

THIN-FILM DEPOSITION APPARATUS AND THIN-FILM DEPOSITION METHOD

TECHNICAL FIELD

The present application relates to the technical field of semiconductor, and in particular 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 the thin films is one of the key parameters of the thin-film deposition process, which directly affects the properties and yield of the thin films. However, the thickness uniformity of the thin films is affected by many adverse factors, and in particular, the non-uniform heating of the substrate is one of the significant adverse factors for the thickness uniformity of the thin films on the substrate.

In the process of thin-film deposition, the substrate on which a thin film is to be deposited is placed on a heating tray, and the heating tray heats the substrate. However, the non-uniform temperature of the heating tray leads to non-uniform heating of the substrate, and thus the thickness of the thin film deposited on the surface of the substrate is also non-uniform.

Therefore, it is necessary to provide a thin-film deposition apparatus and a thin-film deposition method that can achieve uniform thin-film thickness.

SUMMARY

In view of the above-mentioned shortcomings of the prior art, the objective of the present invention is to provide a thin-film deposition apparatus and a thin-film deposition method, so as to solve the problem of poor uniformity of the thin film deposited on the substrate in the prior art.

To achieve the above objective and other related objectives, the present application provides a thin-film deposition apparatus, comprising:

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

a rotating ring, for supporting the substrate, the rotating ring being arranged around the heating tray;

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

a two-stage magnetic fluid, fixedly connected to the power transmission unit;

wherein, the power transmission unit and the two-stage magnetic fluid are movably mounted on the support shaft; when driven, the power transmission unit and the two-stage magnetic fluid drive the rotating ring to move, and drive the substrate to perform a rotational motion and/or a lifting motion via the rotating ring.

Optionally, the two-stage magnetic fluid includes an intermediate ring, and the intermediate ring is fixedly connected to the power transmission unit.

Optionally, the inner diameter of the rotating ring is smaller than the outer diameter of the substrate.

Optionally, a gap is present in the horizontal direction between the rotating ring and the heating tray.

Optionally, the thin-film deposition apparatus further comprises a first support portion and a third support portion, the support shaft is fixed to the first support portion and penetrates the third support portion, and when the first support portion moves relative to the third support portion in the extending direction of the support shaft, the first support portion drives the support shaft to move and drives the heating tray to move up and down via the support shaft.

Optionally, the two-stage magnetic fluid and the power transmission unit are coupled to the first support portion, and the first support portion drives the rotating ring to move up and down via the two-stage magnetic fluid and the power transmission unit.

Optionally, the thin-film deposition apparatus further comprises a second support

portion located between the first support portion and the third support portion, the support shaft further penetrates the second support portion, the two-stage magnetic fluid, and the power transmission unit, the two-stage magnetic fluid is fixedly connected to the second support portion, and when the second support portion moves relative to the first support portion, the second support portion drives the two-stage magnetic fluid and the power transmission unit to perform a lifting motion along the support shaft.

Optionally, a first bellow is arranged between the two-stage magnetic fluid and the third support portion, and a second bellow is arranged between the first support portion and the second support portion.

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

S1: placing a substrate at the end of a substrate support unit;

S2: driving a heating tray and a rotating ring to move up, allowing both the heating tray and the rotating ring to be in contact with the substrate;

S3: depositing a thin film with a certain thickness on the surface of the substrate;

S4: after the completion of thin-film deposition in step S3, driving the rotating ring to move up, allowing the rotating ring to lift the substrate off a heating unit;

S5: driving the rotating ring to rotate, and driving the substrate to rotate from a first angular position to a second angular position;

S6: driving the rotating ring to move down until the heating unit is in contact with the substrate again, and then performing the next thin-film deposition.

As mentioned above, according to the thin-film deposition apparatus and the thin-film deposition method of the present invention, the rotating ring lifts the substrate to perform a lifting motion to separate the substrate from the heating unit. With the heating unit kept stationary, the rotating ring drives the substrate to rotate by a certain angle, and then the rotating ring drives the substrate to perform a lifting motion again

until the heating unit contacts the substrate. Multiple thin-film depositions are achieved through the independent movement of the rotating ring and the heating unit, thereby improving the uniformity of the thin film on the surface of the substrate.

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 diagram of a thin-film deposition apparatus according to an embodiment of the present invention;

FIG. 2 is a cross-sectional view of a thin-film deposition apparatus according to an embodiment of the present invention;

FIG. 3 is a partial structural schematic diagram of a thin-film deposition apparatus according to an embodiment of the present invention;

FIG. 4 is a side view of the thin-film deposition apparatus in FIG. 3.

PREFERRED EMBODIMENTS OF THE PRESENT APPLICATION

The embodiments of the present invention are described below through 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. The present invention can also be implemented or applied through other different specific embodiments, and various modifications or changes can be made to the details in this specification based on different viewpoints and applications without departing from the spirit of the present invention.

When the embodiments of the present invention are described in detail, for the convenience of description, the cross-sectional views showing the device structure will be partially enlarged not according to the general proportion, and the schematic diagrams are only examples, which should not limit the protection scope of the present invention herein. In addition, the three-dimensional spatial dimensions of length, width, and depth should be included in actual production.

For the convenience of description, spatial relationship terms such as "below," "under," "lower than," "beneath," "above," and "on" may be used here to describe the relationship between one element or feature and other elements or features shown in the accompanying drawings. It will be understood that these spatial relationship terms are intended to include orientations of a device in use or operation other than the orientation depicted in the accompanying drawings. In addition, when a layer is referred to as being "between" two layers, the layer may be the only layer between the two layers, or one or more intermediate layers may also exist. As used herein, "between" includes the two endpoint values.

In the context of the present application, the structure where a first feature is "above" a second feature may include embodiments where the first feature and the second feature are in direct contact, and may also include embodiments where another feature is disposed between the first feature and the second feature, where the first feature and the second feature may not be in direct contact.

It should be noted that the diagrams provided in this embodiment only schematically illustrate the basic concept of the present invention, so the diagrams only show the components related to the present invention rather than being drawn according to the number, shape, and size of the components in actual implementation. The type, quantity, and proportion of each component in actual implementation can be changed arbitrarily, and the component layout type may also be more complex.

As shown in FIGS. 1 to 4, the present embodiment provides a thin-film deposition apparatus, comprising a heating unit 100, a rotating unit 200, a substrate support unit 300, a power transmission unit 400, a two-stage magnetic fluid 500, a bellows 600, a support portion 700, and a power unit 800. Wherein, the two-stage magnetic fluid 500 is coupled to the rotating unit 200 via the power transmission unit 400 to drive the rotating unit 200 to perform a rotational motion and a lifting motion, and the power unit 800 drives the rotating unit 200 and/or the heating unit 100 to perform a lifting motion.

As shown in FIG. 2, the heating unit 100 includes a heating tray 110 and a support shaft 120 for supporting the heating tray 110. In the substrate processing process, the heating tray 110 conforms to a substrate W and heats the substrate W, and the support

shaft 120 extends down from the heating tray 110 to stably support the heating tray 110.

The rotating unit 200 includes a rotating ring 210 arranged around the heating tray 110, a motor 220 for driving the rotating ring 210 to rotate, and a rotating ring support portion 230 for supporting the rotating ring 210. As shown in FIGS. 1 and 2, the inner diameter of the rotating ring 210 is smaller than the outer diameter of the substrate W; thus, when the rotating ring 210 is in contact with the substrate W, the rotating ring 210 can be used to support the substrate W. When the rotating ring 210 moves up and down or rotates, the rotating ring 210 can drive the substrate W to perform a lifting motion and a rotational motion. To facilitate the lifting motion of the rotating ring 210, a gap is left in the horizontal direction between the rotating ring 210 and the heating tray 110, that is, the inner diameter of the rotating ring 210 is greater than the outer diameter of the heating tray 110, and the range of the gap is smaller than 5 mm.

The motor 220 is coupled to the rotating ring 210 via the two-stage magnetic fluid 500 and the power transmission unit 400 for driving the rotating ring 210 to perform a rotational motion. Specifically, an intermediate ring 520 of the two-stage magnetic fluid 500 is fixedly connected to the power transmission unit 400 via a flange (not shown), and one end of the rotating ring support portion 230 is connected to the rotating ring 210, and the other end of the rotating ring support portion 230 is fixedly connected to the power transmission unit 400. Thus, when the motor 220 drives the intermediate ring 520 of the two-stage magnetic fluid 500 to perform a rotational motion, the intermediate ring 520 drives the rotating ring 210 to perform a synchronous rotational motion via the power transmission unit 400 and the rotating ring support portion 230. The motor 220 is preferably a direct drive motor, which directly drives the intermediate ring 520 to rotate without a speed reduction structure or a belt transmission structure, thereby simplifying the structure and greatly saving space. Wherein, the two-stage magnetic fluid 500 further includes an outer ring 510, an inner ring 530, an inner magnetic fluid (not shown) located between the inner ring 530 and the intermediate ring 520, and an outer magnetic fluid (not shown) located between the outer ring 510 and the intermediate ring 520. In the embodiment shown in FIG. 1, the motor 220 is arranged between the inner ring 530 and the outer ring 510 of the two-stage magnetic fluid 500, specifically, the rotor of the motor 220 is connected to the intermediate ring

520, and the stator of the motor 220 is connected to the inner wall of the outer ring 510. The two-stage magnetic fluid 500 is sleeved on the outer side of the lower portion of the support shaft 120, the power transmission unit 400 is sleeved on the outer side of the upper portion of the support shaft 120, and the two-stage magnetic fluid 500 is fixedly connected to the power transmission unit 400, so that the intermediate ring 520 of the two-stage magnetic fluid 500 and the power transmission unit 400 rotate synchronously about the central axis of the support shaft, and the two-stage magnetic fluid 500 and the power transmission unit 400 perform a synchronous lifting motion along the support shaft. Herein, the use of the two-stage magnetic fluid 500 can ensure the sealed vacuum inside the support shaft 120 during the thin-film deposition process, and the two-stage magnetic fluid 500 can also be coupled to the rotating unit 200 to achieve the rotational motion and the lifting motion of the rotating unit 200. In addition, under the drive action of the motor 220, the rotating unit 200 drives the substrate W to perform a rotational motion. Since the power transmission unit 400 is fixedly connected to the rotating ring 210 via the rotating ring support portion 230, when the rotating ring 210 drives the substrate W to rotate synchronously, the heating unit 100 remains stationary, and the relative position between the heating unit and the substrate W changes.

The substrate support unit 300 includes a substrate support rod 310 for supporting the substrate W and a substrate support portion 320 fixedly connected to the substrate support rod 310, and the substrate support portion 320 is sleeved on the outer side of the power transmission unit 400 to provide stable support for the substrate W. When the power transmission unit 400 performs a lifting motion or a rotational motion, the position of the substrate support unit 300 remains unchanged, and the substrate support rod 310 penetrates the heating tray 110 and supports the substrate W via the end of the substrate support rod 310.

As shown in FIGS. 3 and 4, the support portion 700 includes a first support portion 710, a second support portion 720, and a third support portion 730, and the first support portion 710, the second support portion 720, and the third support portion 730 are distributed at different positions along the support shaft 120 from low to high. A second bellow 620 is arranged between the first support portion 710 and the second support portion 720, and since both ends of the second bellow 620 are fixedly connected to the

first support portion 710 and the second support portion 720, the second bellow 620 can extend and contract correspondingly when the first support portion 710 moves relative to the second support portion 720 along the support shaft 120. The two-stage magnetic fluid 500 and a first bellow 610 are disposed between the second support portion 720 and the third support portion 730, wherein both ends of the first bellow 610 are fixedly connected to the bottom of the third support portion 730 and the top of the two-stage magnetic fluid 500, respectively. Therefore, the first bellow 610 can perform an extension or contraction motion and the second bellow 620 can perform a contraction or extension motion when the first support portion 710 moves relative to the second support portion 720 in the extending direction of the support shaft 120. According to FIG. 2 herein, since the bottom of the two-stage magnetic fluid 500 is fixedly connected to the second support portion 720, the two-stage magnetic fluid 500 is driven to perform a lifting motion along the support shaft 120 by the second support portion 720. According to FIG. 2, one end of the support shaft 120 is fixed to the first support portion 710, and penetrates the second support portion 720, the two-stage magnetic fluid 500, and the power transmission unit 400 in sequence from bottom to top, and the other end of the support shaft 120 is connected to the bottom of the heating tray 110. It should be noted that the position of the third support portion 730 is fixed, and when the first support portion 710 moves relative to the third support portion 730 in the extending direction of the support shaft 120, the support shaft 120 drives the two-stage magnetic fluid 500, the power transmission unit 400, the heating tray 110, and the rotating unit 200 to perform a lifting motion together. Wherein, the relative movement between the first support portion 710 and the third support portion 730 is driven by a first power portion 810, the relative movement between the first support portion 710 and the second support portion 720 is driven by a second power portion 820, and both the first power portion 810 and the second power portion 820 of the power unit 800 can adopt an electric cylinder or a pneumatic cylinder. For example, when the first power portion 810 extends, the first power portion 810 drives the first support portion 710 to move down, and when the first power portion 810 contracts, the first power portion 810 drives the first support portion 710 to move up. When the second power portion 820 extends, the second power portion 820 drives the second support portion 720 to move up, and when the second power portion 820 contracts, the second power portion 820 drives the second support portion 720 to move down. Wherein, the number of the first power portions 810 is two or three, which are

uniformly arranged between the first support portion 710 and the third support portion 730. Preferably, the number of the first power portions 810 is three, allowing the first support portion 710 and the third support portion 730 to be stressed uniformly. Wherein, the number of the second power portions 820 is two or three, which are uniformly arranged between the first support portion 710 and the second support portion 720. Preferably, the number of the second power portions 820 is three, allowing the first support portion 710 and the second support portion 720 to be stressed uniformly.

The first power portion 810 and the second power portion 820 drive the first support portion 710 and the second support portion 720 to move in the extending direction of the support shaft 120, respectively, thereby driving the rotating unit 200 to perform a lifting motion. Wherein, when the first power portion 810 drives the first support portion 710 to move relative to the third support portion 730 in the extending direction of the support shaft 120, the first power portion 810 drives the second support portion 720, the heating unit 100, the two-stage magnetic fluid 500, the rotating unit 200, the power transmission unit 400, and the rotating unit 200 to perform a lifting motion. When the second power portion 820 drives the second support portion 720 to move relative to the first support portion 710 in the extending direction of the support shaft 120, the second power portion 820 drives the two-stage magnetic fluid 500, the power transmission unit 400, and the rotating unit 200 to move relative to the support shaft 120, and at the same time, the substrate W is driven by the rotating unit 200 to move up and down synchronously, while the heating unit 100 fixedly connected to the support shaft 120 remains stationary.

The first power portion 810 can drive the relative movement between the first support portion 710 and the third support portion 730. Since the bottom of the support shaft 120 is fixedly connected to the first support portion 710 and penetrates the third support portion 730, the support shaft 120 can move synchronously with the first support portion 710 relative to the third support portion 730, and the heating unit 100 fixedly connected to the support shaft 120 moves synchronously. Herein, the first support portion 710 is coupled to the second support portion 720 via the second power portion 820, and the first support portion 710 can drive the second support portion 720 to move synchronously, and the two-stage magnetic fluid 500 and the rotating unit 200 fixedly connected to the second support portion 720 also move synchronously.

Therefore, under the drive action of the first power portion 810, when the first support portion 710 moves relative to the third support portion 730, the heating unit 100 and the rotating unit 200 move synchronously in a direction close to the substrate W.

The second power portion 820 can drive the relative movement between the second support portion 720 and the first support portion 710. Since the support shaft 120 penetrates the second support portion 720, the second support portion 720 can move relative to the support shaft 120. Herein, the bottom of the two-stage magnetic fluid 500 is fixedly connected to the second support portion 720, the top of the two-stage magnetic fluid 500 is connected to the power transmission unit 400, and the power transmission unit 400 is coupled to the rotating unit 200. Thus, when the second support portion 720 performs a lifting motion relative to the first support portion 710 in the extending direction of the support shaft, the rotating unit 200 lifts the substrate W to perform a synchronous lifting motion, but the heating unit 100 fixedly connected to the support shaft 120 remains stationary.

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

S1: placing the substrate at the end of the substrate support unit;

S2: driving the heating tray and the rotating ring to move up, allowing both the heating tray and the rotating ring to be in contact with the substrate;

in step S2, the first power portion 810 can drive the first support portion 710 to move up; since the bottom of the support shaft 120 is fixedly connected to the first support portion 710 and penetrates the third support portion 730, the support shaft 120 can move up synchronously with the first support portion 710 relative to the third support portion 730, and drive the heating unit 100 fixedly connected to the support shaft 120 to move up synchronously. Herein, the first support portion 710 is coupled to the second support portion 720 via the second power portion 820, and the first support portion 710 can drive the second support portion 720 to move up synchronously, and the two-stage magnetic fluid 500 and the rotating unit 200 fixedly connected to the second support portion 720 also move up synchronously. Therefore, under the drive action of the first power portion 810, when the first support portion 710

moves up relative to the third support portion 730, the heating unit 100 and the rotating unit 200 move synchronously in a direction close to the substrate W.

S3: depositing a thin film with a certain thickness on the surface of the substrate;

in step S3, a conventional method in the art can be adopted for thin-film deposition, which is not limited to the present application.

S4: after the completion of thin-film deposition in step S3, driving the rotating ring 210 to move up, allowing the rotating ring 210 to lift the substrate W off the heating unit 100;

in step S4, the second power portion 820 can drive the relative movement between the second support portion 720 and the first support portion 710; since the support shaft 120 penetrates the second support portion 720, the second support portion 720 can move relative to the support shaft 120. Herein, the bottom of the two-stage magnetic fluid 500 is fixedly connected to the second support portion 720, the top of the two-stage magnetic fluid 500 is connected to the power transmission unit 400, and the power transmission unit 400 is coupled to the rotating unit 200. Thus, when the second support portion 720 moves up relative to the first support portion 710 in the extending direction of the support shaft, the rotating unit 200 lifts the substrate W to move up synchronously. At this time, the position of the first support portion 710 remains unchanged, the height of the support shaft 120 remains unchanged, and the heating unit 100 fixedly connected to the support shaft 120 remains stationary.

S5: driving the rotating ring 210 to rotate, and driving the substrate W to rotate from a first angular position to a second angular position;

in step S5, the motor 220 drives the rotating ring 210 to perform a rotational motion. It can be understood that the second angular position is different from the first angular position.

S6: driving the rotating ring 210 to move down until the heating unit 100 is in contact with the substrate W again, and then performing the next thin-film deposition.

In step S6, the second power portion 820 drives the second support portion 720

to move down relative to the first support portion 710 in the extending direction of the support shaft, and the rotating unit 200 also moves down synchronously to a position where the substrate W is in contact with the heating unit 100. During the downward movement of the rotating ring 210, the position of the first support portion 710 is fixed, so the position of the heating unit 100 is also fixed.

In the thin-film deposition process, the process gas is dissociated into plasma gas, and the dissociated plasma gas is used to perform thin-film deposition on the surface of the heated substrate W.

According to the thin-film deposition apparatus and the thin-film deposition method of the present invention, the two-stage magnetic fluid 500 is coupled to the rotating unit 200 to ensure that the rotating unit 200 drives the substrate W to perform a lifting motion to separate the substrate W from the heating unit 100. After the rotating unit 200 drives the substrate W to rotate, the contact position between the substrate W and the heating unit 100 is adjusted, and then the substrate W is brought into contact with the heating unit 100 for heating, allowing the substrate W to be heated more uniformly, which overcomes the problem of non-uniform temperature of the heating tray. In the process of multiple thin-film depositions, the uniformity of the thin film on the surface of the substrate W is improved through the independent movement of the substrate W and the heating unit 100 and the multiple adjustments of the position of the substrate W.

The above embodiments only 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 above embodiments without departing from the spirit and scope of the present invention. Therefore, all equivalent modifications or changes made by those with ordinary knowledge in the technical field without departing from the spirit and technical ideas 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 apparatus, comprising:

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

a rotating ring, for supporting the substrate, the rotating ring being arranged around the heating tray;

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

a two-stage magnetic fluid, fixedly connected to the power transmission unit;

wherein, the power transmission unit and the two-stage magnetic fluid are movably mounted on the support shaft; when driven, the power transmission unit and the two-stage magnetic fluid drive the rotating ring to move, and drive the substrate to perform a rotational motion and/or a lifting motion via the rotating ring.

2. The thin-film deposition apparatus according to claim 1, wherein the two-stage magnetic fluid includes an intermediate ring, and the intermediate ring is fixedly connected to the power transmission unit.

3. The thin-film deposition apparatus according to claim 1, wherein the inner diameter of the rotating ring is smaller than the outer diameter of the substrate.

4. The thin-film deposition apparatus according to claim 1, wherein a gap is present in the horizontal direction between the rotating ring and the heating tray.

5. The thin-film deposition apparatus according to claim 1, wherein the thin-film deposition apparatus further comprises a first support portion and a third support portion, the support shaft is fixed to the first support portion and penetrates the third support portion, and when the first support portion moves relative to the third support portion in the extending direction of the support shaft, the first support portion drives the support shaft to move and drives the heating tray to move up and down via the support shaft.

6. The thin-film deposition apparatus according to claim 5, wherein the two-stage magnetic fluid and the power transmission unit are coupled to the first support portion, and the first support portion drives the rotating ring to move up and down via the two-stage magnetic fluid and the power transmission unit.

7. The thin-film deposition apparatus according to claim 5 or 6, wherein the thin-film deposition apparatus further comprises a second support portion located between the first support portion and the third support portion, the support shaft further penetrates the second support portion, the two-stage magnetic fluid, and the power transmission unit, the two-stage magnetic fluid is fixedly connected to the second support portion, and when the second support portion moves relative to the first support portion, the second support portion drives the two-stage magnetic fluid and the power transmission unit to perform a lifting motion along the support shaft.

8. The thin-film deposition apparatus according to claim 7, wherein a first bellow is arranged between the two-stage magnetic fluid and the third support portion, and a second bellow is arranged between the first support portion and the second support portion.

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

S1: placing a substrate at the end of a substrate support unit;

S2: driving a heating tray and a rotating ring to move up, allowing both the heating tray and the rotating ring to be in contact with the substrate;

S3: depositing a thin film with a certain thickness on the surface of the substrate;

S4: after the completion of thin-film deposition in step S3, driving the rotating ring to move up, allowing the rotating ring to lift the substrate off a heating unit;

S5: driving the rotating ring to rotate, and driving the substrate to rotate from a first angular position to a second angular position;

S6: driving the rotating ring to move down until the heating unit is in contact with the substrate again, and then performing the next thin-film deposition.