate tower shelves 222 in the chamber 21, and the second bearing portions 321 are used for taking and placing the substrates 6.

The distance between two adjacent substrates 6 in the substrate box of the present invention is the same as the distance between adjacent second bearing portions 321. The second bearing portions 321 take the substrates 6 from the substrate box, and the atmospheric manipulator mechanism 32 can take two or more substrates 6 to be processed at a time.

The process of transporting the substrates 6 between the atmospheric environment and the vacuum environment is described below. The atmospheric manipulator mechanism 32 takes out the substrates 6 to be processed from the substrate boxes, and the first gate valves 231 and the second gate valves 232 are both closed. The inflation assembly 25 works, so that the pressure in the chamber 21 is equivalent to the atmospheric pressure. And then the first gate valves 231 are opened, and the atmospheric manipulator mechanism 32 places substrates 6 to be processed on the substrate tower shelf 222 of the corresponding layers in the chamber 21 at a time. Then, the first gate valves 231 are closed, the vacuum pumping assembly 26 works, and the chamber 21 is evacuated inside. And then the second gate valves 232 are opened, the vacuum manipulator mechanism 41 takes out two or more substrates 6 to be processed from the chamber 21 at a time, and transports the substrates 6 to the process chamber 1. The second gate valves 232 are then closed. After the process treatment of the substrates 6 is completed, the second gate valves 232 are opened again, the vacuum manipulator mechanism 41 takes outs the two or more processed substrates 6 from the process chamber 1 and places the processed substrates 6 into the other chamber 21 of the pre-loading platform 2 or into the above chamber 21. The second gate valves 232 are closed, and the inflation assembly 25 works, so that the pressure in the chamber 21 is equivalent to the atmospheric pressure. The first gate valves 231 are opened again, and the atmospheric manipulator mechanism 32 takes two or more processed substrates

6 from the pre-loading platform 2 at a time and places the processed substrates 6 into the substrate boxes. Hence, the effective transportation of the substrates 6 between the atmospheric environment and the vacuum environment can be achieved.

With reference to FIG. 2(d) and FIG. 3(a), the vacuum chamber 4 is provided with an opening 42. After both the second gate valve 232 on the chamber 21 of the pre-loading platform 2 and the gate valve of the opening 42 are opened, the vacuum chamber 4 connects with the chamber 21 of the pre-loading platform 2 through the opening 42 and the second chamber port 234, and the vacuum manipulator mechanism 41 enters the chamber 21 to take and place the substrates 6 through the opening 42 and the second chamber port 234.

As shown in FIGS. 4(a) to 4(c), according to one embodiment of the present invention, each process treatment device 11 comprises pins 111, a heating tray 112, and a tray shaft 113. The heating tray 112 is disposed on the tray shaft 113, and the tray shaft 113 is disposed at the bottom of the process chamber 1. The heating tray 112 is provided with accommodation holes, and the pins 111 can move in the accommodation holes. One process treatment device 11 comprises three pins 111, and all of the pins are of fixed height. One ends of the pins 111 are arranged at the bottom of the process chamber 1 through the pin seat 114, and the other ends (i.e. the top ends) of the pins 111 can extend out of the heating tray 112 and carry the substrates 6. The controller 5 controls the tray shaft 113 to elevate and lower, so as to realize relative movement between the heating tray 112 and the pins 111. The distance values between the top ends of the pins 111 on different process treatment devices 11 in the same process chamber 1 and the bottom of the process chamber 1 is not equal. The vacuum manipulator mechanism 41 sequentially places the plurality of substrates 6 on the different process treatment devices 11 according to the distance values from low to high. In FIG. 4 (a), the vacuum manipulator mechanism 41 enters the first process treatment device 11 and places the substrate 6 located at the lowest layer on the three lowest pins 111; In FIG. 4 (b), the vacuum manipulator mechanism 41 enters the second process treatment device 11 and places the substrate 6 at the middle layer on the three pins 111 at the middle height; In FIG. 4 (c), the vacuum manipulator mechanism 41 enters the third process treatment device 11 and places the uppermost substrate 6 on the highest three pins 111.

In other embodiments, the controller 5 controls the elevation and lowering of the pin seat 114, so that the pins 111 are elevated and lowered. Before the pin seat 114 is elevated and lowered, the distance values of the pins 111 on different process treatment devices 11 in the same process chamber 1 with respect to the bottom of the process chamber 1 may be equal. When the substrates 6 are placed, the controller 5 controls the pin seat 114 to be elevated and lowered. The height of the elevation and lowering of pins 111 on different process treatment devices 11 in the same process chamber 1 are different, so that the distance values between the top ends of the pins 111 on different process treatment devices 11 and the bottom of the process chamber 1 are not equal. The vacuum manipulator mechanism 41 sequentially places the substrates 6 according to the different distance values. Optionally, before the pin seat 114 is elevated and lowered, the distance values of the pins 111 on different process treatment devices 11 in the same process chamber 1 with respect to the bottom of the process chamber 1 are not equal. When the substrates 6 are placed, the height of the elevation and lowering of pins 111 on different process treatment devices 11 are different or the same, and the pin seat 114 is elevated and lowered, ultimately making the distance values between the top ends of the pins 111 on different process treatment devices 11 and the bottom of the process chamber 1 unequal. Herein, it should be noted that the distance values between the top ends of the pins 111 on the plurality of process treatment devices 11 in the same process chamber 1 and the bottom of the process chamber 1 may be the same or different, and may be set according to actual process requirements.

As shown in FIG.1, in an alternative embodiment, the front-end module 3 comprises a cooling unit 33 and a centering unit 34. The cooling unit 33 and the centering unit 34 are provided on both sides of the atmospheric manipulator mechanism 32, respectively. The substrate boxes are made of plastic materials and cannot withstand substrates 6 in a high-temperature state. The process treatment devices 11 are thin film treatment devices, and the atmospheric manipulator mechanism 32 places processed substrates 6 on the cooling unit 33, and then places the substrates 6 back into the substrate loading ports 31 after the substrates 6 are cooled to the room temperature.

The position of the substrates 6 in the substrate boxes has free movement range

of about 2 mm, and the center position of the substrates 6 and the position of the substrate notches are uncertain. The centering unit 34 has a rotating member inside, and the rotating member can be used to unify the orientation of the notch position of the substrates. The centering unit 34 feeds back the center position of the substrates to the controller 5, and the controller 5 controls the atmospheric manipulator mechanism 32 to accurately grasp the substrates 6.

The following is an embodiment in which the vacuum manipulator mechanism 41 comprises one mechanical arm.

As shown in FIGS. 5(a) to 5(d), in one embodiment, three process chambers 1 are sequentially arranged on the outer periphery of the vacuum chamber 4. Each process chamber 1 is provided with three process treatment devices 11 inside. The vacuum manipulator mechanism 41 adopts the structure in FIG. 3(b), and the mechanical arm comprises an end effector 411, and the end effector 411 comprises three layers of first bearing portions 4111. The pre-loading platform 2 comprises two chambers 21. The atmospheric manipulator mechanism 32 takes out three substrates 6 to be processed from the substrate boxes and places the substrates 6 to be processed in one of the chambers 21 of the pre-loading platform 2, and the vacuum manipulator mechanism 41 takes out the three substrates 6 and then sequentially places the substrates 6 on different process treatment devices 11 in the same process chamber 1. The other chamber 21 of the pre-loading platform 2 is used for placing processed substrates 6.

FIGS. 5(a) to 5(c) show the movement path of the vacuum manipulator mechanism 41. The pins 111 at the positions of three process treatment devices 11 in each process chamber are defined as No. 1, No. 2, and No. 3 respectively, and the arrangement of the pins 111 is shown in FIGS. 4(a) to 4(c). The vacuum manipulator mechanism 41 firstly places the first substrate 6 located at the lowest layer on the pin 111 of No. 1, then the vacuum manipulator mechanism 41 returns to the vacuum chamber 4, then places the second substrate 6 located at the middle layer on the pin 111 of No. 2, and finally, the vacuum manipulator mechanism 41 returns to the inside of vacuum chamber 4, and then places the third substrate 6 located at the uppermost layer on the pin 111 of No. 3, thereby completing the placement of the three substrates 6. After the substrate processing is completed, the vacuum manipulator mechanism 41 firstly takes the substrate 6 located at the uppermost layer, then takes the substrate 6

located at the middle layer, and finally takes the substrate 6 located at the lowest layer.

As shown in FIGS. 6(a) – 6(b), in contrast to the embodiment described in FIGS. 5 (a) – 5(c), in the embodiment shown in FIGS. 6(a) – 6(b), an end effector 411 comprises four layers of first bearing portions 4111. Four process treatment devices 11 are provided in each process chamber 1. The pins 111 at the positions of four process treatment devices 11 are defined as No. 1, No. 2, No. 3, and No. 4 respectively, and the arrangement of the pins 111 is shown in FIGS. 4(a) to 4(c).

The pre-loading platform 2 comprises two chambers 21. The height of the pin 111 of No. 1 is H1, the height of the pin 111 of No. 2 is H2, the height of the pin 111 of No. 3 is H3, and the height of the pin 111 of No. 4 is H4, and $H2 < H1 < H4 < H3$. It should be noted that the height of the pins 111 refer to the distance values of the pins 111 relative to the bottom of the process chamber 1. The atmospheric manipulator mechanism 32 takes out four substrates 6 to be processed at a time and places the substrates 6 in one of the chambers 21. The vacuum manipulator mechanism 41 takes out the four substrates 6 at the same time and then places the four substrates 6 on different process treatment devices 11 in the same process chamber 1 in sequence, and the vacuum manipulator mechanism 41 places the plurality of substrates 6 on the pins 111 of No. 2, 1, 4, and 3 in sequence according to the height of the pins 111. The other chamber 21 is used for placing processed substrates 6.

As shown in FIGS. 7(a) – 7(c), in contrast to the embodiment described in FIGS. 6 (a) – 6(b), in the embodiment disclosed in FIGS. 7(a) – 7(c), the mechanical arm comprises two horizontally arranged end effectors 411, and each end effector 411 takes and places two substrates 6.

Four process treatment devices 11 are arranged in one process chamber 1. For convenience of description, in one process chamber 1, the direction horizontal to the arrangement direction of the two end effectors 411 when the mechanical arm takes and places the substrates 6 is defined as a row, and the direction perpendicular to the row is defined as a column. Each row and each column are provided with two process treatment devices 11, and the four process treatment devices 11 are arranged in a matrix when viewed from top.

The pins 111 at the positions of four process treatment devices 11 in one process chamber 1 are defined as No. 1, No. 2, No. 3, and No. 4, respectively. The height of the pin 111 of No. 1 equals the height of the pin 111 of No. 3, for example, the height of the pin 111 of No. 1 is H1, the height of pin 111 of No. 2 equals the height of pin 111 of No. 4, for example, the height of the pin 111 of No. 2 is H2, and H2 < H1.

The pre-loading platform 2 comprises four chambers 21. The four chambers 21 are arranged in a matrix when viewed from the side. The two chambers 21 of the upper layer and the two chambers 21 of the lower layer are both horizontally arranged. The spacing between the central positions of the two chambers 21 of the upper layer is equal to the spacing between the central positions of the two chambers 21 of the lower layer. The two chambers 21 of the upper layer are used for placing substrates 6 to be processed, and the two chambers 21 of the lower layer are used for placing processed substrates 6. Certainly, the two chambers 21 of the upper layer can also place processed substrates 6, and the two chambers 21 of the lower layer can place substrates 6 to be processed.

The distance D1 between the central positions of the two end effectors 411 is equal to the distance D2 between the central positions of the two chambers 21 of the upper layer, and is equal to the distance D3 between the central positions of the two process treatment devices 11 in each row.

The two end effectors 411 firstly take the processed substrates 6 of No. 1 and No. 3 at the same time, and then take the processed substrates 6 of No. 2 and No. 4 at the same time. After taking the four substrates 6, the vacuum manipulator mechanism 41 places the processed substrates 6 in the two chambers 21 of the upper layer or the two chambers 21 of the lower layer. Then, the two end effectors 411 take out the four substrates 6 to be processed from the other two chambers 21 and rotate to the positions of process chamber 1. The two end effectors 411 firstly place the two substrates 6 to be processed on the pins 111 of No. 2 and No. 4 respectively at the same time, and then place the two substrates 6 to be processed on the pins 111 of No. 1 and No. 3 respectively at the same time.

As shown in FIGS. 8(a) – 8(b), in contrast to the embodiment described in FIGS. 5 (a) – 5(c), in the embodiment shown in FIGS. 8(a) – 8(b), the pre-loading platform 2

comprises a chamber 21. Six layers of the substrate tower shelf 222 are provided correspondingly in the chamber 21. In the chamber 21, three substrates 6 to be processed are placed on the three upper layers of the substrate tower shelf 222, and the three lower layers of the substrate tower shelf 222 are used for placing three processed substrates 6. This placement method can prevent residues carried by the processed substrates 6 from falling onto the substrates 6 to be processed.

The pins 111 at the positions of three process treatment devices 11 in one process chamber 1 are defined as No. 1, No. 2, and No. 3 respectively. The height of the pin 111 of No. 1 is H1, the height of the pin 111 of No. 2 is H2, and the height of the pin 111 of No. 3 is H3, and H2 < H1 < H3. The vacuum manipulator mechanism 41 rotates to the position of process chamber 1, firstly takes three processed substrates 6 from the process chamber 1, then rotates to the position of the chamber 21, places the three processed substrates 6 on the substrate tower shelf 222 of the lower three layers, then takes out the three substrates 6 to be processed, and finally the vacuum manipulator mechanism 41 places the three substrates 6 to be processed on the pins 111 of No. 2, No. 1, and No. 3 in sequence.

The following is an embodiment in which the vacuum manipulator mechanism 41 comprises two mechanical arms.

As shown in FIGS. 9(a) – 9(c), in one embodiment, the main arms 412 of both mechanical arms are rotationally disposed on the bottom device 414. The bottom device 414 drives the two mechanical arms to elevate, lower, and rotate simultaneously. Each mechanical arm comprises an end effector 411, and each end effector 411 takes and places four substrates 6. The two end effectors 411 are arranged vertically.

The pins 111 at the positions of four process treatment devices 11 in one process chamber 1 are defined as No. 1, No. 2, No. 3, and No. 4 respectively, and the arrangement of the pins 111 is shown in FIGS. 4(a) to 4(c). The height of the pin 111 of No. 1 is H1, the height of the pin 111 of No. 2 is H2, the height of the pin 111 of No. 3 is H3, and the height of the pin 111 of No. 4 is H4, and H2 < H1 < H4 < H3. The pre-loading platform 2 comprises two chambers 21.

When one of the mechanical arms is working, the secondary arm 413 is rotated

by a set angle relative to the main arm 412, the end effector 411 is rotated by a set angle relative to the secondary arm 413, and the end effector 411 of the mechanical arm is extended by a set length relative to the end effector 411 of the other mechanical arm toward the direction of the process chamber 1. The above end effector 411 is firstly extended, the upper end effector 411 is extended by the set length toward the direction of the process chamber 1 relative to the lower end effector 411. The upper end effector 411 sequentially takes out the processed substrates 6 of No. 3, No. 4, No. 1, and No. 2, and after taking out the processed substrates 6, the upper end effector 411 is withdrawn back into the vacuum chamber 4 through the main arm 412 and the secondary arm 413. Then, the lifting assembly 4142 drives the two mechanical arms to elevate, the lower end effector 411 is elevated to a height that can take and place the substrates 6, the lower end effector 411 extends the set length toward the direction of the same process chamber 1 through the main arm 412 and the secondary arm 413, and the lower end effector 411 places four substrates 6 to be processed on the pins 111 of No. 2, No. 1, No. 4, and No. 3 in sequence.

The two mechanical arms are then rotated to the position of pre-loading platform 2, the upper end effector 411 places the four processed substrates 6 in one of the chambers 21, and the lower end effector 411 takes out substrates 6 to be processed that are placed in advance in the other chamber 21.

After one of the mechanical arms takes out the processed substrates 6 from the process chamber 1, the other mechanical arm can immediately put into substrates 6 to be processed, and in this process, the mechanical arm does not need to return to the pre-loading platform 2 to take the substrates 6 to be processed, thereby further improving the transportation efficiency.

As shown in FIGS. 10(a) to 10(c), compared with the embodiment described in FIGS. 9(a) to 9(c), in the embodiment disclosed in FIGS. 10(a) to 10(c), each mechanical arm comprises two horizontally arranged end effectors 411, and one end effector 411 comprises two layers of first bearing portions 4111. One end effector 411 takes and places two substrates 6, and each mechanical arm can be used to take and place four substrates 6. The two end effectors 411 of one mechanical arm are positioned above and the two end effectors 411 of the other mechanical arm are positioned below.

The pre-loading platform 2 comprises four chambers 21. The four chambers 21 are arranged in a matrix when viewed from the side. The two chambers 21 of the upper layer and the two chambers 21 of the lower layer are both horizontally arranged.

Four process treatment devices 11 are arranged in one process chamber 1. For convenience of description, in one process chamber 1, the direction horizontal to the arrangement direction of the two end effectors 411 when the mechanical arms take and place substrates 6 is defined as a row, and the direction perpendicular to the row is defined as a column. Each row and each column are provided with two process treatment devices 11, and the four processing devices 11 are arranged in a matrix when viewed from top.

The pins 111 at the positions of four process treatment devices 11 in one process chamber 1 are defined as No. 1, No. 2, No. 3, and No. 4 respectively. The height of the pin 111 of No. 1 is equal to the height of the pin 111 of No. 3, for example, the height of the pin 111 of No. 1 is H1, and the height of the pin 111 of No. 2 is equal to the height of the pin 111 of No. 4, for example, the height of the pin 111 of No. 2 is H2, and $H2 < H1$.

The distance D4 between the central positions of the two end effectors 411 is equal to the distance D5 between the central positions of the two chambers 21 of the upper layer (or the distance between the central positions of the two chambers 21 of the lower layer), and is equal to the distance D6 between the central positions of the two process treatment devices 11 in each row. When one of the mechanical arms is working, the two end effectors 411 of the mechanical arm are extended by a set length relative to the two end effectors 411 of the other mechanical arm. In this embodiment, the two upper end effectors 411 are firstly extended. The two upper end effectors 411 are extended by a set length toward the direction of the process chamber 1 relative to the two lower end effectors 411, and the two upper end effectors 411 first simultaneously take the processed substrates 6 of No. 1 and No. 3, and then simultaneously take the processed substrates 6 of No. 2 and No. 4. After the processed substrates 6 are taken, the mechanical arm located above is withdrawn back into the vacuum chamber 4 through the main arm 412 and the secondary arm 413.

Then, the lifting assembly 4142 drives the two mechanical arms to elevate, the

two lower end effectors 411 elevate to a height that can take and place the substrates 6, and the two lower end effectors 411 extend by the set length toward the direction of the same process chamber 1 through the main arms 412 and the secondary arms 413. The two lower end effectors 411 first simultaneously place the two substrates 6 to be processed on the pins 111 of No. 2 and No. 4 respectively, and then simultaneously place the two substrates 6 to be processed on the pins 111 of No. 1 and No. 3 respectively.

Finally, the two mechanical arms rotate to the position of the pre-loading platform 2 and place the processed substrates 6 into the two chambers 21 of the upper layer or the two chambers 21 of the lower layer.

After one of the mechanical arms takes out the four processed substrates 6 from the process chamber 1, the other mechanical arm can immediately place the four substrates 6 to be processed into the process chamber 1, which also improves the transportation efficiency.

As shown in FIGS. 11(a) – 11(c), in contrast to the embodiment described in FIGS. 9(a) – 9(c), in the embodiment shown in FIGS. 11(a) – 11(c), two end effectors 411 are arranged horizontally. After one of the mechanical arms takes out four processed substrates 6 from the process chamber 1, the controller 5 controls the rotating assembly in the bottom device 414 to work so that the two mechanical arms rotate, and the other mechanical arm rotates to the position of the process chamber 1 and places four substrates 6 to be processed into the process chamber 1.

With respect to the embodiment described in FIGS. 9(a) – 9(c), this embodiment reduces the stack height of a plurality of end effectors 411, effectively utilizing the internal space of the vacuum chamber 4.

In other embodiments, the bottom device 414 comprises two rotating assemblies, and the two rotating assemblies respectively control the rotation of corresponding mechanical arms. After one of the mechanical arms takes out four processed substrates 6 from the process chamber 1, the mechanical arm is driven to rotate to another position by the corresponding rotating assembly, and the other mechanical arm is driven to rotate to the position of the process chamber 1 by the corresponding rotating assembly

and places four substrates 6 to be processed into the process chamber 1.

As described above, the above embodiments are merely used to describe the technical solutions of the present invention, and are not intended to limit the present invention. Although the present invention has been described in detail with reference to the aforementioned embodiments, those of ordinary skill in the art should understand that the technical solutions described in the aforementioned embodiments may be modified or some technical features may be equivalently replaced. However, these modifications or substitutions do not deviate the essence of the corresponding technical solutions from the spirit and scope of the technical solutions of each embodiment of the present invention.

What is claimed is:

1. A substrate processing apparatus, comprising a vacuum chamber, a process chamber, and a controller, a vacuum manipulator mechanism being provided in the vacuum chamber, the process chamber being provided on the outer periphery of the vacuum chamber;

the vacuum manipulator mechanism comprising at least two layers of first bearing portions stacked up and down, and the at least two layers of first bearing portions being used for taking and placing at least two substrates;

at least two process treatment devices being arranged in the process chamber, each process treatment device comprising pins, the pins being used for carrying the substrate, and the controller being used for controlling the vacuum manipulator mechanism to sequentially take and place the at least two substrates according to different distance values between the top ends of the pins in each process treatment device and the bottom of the process chamber.

2. The substrate processing apparatus according to claim 1, wherein the vacuum manipulator mechanism comprises at least one mechanical arm, each mechanical arm comprises at least one end effector, and each end effector comprises the at least two layers of first bearing portions.

3. The substrate processing apparatus according to claim 2, wherein the vacuum manipulator mechanism further comprises a bottom device, the mechanical arm further comprises a main arm and a secondary arm, the main arm is rotationally disposed on the bottom device, the secondary arm is rotationally disposed on the main arm, and the end effector is rotationally disposed on the secondary arm.

4. The substrate processing apparatus according to claim 1, further comprising a pre-loading platform and a front-end module, wherein the pre-loading platform is disposed between the front-end module and the process chamber;

the front-end module comprises an atmospheric manipulator mechanism, the atmospheric manipulator mechanism is used for transporting the at least two substrates between the front-end module and the pre-loading platform, and the vacuum

manipulator mechanism is used for transporting the at least two substrates between the pre-loading platform and the process chamber;

the pre-loading platform comprises at least one chamber, and each chamber is used for accommodating the at least two substrates stacked up and down;

the atmospheric manipulator mechanism comprises at least two layers of second bearing portions stacked up and down.

5. The substrate processing apparatus according to claim 1, wherein each process treatment device comprises a plurality of pins, and the distance values between the top ends of the plurality of pins and the bottom of the process chamber are fixed.

6. The substrate processing apparatus according to claim 1, wherein each process treatment device comprises a pin seat, the pins are disposed at the bottom of the process chamber through the pin seat, and the controller is used to control the pin seat to elevate and lower so that the pins are elevated and lowered.

7. The substrate processing apparatus according to claim 4, wherein the pre-loading platform further comprises a substrate tower disposed within each of the chambers, the substrate tower comprises a bracket upright and multi-layer substrate tower shelves, the bracket upright is disposed at the bottom of the chamber, the multi-layer substrate tower shelves are disposed on the bracket upright, and the multi-layer substrate tower shelves are used for placing the at least two layers of substrates.

8. The substrate processing apparatus according to claim 4, wherein the pre-loading platform further comprises a gate valve unit and an upper cover, the upper cover is disposed on the top of the chamber;

the gate valve unit comprises a first chamber port, a first gate valve, a second chamber port, and a second gate valve, the first chamber port is disposed on the side surface of the chamber facing the front-end module, and the first gate valve is used to open or close the first chamber port;

the second chamber port is disposed on the side surface of the chamber facing the vacuum chamber, and the second gate valve is used to open or close the second

chamber port.

9. The substrate processing apparatus according to claim 4, wherein the pre-loading platform further comprises an inflation assembly and a vacuum pumping assembly;

the inflation assembly comprises a first actuator, the first actuator is mounted on the corresponding chamber of the pre-loading platform, and the controller is used to control the opening and closing of the first actuator to control the amount of nitrogen within the corresponding chamber;

the vacuum pumping assembly comprises a second actuator, the second actuator is mounted on the corresponding chamber of the pre-loading platform, and the controller is used to control the opening and closing of the second actuator to control the vacuum degree in the corresponding chamber.

10. The substrate processing apparatus according to claim 9, wherein the inflation assembly further comprises a first gas branch and a second gas branch, and the controller is used to control the opening and closing of the first gas branch and the second gas branch to control the gas flow velocity in the corresponding chamber.

11. The substrate processing apparatus according to claim 1, wherein the substrate processing apparatus comprises at least two of the process chambers, and all of the process chambers are symmetrically arranged on both sides of the vacuum chamber or sequentially arranged on the outer periphery of the vacuum chamber.

12. The substrate processing apparatus according to claim 7, wherein the distance between the adjacent second bearing portions is the same as the distance between the adjacent substrate tower shelves.

13. The substrate processing apparatus according to claim 4, wherein the front-end module comprises a cooling unit, the cooling unit is disposed on one side of the atmospheric manipulator mechanism, and the cooling unit is used to cool the processed substrates.

14. The substrate processing apparatus according to claim 4, wherein the front-

end module comprises a centering unit, the centering unit is used to feed back the center positions of the at least two substrates to the controller, and the controller is used to control the atmospheric manipulator mechanism to grasp the at least two substrates;

the centering unit has a rotating member inside, and the rotating member is used for unifying the orientation of the notch positions of the at least two substrates.

15. The substrate processing apparatus according to claim 2, wherein the vacuum manipulator mechanism comprises the mechanical arm, and the mechanical arm comprises the end effector.

16. The substrate processing apparatus according to claim 2, wherein the vacuum manipulator mechanism comprises the mechanical arm, the mechanical arm comprises two horizontally arranged end effectors, and each end effector is used for simultaneously taking and placing the at least two substrates.

17. The substrate processing apparatus according to claim 2, wherein the vacuum manipulator mechanism comprises two mechanical arms, and each mechanical arm comprises the end effector;

the end effector of the working mechanical arm is extended by a set length toward the direction of the process chamber relative to the end effector of the non-working mechanical arm.

18. The substrate processing apparatus according to claim 2, wherein the vacuum manipulator mechanism comprises two mechanical arms, and each mechanical arm comprises two horizontally arranged end effectors;

wherein the two end effectors of the working mechanical arm are extended by a set length toward the direction of the process chamber relative to the two end effectors of the non-working mechanical arm.

19. The substrate processing apparatus according to claim 2, wherein the vacuum manipulator mechanism comprises two mechanical arms, each mechanical arm comprises the end effector, and the two end effectors are arranged horizontally.

20. The substrate processing apparatus according to claim 16 or 18, wherein a pre-loading platform comprises four chambers, the four chambers are arranged in a matrix when viewed from the side;

the two chambers of the upper layer or the two chambers of the lower layer are used to simultaneously receive the processed or unprocessed substrates on the two end effectors that are arranged horizontally.

21. The substrate processing apparatus according to claim 20, wherein the direction horizontal to the arrangement direction of the two end effectors when the mechanical arm takes and places the substrates is defined as a row in the process chamber;

the distance between the center positions of the two end effectors = the spacing between the center positions of the two chambers of the upper layer = the spacing between the center positions of the two chambers of the lower layer = the spacing between the center positions of the two adjacent process treatment devices on each row.

22. The substrate processing apparatus according to claim 15, wherein the pre-loading platform comprises a chamber, and the chamber is used for stacking at least two processed substrates up and down and stacking at least two substrates to be processed up and down.