

DRYING APPARATUS

FIELD OF THE INVENTION

The present invention relates to the technical field of semiconductor manufacturing, and in particular to a drying apparatus.

BACKGROUND

In the process of integrated circuit manufacturing, a substrate needs to be dried after wet etching or cleaning processes. It is known that a supercritical fluid with zero surface tension can be used for drying the substrate. For example, the substrate covered with Isopropyl Alcohol (IPA) is transferred from a cleaning chamber to a drying apparatus, and the upper chamber and the lower chamber of the drying apparatus are closed to form a sealed chamber. Then, the supercritical fluid is supplied into the sealed chamber, so that the IPA on the surface of the substrate is dissolved into the supercritical fluid to form a mixture of IPA and the supercritical fluid. With the continuous supply of the supercritical fluid into the sealed chamber and the continuous discharge of the mixture of IPA and the supercritical fluid, the replacement between the supercritical fluid and the IPA covered on the surface of the substrate is completed, so as to achieve the purpose of removing IPA from the substrate. Then, the supercritical fluid is vaporized and discharged. After the pressure in the sealed chamber returns to the atmospheric pressure, the sealed chamber is opened, and finally, the dried substrate is taken out.

In view of the above description, the sealed chamber formed by locking the upper chamber to the lower chamber should be capable of maintaining the high pressure required during the substrate drying process, so that the supercritical fluid is in a supercritical state. Therefore, how to lock the upper chamber to the lower chamber to form a pressure-resistant sealed chamber is particularly important.

SUMMARY

The purpose of the present invention is to solve the problem of how to lock an upper chamber to a lower chamber to form a sealed chamber in the prior art.

To solve the above problem, an embodiment of the present invention provides a drying apparatus, comprising:

an upper chamber, provided with a first locking portion;

a lower chamber, disposed below the upper chamber, provided with a second locking portion matched with the first locking portion;

a substrate tray, disposed in the lower chamber, for carrying a substrate;

a rotating mechanism, used to drive at least one of the upper chamber and the lower chamber to rotate, so that the upper chamber and the lower chamber are screwed tightly through the first locking portion and the second locking portion to form a pressure-resistant sealed chamber.

In the drying apparatus provided by the present invention, the upper chamber is provided with a first locking portion, and the lower chamber is provided with a second locking portion matched with the first locking portion. After the upper chamber and the lower chamber move close to each other, a rotating mechanism drives at least one of the upper chamber and the lower chamber to rotate, so that the first locking portion and the second locking portion are locked with each other, and the upper chamber and the lower chamber form a pressure-resistant sealed chamber, so as to meet the high-pressure requirement during the substrate drying process, keep the supercritical fluid in a supercritical state, and dry the substrate.

Other features and corresponding beneficial effects of the present invention are described in the subsequent part of the specification, and it should be understood that at least part of the beneficial effects are obvious from the records in the specification of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and performance of the present invention are further described by the following embodiments and the accompanying drawings of the embodiments.

FIG. 1 is a three-dimensional schematic structure diagram of the drying apparatus

provided in Embodiment 1 of the present invention;

FIG. 2 is a three-dimensional schematic structure diagram of the drying apparatus provided in Embodiment 1 of the present invention when the sealed chamber in the drying apparatus is opened;

FIG. 3 is a three-dimensional schematic structure diagram of the drying apparatus provided in Embodiment 1 of the present invention when the lower chamber and the upper chamber are in a closed but pre-screwed state;

FIG. 4 is a three-dimensional schematic structure diagram of the drying apparatus provided in Embodiment 1 of the present invention after the lower chamber and the upper chamber are screwed tightly;

FIG. 5 is a partial schematic diagram of the drying apparatus provided in Embodiment 1 of the present invention;

FIG. 6 is a cross-sectional schematic structure diagram of the drying apparatus provided in Embodiment 1 of the present invention after the lower chamber and the upper chamber are screwed tightly;

FIG. 7 is a three-dimensional schematic structure diagram of the upper chamber provided in Embodiment 1 of the present invention;

FIG. 8 is a three-dimensional schematic structure diagram of the lower chamber provided in Embodiment 1 of the present invention;

FIG. 9 is a three-dimensional schematic structure diagram of the lifting mechanism, the rotating mechanism, and the supporting members provided in Embodiment 1 of the present invention;

FIG. 10 is a schematic structure diagram of the lifting mechanism and the rotating mechanism provided in Embodiment 2 of the present invention;

FIG. 11 is a three-dimensional schematic structure diagram of the drying apparatus provided in Embodiment 2 of the present invention after the lower chamber

and the upper chamber are screwed tightly;

FIG. 12 is a bottom-view schematic structure diagram of the lower chamber provided in Embodiment 2 of the present invention;

FIG. 13 is a three-dimensional schematic structure diagram of the drying apparatus provided in Embodiment 3 of the present invention after the lower chamber and the upper chamber are screwed tightly;

FIG. 14 is a schematic structure diagram of the lifting mechanism and the rotating mechanism provided in Embodiment 4 of the present invention;

FIG. 15 is a schematic structure diagram of the lifting mechanism and the rotating mechanism provided in Embodiment 4 of the present invention from another perspective; and

FIG. 16 is a three-dimensional schematic structure diagram of the drying apparatus provided in Embodiment 4 of the present invention when the sealed chamber is opened.

PREFERRED EMBODIMENTS OF THE INVENTION

The implementation of the present invention will be described below with specific embodiments, and those skilled in the art can easily understand other advantages and effects of the present invention from the content disclosed in this specification. Although the description of the present invention will be made in conjunction with the preferred embodiments, it does not mean that the features of the present invention are limited to these embodiments. On the contrary, the purpose of introducing the invention in conjunction with the embodiments is to cover other options or modifications that may be extended based on the claims of the present invention. In order to provide a thorough understanding of the present invention, many specific details will be included in the following description. The present invention can also be implemented without using these details. In addition, some specific details will be omitted from the description to avoid confusing or obscuring the focus of the present invention. It should be noted that the embodiments in the present invention and the features in the embodiments can be combined with each other, provided no conflict arises.

It should be noted that in this specification, similar reference numerals and letters denote similar items in the following drawings, so once an item is defined in one drawing, the item does not need to be further defined and explained in subsequent drawings.

The technical solutions of the present invention will be clearly and completely described below with reference to the accompanying drawings. Obviously, the described embodiments are part of the embodiments of the present invention, but not all of the embodiments. Based on the embodiments of the present invention, all other embodiments obtained by those of ordinary skill in the art without making creative efforts shall fall within the protection scope of the present invention.

In the description of the present invention, it should be noted that the terms "center," "upper," "lower," "left," "right," "vertical," "horizontal," "inner," "outer," and the like indicate the orientation or positional relationship based on the orientation or positional relationship shown in the drawings, which are only for the convenience of describing the present invention and simplifying the description, and do not indicate or imply that the device or element referred to must have a specific orientation, be constructed and operated in a specific orientation, and thus should not be construed as limiting the present invention. In addition, the terms "first," "second," and "third" are only used for describing the purpose, and should not be construed as indicating or implying relative importance.

In the description of the present invention, it should be noted that unless otherwise clearly specified and limited, the terms "installation," "interconnection," and "connection" should be understood in a broad sense, for example, the connection can be a fixed connection, a detachable connection, or an integral connection; the connection can be a mechanical connection or an electrical connection; the connection can be a direct connection, an indirect connection through an intermediate medium, or an internal connection of two elements. For those of ordinary skill in the art, the specific meanings of the above terms in the present invention can be understood according to specific situations.

In order to further clarify the purpose, technical solutions, and advantages of the present invention, the embodiments of the present invention will be further described

in detail below with reference to the accompanying drawings.

Embodiment 1

According to FIGS. 1 to 5, Embodiment 1 proposes a drying apparatus for drying a cleaned substrate. In Embodiment 1, the surface of the cleaned substrate is covered with a layer of Isopropyl Alcohol (IPA).

The drying apparatus comprises a frame 100, an upper chamber 200, a lower chamber 300, a substrate tray 400, a lifting mechanism 500, and a rotating mechanism 600. The upper chamber 200 is fixed to the frame 100 and is provided with a first locking portion 210. The lower chamber 300 is disposed below the upper chamber 200 and is provided with a second locking portion 310 matched with the first locking portion 210. The substrate tray 400 is disposed in the lower chamber 300 for carrying a substrate. The lower chamber 300 and the upper chamber 200 move relatively along the vertical direction under the drive of the lifting mechanism 500. The rotating mechanism 600 is used to drive the lower chamber 300 to rotate around the axial direction O of the lower chamber 300, for example, to rotate clockwise along the direction R1, so that the first locking portion 210 and the second locking portion 310 are locked with each other. The upper chamber 200 and the lower chamber 300 are screwed tightly to form a sealed chamber 233 (as shown in FIG. 6), so as to dry the substrate covered with IPA on the surface. The angle range of rotation of the lower chamber 300 driven by the rotating mechanism 600 is 10 degrees to 40 degrees, and preferably, the angle range of rotation of the lower chamber 300 driven by the rotating mechanism 600 is 20 degrees to 30 degrees.

When the sealed chamber 233 is to be opened, firstly, the rotating mechanism 600 drives the lower chamber 300 to rotate back around the axial direction O of the lower chamber 300, for example, to rotate counterclockwise along the direction R2, so that the first locking portion 210 and the second locking portion 310 are unlocked from each other, that is, separated from each other. Then, the lifting mechanism 500 drives the lower chamber 300 to move downward along the vertical direction, so that the lower chamber 300 and the upper chamber 200 are far away from each other, and the sealed chamber 233 is opened.

In some embodiments, the lower chamber 300 can be fixed to the frame, the lifting mechanism drives the upper chamber 200 to move along the vertical direction, and when the upper chamber 200 is closed against the lower chamber 300, the rotating mechanism 600 drives the upper chamber 200 to rotate around the axial direction of the upper chamber 200. In some embodiments, two lifting mechanisms and two rotating mechanisms can also be provided, wherein one lifting mechanism drives the upper chamber 200 to move along the vertical direction, and the other lifting mechanism drives the lower chamber 300 to move along the vertical direction, so that the upper chamber 200 and the lower chamber 300 move relatively along the vertical direction. One rotating mechanism drives the upper chamber 200 to rotate in a first direction, and the other rotating mechanism drives the lower chamber 300 to rotate in a second direction, wherein the first direction is opposite to the second direction, so that the upper chamber 200 and the lower chamber 300 can rotate simultaneously and be screwed tightly to form a sealed chamber.

According to FIGS. 7 and 8, in the drying apparatus provided by the present application, the shapes of the upper chamber 200 and the lower chamber 300 are both circular, the hollow portion of the sealed chamber 233 is circular, the first locking portion 210 is integrally formed with the upper chamber 200, and the second locking portion 310 is integrally formed with the lower chamber 300.

Specifically, as shown in FIG. 7, the first locking portion 210 of the upper chamber 200 includes a plurality of upper teeth, the plurality of upper teeth are uniformly distributed at intervals along the circumferential direction of the upper chamber 200. As shown in FIG. 8, the second locking portion 310 includes a plurality of lower teeth, the plurality of lower teeth are uniformly distributed at intervals along the circumferential direction of the lower chamber 300, and the plurality of upper teeth are matched with the plurality of lower teeth in a one-to-one correspondence. Wherein, the plurality of lower teeth extend outward along the radial direction of the lower chamber 300 on the side wall of the lower chamber 300 and are in a convex shape. The upper surfaces of the lower teeth are flush with the upper surface of the lower chamber 300 and lower than the upper surface of the substrate tray 400. The plurality of upper teeth extend downward along the side wall of the upper chamber 200 and are provided with grooves 211 matched with the lower teeth. The upper teeth are in an "L" shape.

When the upper teeth and the lower teeth are locked with each other (as shown in FIG. 5), the sealed chamber 233 is formed between the upper chamber 200 and the lower chamber 300 (as shown in FIG. 6). When the sealed chamber 233 is to be opened, rotate the lower chamber 300 firstly to unscrew the lower teeth from the grooves 211 of the upper teeth, that is, the lower teeth and the upper teeth are unlocked from each other, and then move the lower chamber 300 downward along the vertical direction to separate the lower chamber 300 from the upper chamber 200, and open the sealed chamber 233. When the sealed chamber 233 is in an open state (as shown in FIG. 2), the distance between the upper chamber 200 and the lower chamber 300 only needs to meet the requirement for picking and placing the substrate.

In other embodiments, the shapes of the upper teeth and the lower teeth can be interchanged, that is, the upper teeth can be arranged to extend outward along the radial direction of the upper chamber 200 and be in a convex shape, the lower teeth are provided with grooves matched with the upper teeth, and the upper chamber 200 and the lower chamber 300 are screwed tightly through the upper teeth and the lower teeth to form a sealed chamber.

In the drying apparatus provided by the present application, since the external shapes of the upper chamber 200 and the lower chamber 300 are preferably circular, and the plurality of upper teeth and the plurality of lower teeth are respectively uniformly distributed at intervals along the circumferential directions of the upper chamber 200 and the lower chamber 300, the upper chamber 200 and the lower chamber 300 in the present application experience a more uniform stress under high temperature and high pressure conditions. As pressure vessels that are frequently opened and closed, the upper chamber 200 and the lower chamber 300 have longer service lives and are more in line with the design standards of pressure vessels.

In addition, in the present application, the plurality of upper teeth are integrally formed with the upper chamber 200, and the plurality of lower teeth are integrally formed with the lower chamber 300. Moreover, the locking structure of the upper teeth and the lower teeth is simple, making the locking process convenient. For the sealed chamber 233 of the same volume, the locking structure of the upper teeth and the lower teeth also has the advantage of reducing the overall weight of the screwed upper chamber 200 and lower chamber 300.

According to FIG. 9, the lifting mechanism 500 includes a lifting platform 510, a driving device 520, and a transmission device. The driving device 520 drives the lifting platform 510 to move up and down along the vertical direction through the transmission device. The transmission device includes a lead screw 531, a timing belt pulley, and a timing belt 532, and the driving device 520 can be a servo motor. Specifically, the output end of the servo motor is connected to the timing belt pulley, and is connected to the timing belt pulley at one end of the lead screw 531 through the timing belt 532. The other end of the lead screw 531 is connected to the lifting platform 510. The servo motor drives the lead screw 531 to perform a linear motion through the timing belt pulley and the timing belt 532, so as to realize the lifting and lowering of the lifting platform 510.

The rotating mechanism 600 includes a first rotating mechanism 610 and a second rotating mechanism 620. The first rotating mechanism 610 is disposed on the lifting mechanism 500, and the second rotating mechanism 620 is used to drive the first rotating mechanism 610 to drive the lower chamber 300 to rotate. Specifically, the first rotating mechanism 610 includes guide rails 611, sliding blocks 612, and a driven gear 613 (as shown in FIG. 8 and FIG.9). The guide rails 611 are fixed to the lifting platform 510 of the lifting mechanism 500 and extend around the axial direction O of the lower chamber 300. The sliding blocks 612 are slidably connected to the guide rails 611, and the sliding blocks 612 are also fixedly connected to the bottom of the lower chamber 300 (as shown in FIG. 4). The sliding blocks 612 can be fixed to the lower chamber 300 through fixing members, such as screws or bolts. In this embodiment, as shown in FIG. 9, the first rotating mechanism 610 includes two symmetrically arranged guide rails 611, each guide rail 611 is provided with two sliding blocks 612, and each sliding block 612 is fixedly connected to the bottom of the lower chamber 300. Each guide rail 611 is arc-shaped, and limit blocks can be installed at both ends of each guide rail 611 to limit the sliding blocks 612, so that the rotation angle of the lower chamber 300 is limited within a predetermined rotation angle range. In other embodiments, the guide rails 611 can also be in a full circular shape, as long as the guide rails 611 can satisfy the required rotation direction and rotation angle of the lower chamber 300.

According to FIGS. 8 and 9, the driven gear 613 is fixedly connected to the lower chamber 300. The driven gear 613 is in the shape of a segment of an arc, and the

circumference of the driven gear 613 only needs to satisfy that the lower chamber 300 can rotate by a predetermined rotation angle. As shown in FIG. 9, the second rotating mechanism 620 includes a rotation driving portion 621 and a driving gear 622. The rotation driving portion 621 includes a servo motor 6211 and a speed reducer 6212. The servo motor 6211 drives the driving gear 622 to rotate through the speed reducer 6212, and the driving gear 622 drives the driven gear 613 to rotate through meshing. Since the driven gear 613 is fixedly connected to the lower chamber 300, and the lower chamber 300 is also fixedly connected to the sliding blocks 612, when the driven gear 613 rotates, the driven gear 613 drives the lower chamber 300 on the sliding blocks 612 to rotate in the direction of the guide rails 611, so that the lower chamber 300 and the upper chamber 200 are screwed tightly to form a sealed chamber.

As shown in FIG. 9, the rotating mechanism 600 further includes a fixing frame 630, a mounting plate 640, and an adjusting component. The rotation driving portion 621 and the driving gear 622 of the second rotating mechanism 620 are jointly fixed to the mounting plate 640. The mounting plate 640 is movably mounted on the fixing frame 630 through fasteners 641, and the fixing frame 630 is fixedly connected to the lifting platform 510 of the lifting mechanism 500. The mounting plate 640 and the driving gear 622 are located above the fixing frame 630, and the rotation driving portion 621 is located below the fixing frame 630 and connected to the driving gear 622 through the fixing frame 630 and the mounting plate 640. When the lifting platform 510 moves up and down along the vertical direction, the fixing frame 630 carries the rotation driving portion 621 and the driving gear 622 to lift and lower together with the lifting platform 510, and during this lifting and lowering process, the rotation driving portion 621 is in a suspended state. The adjusting component and the mounting plate 640 are mounted on the same mounting surface of the fixing frame 630. The adjusting component is used to adjust the displacement of the mounting plate 640 on the fixing frame 630, so that the center distance between the driving gear 622 and the driven gear 613 can be reduced or increased. The adjusting component includes an adjusting block 651 and a screw (not shown in the figure). A threaded hole 652 is provided in the adjusting block 651, and the screw is threadedly connected to the threaded hole 652. When it is necessary to reduce the center distance between the driving gear 622 and the driven gear 613, loosen the fasteners 641 to make the mounting plate 640 in a movable state, then rotate the screw in the adjusting block 651

to increase the length of the screw extending out of the adjusting block 651, so that the screw pushes against the mounting plate 640, and then the mounting plate 640 carries the driving gear 622 and the rotation driving portion 621 to move together toward the driven gear 613 fixed to the lower chamber 300, so as to reduce the center distance between the driving gear 622 and the driven gear 613 until the driving gear 622 meshes with the driven gear 613. When it is necessary to increase the center distance between the driving gear 622 and the driven gear 613, loosen the fasteners 641 on the mounting plate 640 to make the mounting plate 640 in a movable state, then rotate the screw in the adjusting block 651 to return the screw to a predetermined position into the adjusting block 651, and then manually pull back the mounting plate 640, so that the mounting plate 640 carries the driving gear 622 and the rotation driving portion 621 to move together away from the driven gear 613, so as to increase the center distance between the driving gear 622 and the driven gear 613. It should be noted that when the mounting plate 640 moves on the fixing frame 630, the fixing frame 630 is provided with a guide groove for the mounting plate 640 to carry the rotation driving portion 621 and the driving gear 622 to move.

In addition, as shown in FIG. 2, the drying apparatus further comprises two sets of symmetrically arranged supporting members 700. The two sets of supporting members 700 are movable both vertically and horizontally, and are used to lift and place the substrate on the substrate tray 400, or take the substrate away from the substrate tray 400. Each of the two sets of supporting members 700 is provided with a weighing sensor 710 for weighing the substrate to determine whether it is necessary to supplement the amount of IPA on the surface of the substrate. If supplementation is needed, an IPA supplementing device of the drying apparatus can be used to supplement IPA on the surface of the substrate. The IPA supplementing device can be the same as the IPA supplementing device already used in the existing drying apparatus.

The drying apparatus further comprises a first fluid supply pipe 810, a second fluid supply pipe 820, a fluid discharge pipe 830, and a vacuum pumping pipeline 840. The first fluid supply pipe 810 and the vacuum pumping pipeline 840 are arranged at intervals on the top wall of the upper chamber 200, and the second fluid supply pipe 820 and the fluid discharge pipe 830 are respectively arranged on two opposite side walls of the upper chamber 200. The vacuum pumping pipeline 840 is used for

evacuation through the vacuum groove 240 (as shown in FIG. 7) of the upper chamber 200. Two annular grooves 320 and 330 for placing sealing rings are sequentially arranged around the substrate tray 400 of the lower chamber 300 (as shown in FIG. 8). When the upper chamber 200 and the lower chamber are screwed tightly to form a sealed chamber, the vacuum groove 240 is located between the two annular grooves 320 and 330.

The workflow of drying the substrate by the drying apparatus provided in this embodiment is as follows:

When the drying apparatus starts to work, firstly, the two sets of supporting members 700 are lifted from the initial position to a predetermined height, and then the two sets of supporting members 700 move toward the substrate tray 400 to the minimum stroke; then a manipulator transfers the substrate to a position between the upper chamber 200 and the lower chamber 300, places the substrate on the supporting members 700, and then withdraws. The weighing sensor 710 on each supporting member 700 weighs the substrate to detect the amount of IPA on the surface of the substrate. After that, the two sets of supporting members 700 carry the substrate downward to the initial position, place the substrate on the substrate tray 400, and then move back to the maximum stroke to withdraw from the lower chamber 300.

Then, the lifting mechanism 500 lifts the lower chamber 300 to move upward along the vertical direction until the lower chamber 300 is closed against the upper chamber 200. The rotating mechanism 600 drives the lower chamber 300 to rotate by a predetermined angle, so that the upper chamber 200 and the lower chamber 300 are locked through the upper teeth and the lower teeth to form the sealed chamber 233. In this embodiment, since the sliding blocks 612 are fixedly connected to the lower chamber 300 through fixing members, after the upper chamber 200 and the lower chamber 300 are screwed tightly to form the sealed chamber 233, the lifting platform 510 of the lifting mechanism 500 does not need to withdraw from the lower chamber 300 during the operation of the drying apparatus.

After the sealed chamber 233 is formed, the vacuum groove 240 of the upper chamber 200 is evacuated through the vacuum pumping pipeline 840. When it is detected that the pressure inside the vacuum pumping pipeline 840 is within the target

pressure range, it indicates that the sealing is completed, and a supercritical fluid can be supplied into the sealed chamber 233.

Open the first fluid supply pipe 810 to supply the supercritical fluid from above the sealed chamber 233. With the supply of the supercritical fluid, the air and fluid inside the sealed chamber 233 are discharged from the sealed chamber 233 through the fluid discharge pipe 830, so that the air inside the sealed chamber 233 is completely displaced by the fluid, and the supply amount of the supercritical fluid is continuously increased, so that the pressure inside the sealed chamber 233 rises above the critical pressure.

After the interior of the sealed chamber 233 reaches a supercritical state, close the first fluid supply pipe 810 and stop supplying the supercritical fluid from above the sealed chamber 233. The supercritical fluid is supplied from one side of the sealed chamber 233 through the second fluid supply pipe 820, and the supercritical fluid dries the substrate inside the sealed chamber 233. At this time, the fluid discharged from the fluid discharge pipe 830 is the supercritical fluid.

After the drying treatment is completed, close the second fluid supply pipe 820. The fluid inside the sealed chamber 233 is continuously discharged through the fluid discharge pipe 830, which reduces the internal pressure of the sealed chamber 233, so that the supercritical fluid inside the sealed chamber 233 turns into gas and is discharged from the sealed chamber 233 through the fluid discharge pipe 830. Close the vacuum pumping pipeline 840, and the vacuum state is maintained in the vacuum groove 240 of the upper chamber 200. When the pressure inside the sealed chamber 233 reaches atmospheric pressure, the rotating mechanism 600 drives the lower chamber 300 to rotate back by a predetermined angle, and the upper teeth and the lower teeth are unlocked from each other. The lifting mechanism 500 drives the lower chamber 300 to move downward along the vertical direction, and the sealed chamber 233 is opened.

Finally, the two sets of supporting members 700 move toward each other from the maximum stroke to the minimum stroke. The dried substrate is lifted from the substrate tray 400, and finally, the drying apparatus is taken out by the manipulator.

In this embodiment, the supercritical fluid is supercritical carbon dioxide.

Embodiment 2

According to FIGS. 10 to 12, Embodiment 2 provides another drying apparatus. The difference between Embodiment 2 and Embodiment 1 is that the structure of the driven gear is different, and the connection relationship between the driven gear, the lower chamber, and the sliding blocks is different.

According to FIGS. 10 and 11, a driven gear 613A of a first rotating mechanism 610A in this embodiment is in the shape of a disc. The driven gear 613A connects the sliding blocks 612A and a lower chamber 300A. The bottom of the driven gear 613A is fixedly connected to the sliding blocks 612A, and the top of the driven gear 613A is detachably connected to the lower chamber 300A. Specifically, as shown in FIG. 10, the driven gear 613A includes a gear body 6101A, an upper supporting plate 6102A, and a lower supporting plate 6103A. The upper supporting plate 6102A is fixed to the upper side of the gear body 6101A. The lower supporting plate 6103A is fixed to the lower side of the gear body 6101A and is fixedly connected to the sliding blocks 612A. The top of the upper supporting plate 6102A is provided with a plurality of fixing pins 6104A. The driven gear 613A supports the lower chamber 300A through the fixing pins 6104A. The bottom of the lower chamber 300A is provided with fixing grooves 340A (as shown in FIG. 12), and the fixing grooves 340A are matched with the fixing pins 6104A. By inserting the fixing pins 6104A into the fixing grooves 340A at the bottom of the lower chamber 300A, the lower chamber 300A is installed on the upper supporting plate 6102A, so that the driven gear 613A drives the lower chamber 300A to rotate and is screwed tightly with an upper chamber 200A to form a sealed chamber.

When a second rotating mechanism 620A drives the driven gear 613A to rotate, the driven gear 613A fixed on the sliding blocks 612A drives the lower chamber 300A to rotate together, so that the lower chamber 300A and the upper chamber 200A are screwed tightly to form a sealed chamber (according to the sealed chamber 233 in FIG. 6 of Embodiment 1). After the sealed chamber is formed, a lifting platform 510A moves downward, the fixing pins 6104A are separated from the fixing grooves 340A at the bottom of the lower chamber 300A, and the lifting platform 510A and a rotating mechanism 600A withdraw from the lower chamber 300A. In this way, when a

substrate is dried in the sealed chamber, the deformation force generated by the upper chamber 200A and the lower chamber 300A will not be applied to the rotating mechanism 600A and a lifting mechanism 500A. After the lifting platform 510A and the rotating mechanism 600A withdraw from the lower chamber 300A, the upper chamber 200A is still fixed to a frame (according to the frame 100 in Embodiment 1), and the lower chamber 300A is in a suspended state, suspended on the upper chamber 200A.

Embodiment 3

According to FIG. 13, Embodiment 3 provides another drying apparatus. The difference between Embodiment 3 and Embodiment 2 is that the lifting mechanism includes a six-degree-of-freedom robot platform.

In this embodiment, the six-degree-of-freedom robot platform includes an upper platform 510B, a lower platform 541B, telescopic cylinders 542B, and Hooke joints 543B. A second rotating mechanism 620B is fixed to the upper platform 510B through a fixing frame 630B and moves up and down in synchronization with the upper platform 510B. The way the second rotating mechanism 620B is installed on the fixing frame 630B is the same as the way the second rotating mechanism 620 is installed on the fixing frame 630 in Embodiment 1, which will not be repeated here.

The guide rails 611B of a first rotating mechanism 610B are fixed to the upper platform 510B. In some embodiments, the guide rails 611B can be fixed to the upper platform 510B through a base 670B. In some embodiments, the guide rails 611B can be directly fixed to the upper platform 510B. The upper platform 510B and the lower platform 541B are connected through six telescopic cylinders 542B and Hooke joints 543B. The Hooke joints 543B are located at the joints where the telescopic cylinders 542B connect the upper platform 510B and the lower platform 541B. Through the coordinated action of the six telescopic cylinders 542B, a lower chamber 300B can be lifted and lowered along the vertical direction. After the lower chamber 300B and an upper chamber 200B are screwed tightly to form a sealed chamber, the six-degree-of-freedom robot and a rotating mechanism 600B withdraw from the lower chamber 300B.

Embodiment 4

According to FIGS. 14 to 16, Embodiment 4 provides another drying apparatus. The difference between Embodiment 4 and Embodiment 2 is that the structures and arrangement modes of the first rotating mechanism and the lifting mechanism are different, and the fixing mode between the second rotating mechanism and the lifting mechanism is different.

In this embodiment, a first rotating mechanism 610C of the rotating mechanism includes a driven gear 613C, and the driven gear 613C is in a cylindrical shape. A second rotating mechanism 620C of the rotating mechanism includes a rotation driving portion 621C and a driving gear 622C. The rotation driving portion 621C includes a servo motor and a speed reducer. The servo motor drives the driving gear 622C to rotate through the speed reducer, and the driving gear 622C drives the driven gear 613C to rotate through meshing.

The structure and arrangement mode of the driven gear 613C will be described below in combination with the structure and arrangement mode of a lifting mechanism 500C.

According to FIGS. 14 and 15, the lifting mechanism 500C is a gear-screw transmission mechanism. The gear-screw transmission mechanism includes a lifting platform 510C, a driving device 520C, a lifting driving gear 521C, a lifting driven gear 522C, a lead screw 523C, a nut 524C, and a base 525C. The driving device 520C is connected to the lifting driving gear 521C. The lifting driving gear 521C meshes with the lifting driven gear 522C. The lifting driven gear 522C is fixedly connected to the lead screw 523C. The lead screw 523C is threadedly connected to the nut 524C. The nut 524C is fixedly connected to the lower portion of the driven gear 613C. The upper portion of the driven gear 613C is fixed to the lifting platform 510C. The lifting platform 510C is provided with fixing pins 511C. The fixing pins 511C are inserted into the fixing grooves at the bottom of a lower chamber 300C (according to the fixing grooves 340A in FIG. 12 of Embodiment 2), so that the lower chamber 300C is fixed to the lifting platform 510C (as shown in FIG. 16). In addition, the second rotating mechanism 620C is installed on a fixing frame 630C. The fixing frame 630C is fixed to the base 525C, and the second rotating mechanism 620C does not move up and down with the lifting platform 510C.

The working principle of the gear-screw transmission mechanism and the second rotating mechanism 620C driving the lower chamber 300C to lift and rotate is described below:

When the gear-screw transmission mechanism drives the lower chamber 300 to lift, the driving device 520C of the gear-screw transmission mechanism drives the lifting driving gear 521C to rotate. The lifting driving gear 521C drives the lifting driven gear 522C to rotate through meshing. The lead screw 523C rotates with the lifting driven gear 522C. The driven gear 613C makes a linear lifting motion on the lead screw 523C with the nut 524C. The lifting platform 510C lifts with the driven gear 613C.

When the lower chamber 300C on the lifting platform 510C contacts an upper chamber 200C, the rotation driving portion 621C of the second rotating mechanism 620C drives the driving gear 622C to rotate. The driving gear 622C drives the driven gear 613C to rotate through meshing. The lifting platform 510C rotates with the driven gear 613C and drives the lower chamber 300C to rotate, so that a first locking portion 210C and a second locking portion 310C are locked with each other, and the upper chamber 200C and the lower chamber 300C are screwed tightly to form a sealed chamber. After that, the gear-screw transmission mechanism drives the lifting mechanism 500C to descend and withdraw from the lower chamber 300C.

Finally, it should be noted that the above embodiments are only used to illustrate the technical solutions of the present invention, but not to limit the technical solutions of the present invention. Although the present invention has been described in detail with reference to the foregoing embodiments, those of ordinary skill in the art should understand that they can still modify the technical solutions recorded in the foregoing embodiments, or equivalently replace some or all of the technical features; and these modifications or replacements do not make the essence of the corresponding technical solutions deviate from the scope of the technical solutions of the embodiments of the present invention.

What is claimed is:

1. A drying apparatus, comprising:

an upper chamber, provided with a first locking portion;

a lower chamber, disposed below the upper chamber, provided with a second locking portion matched with the first locking portion;

a substrate tray, disposed in the lower chamber, for carrying a substrate;

a rotating mechanism, used to drive at least one of the upper chamber and the lower chamber to rotate, so that the upper chamber and the lower chamber are screwed tightly through the first locking portion and the second locking portion to form a pressure-resistant sealed chamber.

2. The drying apparatus according to claim 1, wherein the first locking portion includes a plurality of upper teeth, the plurality of upper teeth are distributed at intervals along the circumferential direction of the upper chamber, the second locking portion includes a plurality of lower teeth, the plurality of lower teeth are distributed at intervals along the circumferential direction of the lower chamber, and the plurality of upper teeth respectively correspond to and are matched with the plurality of lower teeth.

3. The drying apparatus according to claim 2, wherein the plurality of lower teeth extend outward along the radial direction of the lower chamber and are in a convex shape, and the plurality of upper teeth are provided with grooves matched with the plurality of lower teeth.

4. The drying apparatus according to claim 1, wherein the angle range of rotation of at least one of the upper chamber and the lower chamber driven by the rotating mechanism is 10 degrees to 40 degrees.

5. The drying apparatus according to claim 1, wherein the shapes of the upper chamber and the lower chamber are both circular, and the hollow portion of the sealed chamber is circular.

6. The drying apparatus according to claim 1, wherein the first locking portion is integrally formed with the upper chamber, and the second locking portion is integrally formed with the lower chamber.

7. The drying apparatus according to claim 1, further comprising:

a lifting mechanism, used to drive at least one of the upper chamber and the lower chamber to move along the vertical direction, so that the upper chamber and the lower chamber move relatively;

when the upper chamber and the lower chamber move close to each other, the rotating mechanism drives at least one of the upper chamber and the lower chamber to rotate, so that the upper chamber and the lower chamber are screwed tightly through the first locking portion and the second locking portion to form the sealed chamber.

8. The drying apparatus according to claim 7, wherein the lifting mechanism is used to drive the lower chamber to move along the vertical direction, and the rotating mechanism is used to drive the lower chamber to rotate.

9. The drying apparatus according to claim 8, wherein the lifting mechanism includes a lifting platform, a driving device, and a transmission device, the lifting platform is used to support the lower chamber, and the driving device drives the lifting platform to move along the vertical direction through the transmission device.

10. The drying apparatus according to claim 8, wherein the lifting mechanism includes a six-degree-of-freedom robot platform or a gear-screw transmission mechanism.

11. The drying apparatus according to claim 8, wherein the rotating mechanism further comprising:

a first rotating mechanism, disposed on the lifting mechanism;

a second rotating mechanism, used to drive the first rotating mechanism to drive the lower chamber to rotate.

12. The drying apparatus according to claim 11, wherein the first rotating mechanism comprising:

a guide rail, fixed to the lifting mechanism;

a sliding block, slidably connected to the guide rail and fixedly connected to the lower chamber;

a driven gear, fixedly connected to the lower chamber;

when the second rotating mechanism drives the first rotating mechanism to drive the lower chamber to rotate, the second rotating mechanism drives the driven gear to rotate, and the driven gear drives the lower chamber on the sliding block to rotate in the direction of the guide rail.

13. The drying apparatus according to claim 11, wherein the first rotating mechanism comprising:

a guide rail, fixed to the lifting mechanism;

a sliding block, slidably connected to the guide rail;

a driven gear, connected between the sliding block and the lower chamber;

when the second rotating mechanism drives the first rotating mechanism to drive the lower chamber to rotate, the second rotating mechanism drives the driven gear to rotate, and the driven gear drives the lower chamber to rotate in the direction of the guide rail on the sliding block.

14. The drying apparatus according to claim 13, wherein the bottom of the driven gear is fixedly connected to the sliding block, and the top of the driven gear is provided with a fixing pin, the bottom of the lower chamber is provided with a fixing groove, and the fixing pin is used to be inserted into the fixing groove, so that the lower chamber is installed on the driven gear.

15. The drying apparatus according to claim 11, wherein the first rotating mechanism comprising:

a driven gear, rotatably disposed on the lifting mechanism, and the second rotating mechanism driving the lower chamber to rotate by driving the driven gear.

16. The drying apparatus according to any one of claims 12 to 15, wherein the second rotating mechanism includes a rotation driving portion and a driving gear, and the rotation driving portion drives the driving gear to rotate, so that the driving gear drives the driven gear to rotate.

17. The drying apparatus according to claim 16, wherein the rotating mechanism further includes a fixing frame, the fixing frame is fixedly connected to the lifting mechanism, and the rotation driving portion and the driving gear are jointly installed on the fixing frame.

18. The drying apparatus according to claim 17, wherein the rotating mechanism further comprising:

a mounting plate, movably mounted on the fixing frame, and the rotation driving portion and the driving gear being jointly mounted on the fixing frame through the mounting plate;

an adjusting component, reducing or increasing the center distance between the driving gear and the driven gear by adjusting the displacement of the mounting plate on the fixing frame.