

THIN-FILM DEPOSITION APPARATUS AND THIN-FILM DEPOSITION METHOD

TECHNICAL FIELD

The present application relates to the technical field of semiconductors, and relates to a thin-film deposition apparatus and a thin-film deposition method.

BACKGROUND

Plasma enhanced chemical vapor deposition (PECVD) equipment is used to deposit various dielectric thin films on the surface of a substrate. The thickness uniformity of a thin film is one of the key parameters of a thin-film deposition process, which directly affects the properties and yield of the thin film. However, the thickness uniformity of the thin film is affected by many adverse factors. In particular, non-uniform heating of the substrate is one of the important adverse factors for the non-uniform thickness of the thin film on the substrate.

During thin-film deposition, a substrate to be deposited with a thin film is placed on a heating tray, and the heating tray heats the substrate. However, non-uniform temperature of the heating tray results in non-uniform heating of the substrate and non-uniform thickness of the thin film deposited on the surface of the substrate. Therefore, it is necessary to provide a thin-film deposition apparatus and a thin-film deposition method capable of uniformizing thin-film thickness.

SUMMARY

In view of the above-mentioned shortcomings of the prior art, the object of the present invention is to provide a thin-film deposition apparatus and a thin-film deposition method 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 application provides a thin-film deposition apparatus, comprising: a radio frequency power supply, for providing radio frequency power to generate an electric field in a processing chamber; a heating unit, including a heating tray for heating the substrate

and a rotating shaft supporting the heating tray; a support unit, including a support ring disposed around the heating tray and a support seat supporting the support ring; a power transmission unit, fixedly connected to the rotating shaft; a bearing portion, including a second bearing portion and a third bearing portion, wherein the power transmission unit is mounted on the third bearing portion, penetrates through the second bearing portion and is fixedly connected to the rotating shaft, and the support seat is sleeved on the rotating shaft and fixedly connected to the second bearing portion, so that when the third bearing portion moves up and down relative to the second bearing portion, the power transmission unit and the heating unit move up and down relative to the support unit; a power source, including a first power source capable of driving the second bearing portion and the third bearing portion to move up and down synchronously, and a second power source capable of driving the third bearing portion to move up and down relative to the second bearing portion, wherein when the first power source drives the second bearing portion to drive the support unit to move up and down, the third bearing portion is used for driving the power transmission unit and the heating unit to move up and down synchronously; when the second power source drives the third bearing portion to drive the power transmission unit and the heating unit to move up and down synchronously, the second bearing portion and the support unit are stationary.

Optionally, when the first power source drives the second bearing portion and the third bearing portion to move up synchronously, the third bearing portion drives the heating unit to move up until the heating tray supports the substrate, or until the support ring and the heating tray jointly support the substrate. Optionally, when the second power source drives the third bearing portion to move up, the third bearing portion drives the heating unit to move up until the substrate is separated from the support ring.

Optionally, the support unit further includes a plurality of support rods located between the support ring and the support seat, and the support rods are non-fixedly connected to the support ring.

Optionally, when the second power source drives the third bearing portion to move up, the third bearing portion drives the power transmission unit and the heating unit to move up until the support rods are separated from the support ring.

Optionally, the thin-film deposition apparatus further comprises a magnetic fluid mounted on the third bearing portion, the magnetic fluid includes an inner ring fixedly connected to the power transmission unit, and the inner ring is used for driving the heating unit to rotate via the power transmission unit.

Optionally, when the heating unit rotates in a first direction, the support ring is kept in a non-contact state with the heating tray and the substrate, and the heating unit drives the substrate to rotate synchronously.

Optionally, when the heating unit rotates in the first direction, the heating unit drives the support ring and the substrate to rotate synchronously.

Optionally, when the heating unit rotates in a second direction, the support ring supports the substrate, and the substrate is kept in a non-contact state with the heating unit, wherein the second direction is opposite to the first direction.

Optionally, the thin-film deposition apparatus further comprises a connecting unit, and the connecting unit is connected to the heating unit for eliminating electric field variation caused by the rotation and reset of the heating unit.

Optionally, the connecting unit includes an elastic member and a radio frequency cable connected to the heating unit, and the elastic member drives the radio frequency cable to reset to the initial posture when the heating unit performs rotary reset.

Optionally, the radio frequency cable passes through the power transmission unit and extends in the bending direction of the elastic member.

Optionally, the connecting unit includes a slip ring and the radio frequency cable, the heating unit and the radio frequency cable are connected via the slip ring, and the radio frequency cable is stationary when the heating unit rotates and resets.

To achieve the objective described above and other related objectives, the present application further provides a thin-film deposition method, comprising the following steps:

S1: placing a substrate in a processing chamber, and driving a heating tray to drive

the substrate to move up to a process position;

S2: performing a single thin-film deposition on the surface of the substrate;

S3: an inner ring of a magnetic fluid driving the heating unit to rotate synchronously by a certain angle from the initial position via a power transmission unit;

S4: a second power source driving a third bearing portion to drive the heating unit to move down until the heating unit is separated from the substrate, and a support ring supporting the substrate;

S5: the power transmission unit driving the heating unit to rotate reversely to the initial position;

S6: the second power source driving the third bearing portion to drive the heating unit to move up synchronously, and the heating unit driving the substrate to move up to the process position;

S7: repeating steps S2 to S6 until n times of thin-film deposition are completed.

Optionally, in step S3, an elastic member is fixedly connected to the heating unit, and when the heating unit rotates, one end of the elastic member stretches to cause deformation of the elastic member and a radio frequency cable; in step S5, when the heating unit performs rotary reset, the elastic member drives the radio frequency cable to rebound to the initial posture.

Optionally, in step S3, the heating unit is fixedly connected to a slip ring so that the heating unit and the slip ring can rotate synchronously in a first direction; in step S5, the power transmission unit drives the rotor of the slip ring to rotate in a second direction, and the first direction is opposite to the second direction.

Optionally, in step S1, the step of driving a heating unit to drive the substrate to move up to a process position includes: a first power source driving a second bearing portion and the third bearing portion to move up synchronously, the second bearing portion driving the support ring to move up, and the third bearing portion driving the heating tray to move up synchronously until the heating tray is in contact with the

substrate, or until both the heating tray and the support ring are in contact with the substrate; the second power source driving the third bearing portion to drive the heating tray and the substrate to continue to move up to the process position.

As described above, according to the thin-film deposition apparatus and the thin-film deposition method of the present invention, the heating unit drives the substrate to rotate, ensuring the uniformity of the thin film deposited on the substrate surface by the plasma gas dissociated from process gases by the electric field under the action of a radio frequency power source, and the heating unit is connected to the connecting unit, so that the electric field remains unchanged after the heating unit rotates and resets.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a structural schematic view of the thin-film deposition apparatus in the present invention;

FIG. 2 is a sectional view of the thin-film deposition apparatus in the present invention, where a substrate is placed at the ends of support pins;

FIG. 3 is a sectional view of another embodiment of the thin-film deposition apparatus in the present invention;

FIGS. 4A and 4B are schematic views of different embodiments of the thin-film deposition apparatus, where the substrate is located at a process position;

FIG. 5 is a circuit diagram of the radio frequency power supply of the thin-film deposition apparatus in the present invention providing radio frequency power to dissociate process gases.

PREFERRED EMBODIMENTS OF THE PRESENT APPLICATION

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 the present specification. The present invention can also be implemented or applied through other different specific embodiments, and various details in the present specification can be modified or changed based on different viewpoints and applications without departing from the spirit of the present invention.

In describing the embodiments of the present invention in detail, for convenience of explanation, sectional views showing device structures are partially enlarged not in general scale, and the schematic views are merely examples, which should not limit the protection scope of the present invention herein. In addition, actual fabrication should include three-dimensional dimensions of length, width, and depth.

For convenience of description, spatially relative terms such as "below," "under," "lower than," "beneath," "above," and "on" may be used herein to describe the relationship of one element or feature shown in the accompanying drawings with other elements or features. It will be understood that these spatially relative terms are intended to encompass other orientations of the device in use or operation in addition to the orientation depicted in the accompanying drawings. In addition, when a layer is referred to as being "between" two layers, the layer can be the only layer between the two layers, or one or more intervening layers may also be present. The term "between" used herein includes both endpoints.

In the context of the present application, a structure where a first feature is "on" a second feature may include embodiments where the first feature and the second feature are formed in direct contact, or embodiments where an additional feature is formed between the first feature and the second feature, so that the first feature and the second feature may not be in direct contact.

It should be noted that the drawings provided in the present embodiment illustrate the basic idea of the present invention only in a schematic manner, so the drawings only show components related to the present invention instead of being drawn according to the number, shape, and size of the components in actual implementation. The shape, number, and proportion of each component in actual implementation can be changed arbitrarily, and the component layout can be more complex.

As shown in FIGS. 1 to 4B, the present embodiment provides a thin-film deposition apparatus, comprising a heating unit 100, a support unit 200, a power transmission unit 300, a magnetic fluid 400, a motor 500, a substrate holding unit 600, a connecting unit 700, a power source 800, and a bearing portion 900. Wherein, the motor 500 is used for driving the heating unit 100 to rotate, and the power source 800 is used for driving the heating unit 100 or the heating unit 100 and the support unit 200 to move up and down together.

As shown in FIG. 2, the heating unit 100 includes a heating tray 110 and a rotating shaft 120 for supporting the heating tray 110. The rotating shaft 120 extends downward from the heating tray 110 and stably supports the heating tray 110.

According to FIGS. 1 and 2, the support unit 200 includes an annular support ring 210 disposed around the heating tray 110, a support seat 230 for supporting the support ring 210, and a plurality of support rods 220 located between the support ring 210 and the support seat 230. The support seat 230 is movably sleeved on the rotating shaft 120, and the rotating shaft 120 can move up and down relative to the support seat 230 during a thin-film deposition process. According to FIG. 4A or 4B, the inner diameter of the support ring 210 is smaller than the outer diameter of a substrate W, so that the support ring 210 supports the substrate W when the support ring 210 is in contact with the substrate W. The heating tray 110 includes a protrusion 111 protruding upward from the upper surface of the heating tray 110 and a rim portion 112 disposed around the protrusion 111, and the diameter of the protrusion 111 is smaller than the diameter of the substrate W.

As shown in FIGS. 4A and 4B, the support ring 210 includes a first stepped portion 211, a second stepped portion 212, and a slope 213 connecting the first stepped portion 211 and the second stepped portion 212. When the support ring 210 supports the substrate W, the slope 213 can play a guiding role. The height of the second stepped portion 212 is higher than the height of the first stepped portion 211, and the first stepped portion 211 is located between the heating tray 110 and the substrate W. In one embodiment, as shown in FIG. 4A, the height difference between the protrusion 111 and the rim portion 112 of the heating tray 110 is greater than the thickness of the first stepped portion 211. Specifically, the height difference is between 1.5 mm and 2.9 mm, and the thickness of the first stepped portion 211 of the support ring 210 is between

0.3 mm and 0.7 mm. The support ring 210 is fixedly connected to the support rods 220, and the support rods 220 can drive the support ring 210 to move up. In a thin-film deposition process state, the support rods 220 drive the support ring 210 to move up, and the heating tray 110 also moves up at the same time until the heating tray 110 or the support ring 210 and the heating tray 110 jointly support the substrate W, then the support rods 220 stop moving up, and the heating tray 110 continues to move up to a process position. As shown in FIG. 4A, the upper and lower surfaces of the first stepped portion 211 of the support ring 210 are not in contact with the substrate W and the heating unit 100 at this time.

In another embodiment, as shown in FIG. 4B, the height difference between the protrusion 111 and the rim portion 112 of the heating tray 110 is equal to the thickness of the first stepped portion 211, and the upper surface of the protrusion 111 is flush with the upper surface of the first stepped portion 211 to prevent the substrate W from shaking when the substrate W is jointly supported. Specifically, the height difference between the protrusion 111 and the rim portion 112 is between 0.3 mm and 0.7 mm. The support ring 210 is non-fixedly connected to the support rods 220. During thin-film deposition, the support ring 210 is separated from the support rods 220, and the support ring 210 is supported by the rim portion 112 of the heating tray 110. At this time, the upper surface of the first stepped portion 211 of the support ring 210 contacts the substrate W, and a part of the lower surface of the support ring 210 contacts the heating tray 110, which can better conduct heat to the substrate W and prevent insufficient temperature at the edge of the substrate W.

As shown in FIG. 2, the substrate holding unit 600 includes support pins 610 for supporting the substrate W and a support base 620 fixedly connected to the support pins 610. The support base 620 is movably sleeved on the outer side of the support seat 230, and the position of the support base 620 remains unchanged when the support seat 230 moves up and down. The support pins 610 penetrate through the heating tray 110, and the ends of the support pins 610 support the substrate W.

As shown in FIG. 2, the power transmission unit 300 is connected between the rotating shaft 120 and the magnetic fluid 400, and can drive the rotating shaft 120 to rotate when the magnetic fluid 400 rotates. Specifically, the magnetic fluid 400 includes an inner ring 420 and an outer ring 410, the inner ring 420 can rotate relative

to the outer ring 410, and the inner ring 420 is connected between the power transmission unit 300 and the motor 500. When the motor 500 drives the inner ring 420 to rotate, the inner ring 420 drives the rotating shaft 120 to rotate via the power transmission unit 300. Wherein, the motor 500 is located between the inner ring 420 and the outer ring 410 and inside the magnetic fluid 400.

As shown in FIG. 5, a radio frequency power supply D provides radio frequency power to form a radio frequency electric field between an upper electrode showerhead S and a lower electrode heating unit 200, exciting process gases supplied by the upper electrode showerhead S to dissociate into plasma gas, and the dissociated plasma gas performs thin-film deposition on the substrate W. As shown in FIG. 5, in one embodiment, the radio frequency power supply D is connected to the upper electrode showerhead S, and the lower electrode heating unit 200 is grounded via a radio frequency cable. In another embodiment, the radio frequency power supply D is connected to the lower electrode heating unit 200 via the radio frequency cable, and the upper electrode showerhead S is grounded (not shown). In addition, a regulating capacitor C counteracts the inductance formed by the radio frequency cable by regulating capacitance, so that impedance in the circuit remains unchanged and the electric field is kept constant.

According to FIG. 2, the heating unit 100 is connected to the connecting unit 700, and the connecting unit 700 is used for eliminating the electric field variation caused by the rotation and reset of the heating unit 100. The rotation and reset of the heating unit 100 will cause change in radio frequency cable posture. In one embodiment, the connecting unit 700 includes a retaining member 710, a radio frequency cable 720, and an elastic member 730. The elastic member 730 can be a spring or a drag chain. The power transmission unit 300 is fixedly connected to the retaining member 710, one end of the elastic member 730 is fixedly connected to the retaining member 710, and the other end of the elastic member 730 is fixedly connected to a matching unit 520. Therefore, when the heating unit 200 drives the power transmission unit 300 and the retaining member 710 to rotate in one direction or rotate reversely in another direction, one end of the elastic member 730 stretches or rebounds along with the power transmission unit 300. One end of the radio frequency cable 720 electrically connected to the heating unit 200 passes through a through-hole (not shown) of the power

transmission unit 300, then passes through the retaining member 710 and the elastic member 730 in sequence, is fixed to the retaining member 710 and the elastic member 730 at multiple positions, and then is grounded or connected to the radio frequency power supply D. The radio frequency cable 720 is fixed to the retaining member 710 and the elastic member 730 at multiple positions via ropes or cable ties. The radio frequency cable 720 extends in the bending direction of the elastic member 730, and can move synchronously with the elastic member 730 when the elastic member 730 stretches or rebounds. In the thin-film deposition process, the heating unit 100 rotates and resets, i.e., rotates by a set angle from the initial position and then reversely rotates to the initial position, and the radio frequency cable 720 also moves synchronously with the heating unit 100. However, since the radio frequency cable 720 is flexible, the radio frequency cable 720 does not return to the initial posture after the heating unit 100 returns to the initial position, resulting in changes in inductance and electric field. In addition, the capacitance cannot be regulated in real time according to inductance change. Therefore, in the present embodiment, the radio frequency cable 720 is fixed to the elastic member 730. When the heating unit 100 performs rotary reset, the radio frequency cable 720 resets to the initial posture under the rebound action of the elastic member 730, i.e., returns to the initial shape, so as to ensure that the inductance in the circuit remains unchanged. Specifically, the set angle by which the power transmission unit 300 rotates can be 60 degrees, and the heating unit 100 can drive the substrate W to rotate through a full revolution under the action that the power transmission unit 300 drives the heating unit 300 to rotate 6 times in one direction. Other angles divisible by 360 degrees can also be selected, so as to ensure that the substrate W is driven to rotate through a full revolution after several rotations. The matching unit 520 is mounted below a fourth bearing portion 940, and the retaining member 710 penetrates through the fourth bearing portion 940 and is fixedly connected to one end of the elastic member 730. Herein, when the power transmission unit 300 drives the heating unit 100 and the retaining member 710 to rotate synchronously, the elastic member 730 stretches and rebounds below the fourth bearing portion 940.

In another embodiment, according to FIGS. 3 and 5, the connecting unit 700 includes a slip ring 740 and the radio frequency cable 720. One end of the connecting unit 700 is inserted into the power transmission unit 300 and electrically connected to the heating unit 200, and the other end of the connecting unit 700 is electrically

connected to the regulating capacitor C in the matching unit 520 or the radio frequency power supply D via the radio frequency cable 720. When the power transmission unit 300 drives the heating unit 100 and the connecting unit 700 to rotate, the radio frequency cable 720 is stationary, which does not cause inductance change and keeps impedance unchanged, so that the electric field between the upper electrode showerhead S and the lower electrode heating unit 100 also remains unchanged. The bottom of the connecting unit 700 is fixedly connected to the fourth bearing portion 940, and the radio frequency cable 720 penetrates through the fourth bearing portion 940 and is grounded or connected to the radio frequency power supply D.

As shown in FIGS. 1 and 2, the bearing portion 900 includes a first bearing portion 910, a second bearing portion 920, a third bearing portion 930, and the fourth bearing portion 940 distributed in sequence from top to bottom in the vertical direction. The power source 800 includes a first power source 810 and a second power source 820. The first power source 810 is connected between the first bearing portion 910 and the second bearing portion 920 so that the first bearing portion 910 and the second bearing portion 920 can move relative to each other in the vertical direction. The second power source 820 is connected between the second bearing portion 920 and the third bearing portion 930 so that the second bearing portion 920 and the third bearing portion 930 can move relative to each other in the vertical direction. Both the first power source 810 and the second power source 820 can be electric cylinders. For example, when the first power portion 810 extends, the first power source 810 drives the second bearing portion 920 to move down; when the first power portion 810 contracts, the first power source 810 drives the second bearing portion 920 to move up. The number of the first power sources 810 and the second power sources 820 is 2 or 3, respectively, and the first power sources 810 and the second power sources 820 are uniformly arranged between adjacent bearing portions. Preferably, the number of the first power sources 810 and the second power sources 820 is 3, respectively, so that adjacent bearing portions are stressed uniformly. The power transmission unit 300 penetrates through the third bearing portion 930 and the second bearing portion 920 in sequence from bottom to top, and is fixedly connected to the rotating shaft 120 penetrating through the first bearing portion 910 from top to bottom. The power transmission unit 300 is fixedly connected to the magnetic fluid 400, and the magnetic fluid 400 is fixedly connected to the third bearing portion 930. Therefore, when the second bearing portion

920 and the third bearing portion 930 move relative to each other, the power transmission unit 300 drives the rotating shaft 120 of the heating unit 100 to move up and down, so that the heating tray 110 of the heating unit 100 can move up and down. Herein, since the support seat 230 is sleeved on the rotating shaft 120 and penetrates through the first bearing portion 910, the bottom of the support seat 230 is fixedly connected to the second bearing portion 920 via a flange (not shown). Thus, when the second bearing portion 920 and the third bearing portion 930 move relative to each other, the power transmission unit 300 drives the heating unit 100 to move up and down, and the support seat 230 and the support rods 220 remain stationary. When the second bearing portion 920 and the first bearing portion 910 move relative to each other, the support seat 230 drives the support ring 210 and the support rods 220 to move up and down. At this time, since the second power source 820 is connected between the second bearing portion 920 and the third bearing portion 930, the second power source 820 becomes rigidly connected, so the second bearing portion 920 drives the third bearing portion 930 to move up and down synchronously, the third bearing portion 930 drives the power transmission unit 300 to move up and down synchronously, and the heating tray 110 also moves up and down synchronously. The two ends of the magnetic fluid 400 are mounted on the third bearing portion 930 and the fourth bearing portion 940, respectively, and the other end of the elastic member 730 is fixedly connected to the fourth bearing portion 940. Therefore, the other end of the elastic member 730 is indirectly fixedly connected to the third bearing portion 930.

The thin-film deposition method using the above thin-film deposition apparatus in the present invention comprises the following steps:

S1: placing the substrate W in a processing chamber, and driving the heating tray to drive the substrate to move up to a process position;

in some embodiments, step S1 specifically includes the following steps S11 to S13:

S11: placing the substrate W in a processing chamber, and the substrate W being placed at the ends of the support pins 610 of the holding unit 600 in the processing chamber;

S12: driving the heating tray 110 and the support ring 210 to move up at the same time until the heating tray 11 or both the heating tray 11 and the support ring 210 are in contact with the substrate W;

in step S12, the first power source 810 can drive the second bearing portion 920 and the third bearing portion 930 to move up synchronously, then the support seat 230 fixedly connected to the second bearing portion 920 drives the support rods 220 and the support ring 210 to move up synchronously, and the power transmission unit 300 fixedly connected to the third bearing portion 930 drives the heating unit 200 to move up synchronously until the heating tray 110 is in contact with the substrate W, or until both the heating tray 110 and the support ring 210 are in contact with the substrate W;

S13: the heating tray 110 driving the substrate W or both the substrate W and the support ring 210 to continue to move up to a process position;

in step S13, in one embodiment, the support rods 220 are fixedly connected to the support ring 210, the second power source 820 drives the third bearing portion 930 to move up, then the power transmission unit 300 fixedly connected to the third bearing portion 930 drives the heating unit 200 and the substrate W to continue to move up to the process position, and the support ring 210 remains stationary; in another embodiment, the support rods 220 are non-fixedly connected to the support ring 210, and when the second power source 820 drives the third bearing portion 930 to move up, the heating unit 200 drives the support ring 210 and the substrate W to move up synchronously to the process position; in addition, in steps S2 and S3, the movement of the substrate to the process position can be replaced by that the holding unit 600 drives the substrate W to move down until the support pins 600 retract into the heating tray 110, and the substrate W is placed on the heating tray 110 or on both the heating tray 110 and the support ring 210;

S2: performing a single thin-film deposition on the surface of the substrate;

S3: the inner ring 420 of the magnetic fluid driving the heating unit 100 to rotate synchronously by a certain angle from the initial position via the power transmission unit 300;

in step S3, the motor 500 drives the inner ring 420 to rotate, the inner ring 420 drives the heating unit 100 to rotate synchronously via the power transmission unit 300, and the heating unit 100 drives the substrate W or both the substrate W and the support ring 210 to rotate from the initial position; in one embodiment, the support rods 220 are fixedly connected to the support ring 210, the heating unit 100 drives the substrate W to rotate, and the support ring 210 remains stationary; in another embodiment, the support rods 220 are non-fixedly connected to the support ring 210, and the heating unit 100 drives the substrate W and the support ring 210 to rotate synchronously; in addition, the heating unit 100 drives the connecting unit 700 to move at the same time; in one embodiment, the heating unit 100 drives one end of the elastic member 730 to stretch to change the shape of the elastic member 730; in another embodiment, the heating unit 100 drives the rotor of the slip ring 740 to rotate;

S4: the second power source 820 driving the third bearing portion 930 to drive the heating unit 100 to move down until the heating unit 100 is separated from the substrate W, and the support ring 210 supporting the substrate W;

in step S4, the second power source 820 drives the third bearing portion 930 to move down, then the heating unit 100 moves down synchronously; in one embodiment, the heating unit 100 drives the substrate W to move down until the substrate W is in contact with the support ring 210, then the support ring 210 supports the substrate W, and the heating unit 100 continues to move down until the heating unit 100 is separated from the substrate W; in another embodiment, the heating unit 100 drives both the substrate W and the support ring 210 to move down until the support ring 210 is in contact with the support rods 220, then the support ring 210 is supported by the support rods 220, the support ring 210 supports the substrate W, and both the support ring 210 and the substrate W stop moving down; at this time, the heating unit 100 continues to move down until the heating unit 100 is separated from the substrate W;

S5: the power transmission unit 300 driving the heating unit 100 to rotate reversely to the initial position;

the motor 500 drives both the power transmission unit 300 and the heating unit 100 to rotate reversely together to the initial position; in one embodiment, the power transmission unit 300 drives the elastic member 730 to rotate back, and the elastic

member 730 rebounds to the initial shape; in another embodiment, the power transmission unit 300 drives the rotor of the slip ring 740 to rotate;

S6: the second power source 820 driving the third bearing portion 930 to drive the heating unit 100 to move up synchronously, and the heating unit 100 driving the substrate W to move up to the process position;

in step S6, the second power source 820 drives the third bearing portion 930 to move up, then the heating unit 100 moves up synchronously; in one embodiment, the heating unit 100 drives the substrate W to move up until the substrate W is separated from the support ring 210 to reach the process position; in another embodiment, the heating unit 100 drives both the substrate W and the support ring 210 to move up synchronously, and the support ring 210 is separated from the support rods 220 to reach the process position;

S7: repeating steps S2 to S6 until n times of thin-film deposition are completed.

According to the thin-film deposition apparatus and the thin-film deposition method of the present invention, the radio frequency power supply D provides radio frequency power to form an electric field between the upper electrode showerhead S and the lower electrode heating unit 200, so that the electric field remains unchanged after the heating unit 200 rotates and resets.

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

What is claimed is:

1. A thin-film deposition apparatus, comprising:

a radio frequency power supply, for providing radio frequency power to generate an electric field in a processing chamber;

a heating unit, including a heating tray for heating a substrate and a rotating shaft supporting the heating tray;

a support unit, including a support ring disposed around the heating tray and a support seat supporting the support ring;

a power transmission unit, fixedly connected to the rotating shaft;

a bearing portion, including a second bearing portion and a third bearing portion, wherein the power transmission unit is mounted on the third bearing portion, penetrates through the second bearing portion and is fixedly connected to the rotating shaft, and the support seat is sleeved on the rotating shaft and fixedly connected to the second bearing portion, so that when the third bearing portion moves up and down relative to the second bearing portion, the power transmission unit and the heating unit move up and down relative to the support unit;

a power source, including a first power source capable of driving the second bearing portion and the third bearing portion to move up and down synchronously, and a second power source capable of driving the third bearing portion to move up and down relative to the second bearing portion, wherein when the first power source drives the second bearing portion to drive the support unit to move up and down, the third bearing portion is used for driving the power transmission unit and the heating unit to move up and down synchronously; when the second power source drives the third bearing portion to drive the power transmission unit and the heating unit to move up and down synchronously, the second bearing portion and the support unit are stationary.

2. The thin-film deposition apparatus according to claim 1, wherein when the first power source drives the second bearing portion and the third bearing portion to move up synchronously, the third bearing portion drives the heating unit to move up until the

heating tray supports the substrate, or until the support ring and the heating tray jointly support the substrate.

3. The thin-film deposition apparatus according to claim 1, wherein when the second power source drives the third bearing portion to move up, the third bearing portion drives the heating unit to move up until the substrate is separated from the support ring.

4. The thin-film deposition apparatus according to claim 1, wherein the support unit further includes a plurality of support rods located between the support ring and the support seat, and the support rods are non-fixedly connected to the support ring.

5. The thin-film deposition apparatus according to claim 4, wherein when the second power source drives the third bearing portion to move up, the third bearing portion drives the power transmission unit and the heating unit to move up until the support rods are separated from the support ring.

6. The thin-film deposition apparatus according to claim 1, wherein the thin-film deposition apparatus further comprises a magnetic fluid mounted on the third bearing portion, the magnetic fluid includes an inner ring fixedly connected to the power transmission unit, and the inner ring is used for driving the heating unit to rotate via the power transmission unit.

7. The thin-film deposition apparatus according to claim 6, wherein when the heating unit rotates in a first direction, the support ring is kept in a non-contact state with the heating tray and the substrate, and the heating unit drives the substrate to rotate synchronously.

8. The thin-film deposition apparatus according to claim 6, wherein when the heating unit rotates in a first direction, the heating unit drives the support ring and the substrate to rotate synchronously.

9. The thin-film deposition apparatus according to claim 7 or 8, wherein when the heating unit rotates in a second direction, the support ring supports the substrate, and the substrate is kept in a non-contact state with the heating unit, and the second direction is opposite to the first direction.

10. The thin-film deposition apparatus according to claim 6, wherein the thin-film deposition apparatus further comprises a connecting unit, and the connecting unit is connected to the heating unit for eliminating electric field variation caused by the rotation and rotary reset of the heating unit.

11. The thin-film deposition apparatus according to claim 10, wherein the connecting unit includes an elastic member and a radio frequency cable connected to the heating unit, and the elastic member drives the radio frequency cable to reset to the initial posture when the heating unit performs rotary reset.

12. The thin-film deposition apparatus according to claim 10, wherein the radio frequency cable passes through the power transmission unit and extends in the bending direction of the elastic member.

13. The thin-film deposition apparatus according to claim 10, wherein the connecting unit includes a slip ring and a radio frequency cable, the heating unit and the radio frequency cable are connected via the slip ring, and the radio frequency cable is stationary when the heating unit rotates and resets.

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

S1: placing a substrate in a processing chamber, and driving a heating tray to drive the substrate to move up to a process position;

S2: performing a single thin-film deposition on the surface of the substrate;

S3: an inner ring of a magnetic fluid driving the heating unit to rotate synchronously by a certain angle from the initial position via a power transmission unit;

S4: a second power source driving a third bearing portion to drive the heating unit to move down until the heating unit is separated from the substrate, and a support ring supporting the substrate;

S5: the power transmission unit driving the heating unit to rotate reversely to the initial position;

S6: the second power source driving the third bearing portion to drive the heating unit to move up synchronously, and the heating unit driving the substrate to move up to the process position;

S7: repeating steps S2 to S6 until n times of thin-film deposition are completed.

15. The thin-film deposition method according to claim 14, wherein in step S3, an elastic member is fixedly connected to the heating unit, and when the heating unit rotates, one end of the elastic member stretches to cause posture change of the elastic member and a radio frequency cable; in step S5, when the heating unit performs rotary reset, the elastic member drives the radio frequency cable to rebound to the initial posture.

16. The thin-film deposition method according to claim 14, wherein in step S3, the heating unit is fixedly connected to a slip ring so that the heating unit and the slip ring can rotate synchronously in a first direction; in step S5, the power transmission unit drives the rotor of the slip ring to rotate in a second direction, and the first direction is opposite to the second direction.

17. The thin-film deposition method according to claim 14, wherein in step S1, the step of driving a heating unit to drive the substrate to move up to a process position includes: a first power source driving a second bearing portion and the third bearing portion to move up synchronously, the second bearing portion driving the support ring to move up, and the third bearing portion driving the heating tray to move up synchronously until the heating tray is in contact with the substrate, or until both the heating tray and the support ring are in contact with the substrate; the second power source driving the third bearing portion to drive the heating tray and the substrate to continue to move up to the process position.