

THIN-FILM DEPOSITION DEVICE, THIN-FILM DEPOSITION METHOD, AND THIN-FILM DEPOSITION APPARATUS

TECHNICAL FIELD

The present invention relates to the field of semiconductor manufacturing equipment, and in particular to a thin-film deposition device, a thin-film deposition method, and a thin-film deposition apparatus.

BACKGROUND

Semiconductor manufacturing often involves depositing one or more material layers onto a heated substrate using Plasma Enhanced Chemical Vapor Deposition (PECVD). A multi-station thin-film deposition apparatus is widely used at present. The multi-station design can significantly improve the process efficiency of thin-film deposition and reduce the equipment footprint in a clean room.

In existing multi-station thin-film deposition apparatuses, processing chambers all adopt a centrally symmetric layout. Due to crosstalk among processing stations, process factors such as radio frequency energy and gas flow adopt a center-biased distribution within a processing chamber, resulting in thicker thin film in the region on the substrate facing the center of the processing chamber.

When the number of deposited thin-film layers exceeds 200, the uniformity and quality of the thin films degrade. Deviations at fixed positions are continuously amplified during the continuous stacking of different types of thin films, making the uniformity of the thin films on the substrate deviate from a controllable range. This makes subsequent etching process fail to achieve the precision of through-hole etching, causing etched through-holes to deviate from the vertical direction during the etching process, and further resulting in the failure of semiconductor devices.

SUMMARY

The object of the present invention is to provide a thin-film deposition device, a thin-film deposition method, and a thin-film deposition apparatus for solving the problem of poor uniformity of thin films deposited on a substrate in the prior art.

To achieve the objective described above and other related objectives, the present invention provides a thin-film deposition device comprising a processing chamber, and the processing chamber includes:

N processing stations distributed in a regular polygonal distribution for performing thin-film deposition, wherein N is greater than or equal to 3;

N process robots respectively disposed between two adjacent processing stations for transferring a substrate between two adjacent processing stations; one end of each process robot being rotatably connected to the processing chamber, and the rotary joint being located on the perpendicular bisector plane of the line connecting the centers of two adjacent processing stations.

Optionally, the rotation angle of the process robot between two adjacent processing stations is $360^\circ/N$.

Optionally, each processing station includes: a heating tray, for supporting and heating the substrate; a support member, penetratingly disposed in the heating tray for supporting the substrate; a lifting mechanism, for driving the support member to move up or down so as to lift the substrate off the heating tray or the process robot, or place the substrate on the heating tray or the process robot.

Optionally, the rotary joint is fixed relative to the processing chamber, and the position of the rotary joint is higher than the processing stations.

Optionally, the rotary joint is liftable relative to the processing chamber, and the rotary joint is disposed at any height in the processing chamber.

Optionally, both the number of the processing stations and the number of the process robots are four.

Optionally, the support member includes lift pins, through-holes are provided on the heating tray, and the lift pins are disposed in the through-holes.

Optionally, the number of the lift pins is three, the number of the through-holes is three, and the through-holes are in one-to-one correspondence with the lift pins.

Optionally, all through-holes are equidistant from the edge of the heating tray, the lift pins are arranged in an equilateral triangle distribution, one of the lift pins is a central lift pin, and the central lift pin is located on the line connecting the center of the processing station and the center of the processing chamber.

Optionally, the length of the process robot is shorter than the distance between the rotary joint and any central lift pin on both sides of the process robot.

Optionally, the length of the process robot is longer than the distance between the rotary joint and the center of any adjacent processing station.

The present invention further provides a thin-film deposition method, comprising the following steps:

S11: placing a substrate into a processing chamber;

S12: depositing a certain number of thin-film layers on the substrate;

S13: a plurality of process robots synchronously rotating to respectively transfer the substrate between two adjacent processing stations;

S14: taking the substrate out of the processing chamber after the substrate completes deposition at all processing stations, and repeating steps S11 to S14; otherwise, repeating steps S12 to S14.

The present application further provides a thin-film deposition apparatus, comprising:

a substrate loading port, for placing a substrate;

a buffer device, for placing a substrate to be deposited;

a front-end robot, for transferring the substrate between the substrate loading port and the buffer device;

the thin-film deposition device as described above, for performing thin-film deposition on the substrate;

a transfer robot, for transferring the substrate between the buffer device and the processing chamber of the thin-film deposition device.

Optionally, a door is disposed on a side wall of the processing chamber to allow the transfer robot to enter the interior of the processing chamber to place or take out the substrate.

Optionally, a plurality of processing chambers are provided, and the plurality of processing chambers are symmetrically arranged on two sides of the transfer robot or sequentially arranged on the periphery of the transfer robot.

Optionally, the thin-film deposition apparatus further comprises a processing module for performing pre-heating or surface reduction on the substrate before deposition, or for performing thin-film surface modification after deposition.

Optionally, a plurality of buffer devices are provided, and a transfer robot is further disposed between two adjacent buffer devices for transferring the substrate between two buffer devices.

As described above, the present invention provides a thin-film deposition device, a thin-film deposition method, and a thin-film deposition apparatus, which have the following beneficial effects: the substrate is transferred among a plurality of processing stations by the process robots, and the region on the substrate close to the center of the processing chamber is changed after the transfer, so that the thin films deposited at the plurality of processing stations can produce a compensation effect, the uniformity of the multi-layer thin films deposited on the substrate is improved, the phenomenon that etched through-holes deviate from the vertical direction during the subsequent etching process of the thin films deposited on the substrate is prevented, and the performance stability of semiconductor devices is further ensured.

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 schematic diagram of the thin-film deposition device of the present

invention;

FIGS. 2A to 2C are schematic diagrams of different numbers of processing stations in the thin-film deposition device of the present invention;

FIGS. 3A to 3C are schematic diagrams of a process robot taking out a substrate in the thin-film deposition device of the present invention;

FIGS. 4A to 4C are schematic diagrams of a process robot placing a substrate in the thin-film deposition device of the present invention;

FIG. 5 is a schematic diagram of the motion trajectory of a process robot transferring a substrate between two processing stations in the thin-film deposition device of the present invention;

FIGS. 6A to 6D are schematic diagrams of process robots transferring a plurality of substrates among a plurality of processing stations in the thin-film deposition device of the present invention;

FIGS. 7A and 7B are schematic diagrams of substrate loading in the thin-film deposition device of the present invention;

FIGS. 8A to 8C are schematic layout diagrams of the thin-film deposition apparatus of the present invention.

PREFERRED EMBODIMENTS OF THE PRESENT INVENTION

The embodiments of the present invention are described below through specific examples, and those skilled in the art can easily understand other advantages and effects of the present invention from the content disclosed in this specification. The present invention may also be implemented or applied through other specific embodiments, and various details in this specification may also be modified or changed based on different viewpoints and applications without departing from the spirit of the present invention.

It should be noted that the drawings provided in this embodiment illustrate the

basic concept of the present invention in a schematic manner only. The drawings only show the components related to the present invention instead of being drawn according to the number, shape, and size of the components in actual implementation; the form, quantity, and proportion of all components in actual implementation may be changed arbitrarily, and the component layout may be more complicated. In addition, parts denoted by the same reference numerals in a plurality of accompanying drawings represent the same or equivalent parts or components.

As shown in FIG. 1, the present invention provides a thin-film deposition device comprising a centrosymmetric processing chamber 1 for performing thin-film deposition. The processing chamber 1 includes a plurality of groups of processing stations 101 and process robots 201 in one-to-one correspondence. The plurality of process robots 201 are respectively disposed between two adjacent processing stations 101 for transferring a substrate w between two adjacent processing stations 101.

The shape of the processing chamber 1 may be a regular polygon, and the number of processing stations 101 and the number of process robots 201 correspond to the number of sides of the processing chamber 1, that is, at least three processing stations 101 may be provided, and correspondingly, at least three process robots 201 are provided. In some embodiments, as shown in FIG. 1, the processing chamber 1 is square in shape with rounded corners for safety and process considerations, four processing stations 101 are provided, and four corresponding process robots 201 are provided. In other embodiments, as shown in FIGS. 2A to 2C, embodiments where three processing stations 101, five processing stations 101, and six processing stations 101 are provided are shown, respectively.

Specifically, as shown in FIG. 5, one end of each process robot 201 may be rotatably connected to the processing chamber 1, and the rotary joint O is located on the perpendicular bisector plane of the line connecting the centers of two adjacent processing stations 101. The process robot 201 may be directly disposed on a side wall of the processing chamber 1, or may be disposed at the bottom or top of the processing chamber 1 via a connecting rod. In some embodiments, the rotary joint O is always fixed relative to the processing chamber 1, and the rotary joint O is higher than the positions of the processing stations 101. In other embodiments, the rotary joint O is liftable relative to the processing chamber 1, and the rotary joint O may be disposed at

any height in the processing chamber 1. The initial position of each process robot 201 is the middle position of corresponding two adjacent processing stations 101, that is, located on the perpendicular bisector plane of the line connecting the centers of the corresponding two adjacent processing stations 101.

FIG. 5 shows the motion trajectory of the process robot 201 between two processing stations 101. During transfer, the motion trajectory of the process robot 201 is an arc, and the center of the arc trajectory is the rotary joint O of the process robot 201 and the processing chamber 1. In this embodiment, four processing stations 101 are provided, and the rotation angle of the process robot 201 during each transfer between two processing stations 101 may be 90° . The substrate w is subjected to thin-film deposition four times on four processing stations 101 to form one cycle, so that the substrate w rotates exactly 360° after one cycle of thin-film deposition, ensuring uniform thin-film deposition on the substrate w. To ensure the stability of the process robot 201 supporting the wafer, the length of the process robot 201 may extend beyond the centers of heating trays 11 (points A and B in FIG. 5).

In the embodiment shown in FIG. 1, the processing chamber 1 includes four processing stations 101A, 101B, 101C, and 101D and four process robots 201A, 201B, 201C, and 201D. Based on such a configuration of processing stations 101 and process robots 201, various processing sequences may be adopted to enable thin-film deposition cycles to be performed in parallel on a plurality of substrates w. FIG. 1 also shows the process of transferring one substrate w among the four processing stations 101A, 101B, 101C, and 101D.

As shown in FIG. 1, the steps of performing thin-film deposition on the substrate w in this embodiment are as follows:

S1: As shown in the upper left figure, the substrate w is loaded to the processing station 101A, and after the first thin-film deposition, the process robot 201A moves from the initial position to the processing station 101A to transfer the substrate w to the processing station 101B for the second thin-film deposition;

S2: As shown in the upper right figure, the process robot 201A returns to the initial position, and at the same time, the process robot 201B moves from the initial position

to the processing station 101B to transfer the substrate w to the processing station 101C for the third thin-film deposition;

S3: As shown in the lower right figure, the process robot 201B returns to the initial position, and at the same time, the process robot 201C moves from the initial position to the processing station 101C to transfer the substrate w to the processing station 101D for the fourth thin-film deposition;

S4: As shown in the lower left figure, the process robot 201C returns to the initial position, and at the same time, the process robot 201D moves from the initial position to the processing station 101D to transfer the substrate w to the processing station 101A, and then the process robot 201D returns to the initial position; at this time, a complete thin-film deposition cycle is completed, and then the substrate w can be taken out of the processing chamber 1.

In other embodiments, the process of thin-film deposition and transferring the substrate w may be adjusted according to actual process requirements. For example, thin-film deposition may be performed a plurality of times at each processing station 101 before the substrate is transferred to the next processing station 101. For example, in S4, after the substrate w is subjected to thin-film deposition at the processing station 101D, the substrate w may also be transferred to the processing station 101A to perform thin-film deposition cycles among a plurality of processing stations 101, and the substrate w is taken out of the processing chamber 1 after a plurality of cycles.

During the thin-film deposition cycle, the region on the substrate w close to the center of the processing chamber 1 changes with the transfer by the process robots 201. For example, with reference to FIG. 1, as shown in the upper left figure, when the substrate w is located at the processing station 101A, the region on the substrate w close to the center of the processing chamber 1 is marked as a sector region S. When the process robot 201A transfers the substrate w from the processing station 101A to the processing station 101B, the substrate w rotates together with the process robot 201A, and accordingly, the region on the substrate w close to the center of the processing chamber 1 also changes accordingly. For example, in FIG. 1, as shown in the upper right figure, when the substrate w is located at the processing station 101B, the sector region S marked at the processing station 101A has rotated to a position

away from the center of the processing chamber 1. In the thin-film deposition device provided by the present invention, the substrate w is transferred among a plurality of processing stations 101 by the process robots 201, and the region on the substrate w close to the center of the processing chamber 1 is changed after the transfer, so that the thin films deposited at the plurality of processing stations 101 can produce a compensation effect, the uniformity of the multi-layer thin films deposited on the substrate w is improved, the phenomenon that etched through-holes deviate from the vertical direction during the subsequent etching process of the thin films deposited on the substrate w is prevented, and the performance stability of semiconductor devices is further ensured.

The rotation angles of the process robots 201 between two adjacent processing stations 101 are the included angles between the projections of the axes of the process robots 201 on the planes where the processing stations 101 are located and the lines connecting the centers of two adjacent processing stations 101. Preferably, the rotation angles of the process robots 201 between two adjacent processing stations 101 are $360^\circ/N$, where N is the number of processing stations 101 in the processing chamber 1, so as to save the internal space of the processing chamber 1, thereby reducing the volume of the processing chamber 1 and making full use of the internal space of the processing chamber 1. Moreover, when the substrate w is transferred among a plurality of processing stations 101, the region on the substrate w originally close to the center of the processing chamber 1 is rotated to a position away from the center of the processing chamber 1, ensuring the uniformity of the multi-layer thin films deposited on the substrate w. In some embodiments, the rotation angles of the process robots 201 between two adjacent processing stations 101 may also be $360^\circ/N \pm 30^\circ$. For example, in the embodiment where four processing stations 101 are provided, as shown in FIG. 1, the rotation angles may be set to 80° , 100° , etc., and the lengths of the process robots 201 may be configured corresponding to the rotation angles.

Each processing station 101 is internally provided with a heating tray 11, a support member, and a lifting mechanism. The heating tray 11 is used for supporting and heating the substrate w, the support member is used for supporting the substrate w, and the lifting mechanism is connected to the support member for driving the support member to move up or down in the vertical direction so as to lift the substrate w off

the heating tray 11 or place the substrate w on the heating tray 11.

In some embodiments, the support member is usually lift pins 12, through-holes are provided on the heating tray 11, and the lift pins 12 are disposed in the through-holes. Three lift pins 12 may be provided, and correspondingly, three through-holes may be provided in one-to-one correspondence with the lift pins 12. All through-holes are equidistant from the edge of the heating tray 11 and may be distributed in a regular polygon shape to ensure the stability of the lift pins 12 supporting the substrate w. For example, in FIG. 5 and FIG. 7A, the three lift pins 12 are arranged in an equilateral triangle distribution. Specifically, one of the three lift pins 12 is distributed on the line connecting the center of the processing station 101 and the center of the processing chamber 1. Correspondingly, one lift pin 12 in each of the four processing stations 101 is distributed on the line connecting the center of the processing station 101 and the center of the processing chamber 1.

In some embodiments, to avoid interference between the process robots 201 and the lift pins 12 during transfer, the lengths of the process robots 201 cannot be too long. Specifically, as shown in FIG. 5, in the processing stations 101 on both sides of the process robot 201, two central lift pins 12A are respectively located on the lines connecting the centers of the processing stations 101 and the center of the processing chamber 1. The process robot 201 needs to avoid the two central lift pins 12A during transfer, so the length of the process robot 201 is shorter than the distance between the rotary joint O and the two central lift pins 12A.

FIGS. 3A to 3C show the process of one process robot 201 taking out the substrate w. As shown in FIG. 3A, in an initial state, the lift pins 12 are below the surface of the heating tray 11, and the substrate w is on the heating tray 11; as shown in FIG. 3B, the lifting mechanism drives the lift pins 12 to move up and protrude from the surface of the heating tray 11 to lift the substrate w, and the process robot 201 moves to a position below the substrate w; wherein the movement of the process robot 201 and the upward movement of the lift pins 12 may be performed simultaneously or sequentially; as shown in FIG. 3C, the lifting mechanism drives the lift pins 12 to move down below the surface of the heating tray 11, so that the substrate w falls onto the process robot 201 to be transferred to the next processing station 101.

FIGS. 4A to 4C show the process of one process robot 201 placing down the substrate w. As shown in FIG. 4A, the process robot 201 has transferred the substrate w to the next processing station 101, at this time, the lift pins 12 are below the surface of the heating tray 11, and the process robot 201 holds the substrate w; as shown in FIG. 4B, the lifting mechanism drives the lift pins 12 to move up until the lift pins 12 are higher than the process robot 201, so that the substrate w falls onto the lift pins 12; as shown in FIG. 4C, the process robot 201 moves out of the processing station 101, and the lifting mechanism drives the lift pins 12 to move down below the surface of the heating tray 11, so that the substrate w falls onto the heating tray 11; wherein the movement of the process robot 201 and the downward movement of the lift pins 12 may be performed simultaneously or sequentially.

FIGS. 6A to 6D show the process of the process robots 201 transferring a plurality of substrates w among a plurality of processing stations 101. The process is now described with reference to FIGS. 3A to 3C, FIGS. 4A to 4C, and FIGS. 6A to 6D. FIG. 6A shows an initial state before each process robot 201 transfers a substrate w, all process robots 201 are located on the perpendicular bisector planes of the lines connecting the centers of two adjacent heating trays 11, the lift pins 12 are below the surfaces of the heating trays 11, and the substrates w are on the heating trays 11. FIG. 6B shows the process of one process robot 201 taking out the substrate w, the lift pins 12 move up and are higher than the process robot 201, and the lift pins 12 lift the substrate w; the process robot 201 moves to a position below the substrate w, the lift pins 12 move down below the surface of the heating tray 11, and the substrate w falls onto the process robot 201. As shown in FIG. 6C, all process robots 201 rotate simultaneously to transfer the substrates w to the next adjacent heating trays 11; the lift pins 12 move up and are higher than the process robots 201 to lift the substrates w. As shown in FIG. 6D, all process robots 201 return to the initial positions, and the lift pins 12 move down below the surfaces of the heating trays 11, so the substrates w fall onto the heating trays 11. In embodiments where the process robots 201 can move up and down relative to the processing chamber 1, when substrates w are transferred among a plurality of processing stations 101, the process robots 201 need to be raised or lowered from the initial heights to positions between the heating trays 11 and the lift pins 12 to hold the substrates w, and after the transfer is completed, the process robots 201 are lowered or raised to the initial heights.

As shown in FIGS. 8A to 8C, the present invention further provides a thin-film deposition apparatus, comprising: a substrate loading port 100, for placing a substrate w; a buffer device 200, for placing a substrate w to be deposited; a front-end robot 300, for transferring the substrate w between the substrate loading port 100 and the buffer device 200; the thin-film deposition device in the embodiment described above, for performing thin-film deposition on the substrate w; a transfer robot 400, for transferring the substrate w between the buffer device 200 and the processing chamber 1 of the thin-film deposition device.

Specifically, the front-end robot 300 takes out the substrate w to be deposited from the substrate loading port 100 and places the substrate w on the buffer device 200; the transfer robot 400 takes out the substrate w from the buffer device 200 and places the substrate w in the processing chamber 1 of the thin-film deposition device to perform thin-film deposition on the surface of the substrate w; after thin-film deposition is completed, the transfer robot 400 takes out the substrate w from the processing chamber 1 and places the substrate w on the buffer device 200; the front-end robot 300 takes out the substrate w from the buffer device 200 and puts the substrate w back to the substrate loading port 100, completing the process operation of the thin-film deposition apparatus.

Wherein, a door is disposed on a side wall of the processing chamber 1 for the transfer robot 400 to enter the interior of the processing chamber 1 to place or take out the substrate w before and after the thin-film deposition process of the substrate w. As shown in FIGS. 7A and 7B, one or two doors 13 may be disposed on a side wall of the processing chamber 1, and the number of transfer robots 400 may correspond to the number of doors 13, that is, one processing chamber 1 with a single outlet is correspondingly provided with one transfer robot 400, and one processing chamber 1 with two outlets is correspondingly provided with two transfer robots 400.

In some embodiments, as shown in FIGS. 8A to 8B, the processing chamber 1 of the thin-film deposition device may be provided in plurality, and the plurality of processing chambers 1 are sequentially arranged on the periphery of the transfer robot 400.

As shown in FIG. 8A, the thin-film deposition apparatus may further comprise a

processing module 500, for performing pre-heating or surface reduction on the substrate w before deposition, or for performing thin-film surface modification after deposition.

Based on the overall operating speed of the apparatus, optionally, the thin-film deposition apparatus is provided with a plurality of buffer devices 200, and correspondingly, more transfer robots 400 and processing chambers 1 may be provided. As shown in FIG. 8C, the thin-film deposition apparatus is provided with two buffer devices 200, one transfer robot 400 is disposed between the two buffer devices 200 for transferring the substrate w between the two buffer devices 200. Two processing chambers 1 are further disposed on two sides of the transfer robot 400, and the transfer robot 400 can enter the interior of the processing chambers 1 to place or take out the substrate w.

The above embodiments are merely illustrative of the principles and effects of the present invention, and are not intended to limit the present invention. Any person skilled in the art can modify or change the embodiment described above without departing from the spirit and scope of the present invention. Therefore, all equivalent modifications and changes made by those of ordinary skill in the technical field without departing from the spirit and technical idea disclosed in the present invention shall still be covered by the claims of the present invention.

What is claimed is:

1. A thin-film deposition device, wherein the thin-film deposition device comprises a processing chamber, the processing chamber comprising:

N processing stations distributed in a regular polygonal distribution, for performing thin-film deposition, wherein N is greater than or equal to 3;

N process robots, respectively disposed between two adjacent processing stations, for transferring a substrate between two adjacent processing stations; one end of each process robot being rotatably connected to the processing chamber, and the rotary joint being located on the perpendicular bisector plane of the line connecting the centers of two adjacent processing stations.

2. The thin-film deposition device according to claim 1, wherein the rotation angle of the process robot between two adjacent processing stations is $360^\circ/N$.

3. The thin-film deposition device according to claim 1, wherein each processing station includes: a heating tray, for supporting and heating the substrate; a support member, penetratingly disposed in the heating tray for supporting the substrate; a lifting mechanism, for driving the support member to move up or down so as to lift the substrate off the heating tray or the process robot, or place the substrate on the heating tray or the process robot.

4. The thin-film deposition device according to claim 1, wherein the rotary joint is fixed relative to the processing chamber, and the position of the rotary joint is higher than the processing stations.

5. The thin-film deposition device according to claim 1, wherein the rotary joint is liftable relative to the processing chamber, and the rotary joint is disposed at any height in the processing chamber.

6. The thin-film deposition device according to claim 1, wherein both the number of the processing stations and the number of the process robots are four.

7. The thin-film deposition device according to claim 3, wherein the support

member includes lift pins, through-holes are provided on the heating tray, and the lift pins are disposed in the through-holes.

8. The thin-film deposition device according to claim 7, wherein the number of the lift pins is three, the number of the through-holes is three, and the through-holes are in one-to-one correspondence with the lift pins.

9. The thin-film deposition device according to claim 8, wherein all through-holes are equidistant from the edge of the heating tray, the lift pins are arranged in an equilateral triangle distribution, one of the lift pins is a central lift pin, and the central lift pin is located on the line connecting the center of the processing station and the center of the processing chamber.

10. The thin-film deposition device according to claim 9, wherein the length of the process robot is shorter than the distance between the rotary joint and any central lift pin on both sides of the process robot.

11. The thin-film deposition device according to claim 10, wherein the length of the process robot is longer than the distance between the rotary joint and the center of any adjacent processing station.

12. A thin-film deposition method, comprising the following steps:

S11: placing a substrate into a processing chamber;

S12: depositing a certain number of thin-film layers on the substrate;

S13: a plurality of process robots synchronously rotating to respectively transfer the substrate between two adjacent processing stations;

S14: taking the substrate out of the processing chamber after the substrate completes deposition at all processing stations, and repeating steps S11 to S14; otherwise, repeating steps S12 to S14.

13. A thin-film deposition apparatus, comprising:

a substrate loading port, for placing a substrate;

a buffer device, for placing a substrate to be deposited;

a front-end robot, for transferring the substrate between the substrate loading port and the buffer device;

the thin-film deposition device according to any of claims 1 to 11, for performing thin-film deposition on the substrate;

a transfer robot, for transferring the substrate between the buffer device and the processing chamber of the thin-film deposition device.

14. The thin-film deposition apparatus according to claim 13, wherein a door is disposed on a side wall of the processing chamber for allowing the transfer robot to enter the interior of the processing chamber to place or take out the substrate.

15. The thin-film deposition apparatus according to claim 13, wherein a plurality of processing chambers are provided, and the plurality of processing chambers are symmetrically arranged on two sides of the transfer robot or sequentially arranged on the periphery of the transfer robot.

16. The thin-film deposition apparatus according to claim 13, wherein the thin-film deposition apparatus further comprises a processing module for performing pre-heating or surface reduction on the substrate before deposition, or for performing thin-film surface modification after deposition.

17. The thin-film deposition apparatus according to claim 13, wherein a plurality of buffer devices are provided, and a transfer robot is further disposed between two adjacent buffer devices for transferring the substrate between two buffer devices.