

THIN FILM DEPOSITION APPARATUS

FIELD OF THE INVENTION

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

BACKGROUND

In a vacuum process chamber of plasma enhanced chemical vapor deposition (PECVD), a layer stack structure of different materials is deposited onto a substrate. Wherein, the substrate is placed in the vacuum process chamber, and the first process gas is first introduced to form the first layer of the first material on the substrate; Then carrying out plasma purification and gas purification; Then, the second process gas is introduced to form the second layer of the second material on the substrate. The above-described plasma purification and gas purification are repeated, and the first material and the second material are stacked and deposited on the substrate to form a thin film of the layer stack structure. Wherein, three-dimensional (3D) storage may be made of the layer stack structure of alternating thin film materials deposited on the substrate. At present, 3D storage uses alternating layers of oxide and nitride films to achieve the purpose of storing data in three-dimensional structures through related processes. These stacking structures may comprise multiple layers of the first material and the second material, such as a continuous stack of more than 300 or even 1000 layers.

In particular, the stack structure of the first material and the second material in the thin film materials of the 3D storage stack may in some cases be oxide and silicon, silicon and doped silicon, or silicon and nitride. Accordingly, most of the thin film materials of the 3D storage stack of these material combinations can be applied to BiCS (Bit-Cost Scalable), TCAT (Terabit Cell Array Transistor) or other 3D storage structures. In addition, the stack structure of the first material and the second material can also be other material compositions, and the order of the first material and the second material layers deposited on the substrate can be reversed.

However, the thin films deposited on the current existing PECVD equipment suffer from the problem of non-uniformity. As shown in FIG. 1, the thin film thickness

in the middle region of the substrate is uniform, but the thin film thickness in the edge region of 20 to 25mm tends to decrease first and then increase. FIG. 2 is a schematic view of an electric field distribution between the upper and lower electrodes of the existing PECVD equipment. As shown in the figure, the reason for this problem is mainly that the electric field in the middle region of the substrate is uniformly distributed, and thus the thin film thickness in the middle region is uniform. Because the diameter of the gas spray port is about 350mm and is larger than the diameter of the substrate, the electric field distribution between the gas spray port and the substrate is nonuniform. And a local gas concentration gradient is formed at the edge of the substrate, so that a gas deficient region is generated near the edge of the substrate. During the deposition process, the edge of the substrate has the thickest thin film in the most edge area and the thinnest thin film in the second edge area due to the stretching of the electric field. At the same time, the existing PECVD devices still have too many particulate pollutants, and the cleaning frequency during the process is too high.

To sum up, it is necessary to provide a new thin film deposition apparatus to solve the above problems.

SUMMARY

The present invention provides a thin film deposition apparatus capable of improving the uniformity of the thin film.

The present invention provides the thin film deposition apparatus, comprising:

a process chamber, for performing thin film deposition;

a gas supply assembly, disposed on the top wall of the process chamber, for supplying process gas to the inside of the process chamber;

a heating tray, disposed below the gas supply assembly, for carrying and heating a substrate;

an upper electrode and a lower electrode, for forming a uniform electric field in the process chamber;

a radio frequency source, connected to the upper electrode and the lower electrode for providing radio frequency power, exciting process gas inside the process chamber to dissociate into plasma gas, and the plasma gas performing thin film deposition on the substrate;

wherein, the sizes of the upper electrode and the lower electrode are the same or different by $\pm 10\text{mm}$, and the diameter of the lower electrode is smaller than the diameter of the substrate, so that the uniform electric field is generated between the upper electrode and the lower electrode.

the diameter difference between the lower electrode and the substrate is $\leq 15\text{mm}$.

the diameter of the upper electrode and the diameter of the substrate are the same or different by $\pm 10\text{mm}$.

a rotating mechanism is used for controlling the heating tray to rotate relative to the substrate or for controlling the heating tray to rotate together with the substrate or for controlling the gas supply assembly to rotate relative to the substrate or for controlling a support ring to rotate together with the substrate.

when the rotating mechanism controls the rotation of the substrate, the gas supplied into the process chamber is inert gas.

the inert gas is nitrogen.

the temperature of the inert gas introduced into the thin film deposition apparatus is $200\text{-}500^{\circ}\text{C}$.

when the rotating mechanism controls the rotation of the substrate, the radio frequency source is turned on.

the thin film deposition apparatus further comprises a flow guide ring that wraps the sidewall of the upper electrode.

the diameter of the flow guide ring is greater than or equal to the diameter of the support ring.

the flow guide ring is an insulator.

the material of the flow guide ring is AlN or Al₂O₃.

the upper electrode is integrated with the gas supply assembly.

the gas supply assembly is the insulator, the upper electrode is positioned below the gas supply assembly, and the upper electrode is a meshed electrode.

the gas supply assembly is the insulator with a groove at the bottom, the gas outlets of the gas supply assembly are positioned in the groove, and the meshed electrode is also embedded in the groove.

the groove is the circular groove.

the circular groove has the same diameter as the meshed electrode.

The present invention also provides a thin film deposition apparatus, comprising:

a process chamber, for performing thin film deposition;

a gas supply assembly, disposed on the top wall of the process chamber, for supplying process gas to the inside of the process chamber;

a heating tray, disposed below the gas supply assembly, for carrying and heating a substrate;

a radio frequency source, for providing radio frequency power and exciting process gas inside the process chamber to dissociate into plasma gas, and the plasma gas performing thin film deposition on the substrate;

an insulating plate, positioned below the gas supply assembly, the insulating plate having a plurality of gas holes for introducing process gas into the process chamber.

the thickness of the insulating plate is 0.2mm or more.

the insulating plate is in contact with the bottom surface of the gas supply

assembly.

the gas holes have the same diameter as the gas outlets.

the number of the gas holes is greater than or equal to the number of the gas outlets.

each gas outlet of the gas supply assembly has a gas hole on the insulating plate corresponding to the position of the gas outlet.

a gap is left between the insulating plate and the gas supply assembly, a circle of insulating ring is added on the outside of the gap.

the insulating ring is the edge of the insulating plate extending upward to the sidewall that wraps the gas supply assembly.

the gap between the insulating plate and the gas supply assembly is between 0.1 and 2mm.

the insulating plate is the material that does not react with HF.

the insulating plate is the material made of sapphire or silicon carbide.

quartz and silicon are added to the insulating plate material.

the quartz is synthetic quartz mixed with silicon.

the surface treatment of the insulating plate is the rough surface.

the thin film deposition apparatus further comprises a support ring and a rotating mechanism, the support ring is used for supporting the substrate, the rotating mechanism is used for controlling the rotation of the substrate.

The thin film deposition apparatus provided by the present invention can ensure that the electric field in the process chamber is uniformly distributed on the one hand, and the uniformity of the deposited thin film is good, in particular, the uniformity of the thin film can also be guaranteed even when more than 300 layers or even 1000 layers are continuously stacked; On the other hand, this apparatus can realize that

plasma energy is concentrated on the substrate, and chemical reactions also occur on and near the substrate, so that the reactions generated on the wall of the process chamber are reduced or even absent. At the same time, because the flow guide ring and support ring are insulators and produce a few particulate matters, which not only increases the service life of the entire chamber, but also reduces the cleaning time and frequency.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a thin film thickness distribution on a substrate after thin film deposition is performed on the substrate by an existing thin film deposition apparatus;

FIG. 2 is a view of electric field distribution between the upper and lower electrodes of the existing thin film deposition apparatus;

FIG. 3 is a cross-sectional view of the first embodiment of a thin film deposition apparatus according to the present invention;

FIG. 4 is a cross-sectional view of the second embodiment of a thin film deposition apparatus according to the present invention;

FIG. 5 is a cross-sectional view of the third embodiment of a thin film deposition apparatus according to the present invention;

FIG. 6A is a schematic view of gas outlets of a thin film deposition apparatus;

FIG. 6B is a schematic view of a meshed electrode according to the second and the third embodiment of the present invention;

FIG. 7A is a cross-sectional view of the fourth embodiment of a thin film deposition apparatus according to the present invention;

FIG. 7B is a cross-sectional view of the fourth embodiment of a thin film deposition apparatus according to the present invention;

FIG. 8 is a view of electric brush control of a thin film deposition apparatus according to the present invention;

FIG. 9A is a schematic view of a rotating mechanism controlling the rotation of a gas spray port;

FIG. 9B is a schematic view of a rotating mechanism controlling the rotation of a heating tray;

FIG. 9C is a schematic view of a rotating mechanism controlling the rotation of support rings.

EMBODIMENTS OF THE INVENTION

Hereinafter, embodiments of the present invention will be described with specific examples, and those skilled in the art will readily understand other advantages and effects of the present invention from the disclosure of the present specification. The present invention can also be embodied or applied by other different and specific embodiments, and various details in this specification can also be modified or changed based on different viewpoints and applications without departing from the spirit of the present invention.

It should be understood that when one component is referred to as “on the other component”, “connected to the other component”, “coupled to the other component” or “in contact with the other component”, the component can be directly on the other component, connected to or coupled to, or in contact with the other component, or an insertion component may be present. In contrast, when one component is referred to as being “directly on the other component”, “directly connected to”, “directly coupled to” or “directly in contact with” the other component, there is no insertion component.

Please refer to FIGS. 1 to 9C, it should be noted that the illustrations provided in this embodiment only illustrate the basic concept of the present invention in a schematic manner, and although only components related to the present invention are shown in the illustrations rather than drawn according to the number, shape and size of the components in actual implementation, the form, number and proportion of each

component in actual implementation may be arbitrarily changed, and the layout of the components may be more complicated.

In the process of PECVD thin film deposition, the uniformity of thin films deteriorates due to the nonuniform distribution of electric field. When the thin films of different materials are alternately deposited on the substrate, as the number of layers of the first material and the second material alternately stacked on the substrate w increases, for example, a continuous stack of more than 300 layers or even 1000 layers, the thin film thickness of the layer stack structure formed on the substrate w increases, resulting in a phenomenon that the thin film of the stack is uniform in the middle, thin in the edge, and thick in the most edge. That is, as the number of layers of the stack structure of these layers increases, the uniformity of the thin films after the stack is deteriorated, and thus the uniformity of the thin films on the substrate w deviates from the controllable range, so that the accuracy of the hole etching cannot be realized in the subsequent etching process.

To solve the above problems, the present invention provides a specific embodiment of a thin film deposition apparatus. Specifically, referring to FIG. 3, the thin film deposition apparatus comprises a process chamber 1, a gas spray port 2, a heating tray 3, a flow guide ring 5 and a radio frequency source 9. Wherein, the process chamber 1 is used for the substrate w to perform a thin film deposition process, the gas spray port 2 is provided on the top wall of the process chamber 1, and a plurality of gas outlets 201 are set on the gas spray port 2 to form a gas outlet region for supplying process gas to the inside of the process chamber 1, as shown in FIG. 6A. The heating tray 3 is located below the gas spray port 2, and is used for carrying and heating the substrate w. The radio frequency source 9 is used for providing radio frequency power, forming a radio frequency electric field inside the process chamber 1, exciting process gas inside the process chamber 1 to dissociate into plasma gas, and the dissociated plasma gas performs thin film deposition on the substrate w.

The apparatus also comprises an upper electrode and a lower electrode 12. In the embodiment, the gas spray port 2 is the upper electrode, and an existing spray type flat electrode is adopted. In order to form a uniform electric field and ensure that the thin film with uniform thickness is deposited, the upper and lower electrodes have the same size or difference of $\pm 10\text{mm}$. In the context of the present application, the difference

of $\pm 10\text{mm}$ is that the size difference between the upper and lower electrodes is within 10mm . At the same time, the diameter of the lower electrode 12 is smaller than the diameter of the substrate w but not more than 15mm , so that the uniform radio frequency electric field can be formed between the gas spray port 2 and the substrate w , and the thin film deposited on the substrate w can be ensured to be more uniform. Since the gas spray port in the prior art is larger than the heating tray, the gas entering the process chamber 1 will be directly discharged from the gas outlets below both sides of the process chamber 1 because of the block by the gas spray port 2 above. Since the upper and the lower electrodes of the present invention have the same size, after the gas enters the process chamber 1, part of the process gas may go upward and then be discharged from the gas outlets 201, resulting in nonuniform and unstable gas flow, and also affecting the uniformity of thin film deposition on the substrate. Therefore, a circle of flow guide ring 5 is added to the side surface of the showerhead 2. The material of the flow guide ring 5 is preferably AlN or Al_2O_3 .

In order to further ensure that the thin film on the substrate w is more uniform, the apparatus further comprises support rings 4 and a rotating lifting/lowering mechanism 8. The support rings 4 are used to support the substrate w and extends to the outside of the substrate w . At the same time, the support rings 4 are insulators. When the support rings 4 are added, the flow guide ring 5 is more necessary. Without the flow guide ring 5, the support rings 4 protrude from the gas spray port 2 above, blocking the gas from going downward, and the situation of the gas going upward will be more serious. Preferably, the diameter of the flow guide ring 5 is equal to or larger than the diameter of the support rings 4.

The apparatus provided by the present invention further comprises a rotating lifting/lowering mechanism 8, and the rotating lifting/lowering mechanism 8 may be a structure in which rotation and lifting/lowering are integrated, or may be an independent rotating structure and lifting/lowering structure. The rotating lifting/lowering mechanism 8 can drive the support rings 4 or the heating tray 3 to rise or fall in the vertical direction to lift the substrate w away from the heating tray 3 or place the substrate w on the heating tray 3. The rotating assembly of the rotating lifting/lowering mechanism 8 is used to control the rotation of the substrate w . Referring to FIG. 9C, the rotation of the substrate w may be caused by the rotating

lifting/lowering mechanism 8 drives the support rings 4 to thereby drive the substrate w to rotate; Referring to FIG. 9B, the rotating lifting/lowering mechanism 8 may drive the heating tray 3 to rotate relative to the substrate w or the heating tray 3 and the substrate w may rotate together; Referring to FIG. 9A, the rotating lifting/lowering mechanism 8 may drive the above gas spray port 2 to rotate relative to the substrate w. In an embodiment in which the heating tray 3 rotates relative to the substrate w, it is necessary to first lower the heating tray 3 to a certain height by the rotating lifting/lowering mechanism 8. The rotation axis AA' of this rotation is perpendicular and passes through the substrate w. As shown in FIG. 8, the apparatus is further provided with three electric brushes 10, wherein, the two electric brushes 10 are conductive to the heating power supply of the heating tray 3 respectively, and one electric brush 10 is conductive to the radio frequency power supply.

The device also comprises a controller, and the controller is respectively connected to the gas spray port 2, the radio frequency source 9, the heating tray 3 and the rotating lifting/lowering mechanism 8, and is used for controlling the work of the gas spray port 2, the radio frequency source 9, the heating tray 3 and the rotating lifting/lowering mechanism 8. The controller is further configured to construct a program menu that includes keeping the radio frequency source 9 turned on while the substrate w is rotated. When the rotating lifting/lowering mechanism 8 drives the substrate w to rotate, the flow of process gas into the process chamber 1 is stopped, and the flow of inert gas, such as nitrogen or helium, into the process chamber 1 is introduced to maintain the pressure in the process chamber 1 and keep the radio frequency source 9 in an open state. Because some impurity particles are suspended inside the process chamber 1 after a certain layer of thin films are deposited on the substrate w, at this time, the radio frequency source 9 is kept turned on, the inside of the process chamber 1 is filled with the radio frequency electric field. The impurity particles are charged under the action of the radio frequency electric field inside the process chamber 1, and the charged impurity particles keep suspended and do not fall on the surface of the substrate w, effectively preventing the impurity particles from falling on the thin film deposited on the substrate w and avoiding the pollution of the thin film deposited on the substrate w. Preferably, the temperature inside the process chamber 1 is between 200 and 500°C or the temperature of the introduced gas is between 200 and 500°C. At this temperature, the gas neither reacts nor condenses.

In the present embodiment, after the thin film deposition is completed, the number of rotations of the substrate w is 5 times, and the set angle of each rotation is 60 degrees; The number of rotations of the substrate w may also be three times, and the set angle of each rotation may be 90 degrees; The number of rotations of the substrate w may also be twice, and the set angle of each rotation may be 120 degrees; The number of rotations of the substrate w is once, and the set angle of each rotation is 180 degrees. Wherein, the deposition rate of the thin film on the substrate w is related to a multiple of the radio frequency power of the radio frequency source 9. The high frequency of the radio frequency source 9 is an integer multiple n of 13.56MHz, and n satisfies: $n = 1, 2, 3, \dots, 8$; The low frequency range of the radio frequency source 9 is 20KHz-400KHz.

However, during the rotation of the substrate w, the radio frequency source 9 is kept in the open state, and after the substrate w is separated from the heating tray 3, the gap between the back surface of the substrate w and the heating tray 3 is too large, which easily leads to the occurrence of an arc discharge phenomenon. Therefore, in the specific embodiment, in order to avoid the arc discharge phenomenon caused by the substrate w separating from the heating tray 3 when the radio frequency source 9 is turned on, it is necessary to adjust the gap between the substrate w and the heating tray 3 to be smaller than the set value, so as to avoid the occurrence of arc discharge phenomenon caused by the substrate w separating from the heating tray 3 in the atmosphere of plasma gas. In the specific embodiment, the set value of the gap between the substrate w and the heating tray 3 is m, and $0 < m \leq 5\text{mm}$. Therefore, under the condition that the gap between the substrate w and the heating tray 3 is less than the set value, the radio frequency source 9 is kept in the open state, the risk of arc discharge of the substrate w is reduced, and the safety and stability of the thin film deposition process are ensured.

The present invention also provides the second embodiment of a thin film deposition apparatus. As shown in FIG. 4, the thin film deposition apparatus comprises a process chamber 1, a gas spray port 2, a heating tray 3, a flow guide ring 5 and a radio frequency source 9. Wherein, the process chamber 1 is used for performing a thin film deposition process on the substrate w, the gas spray port 2 is provided on the top wall of the process chamber 1, and a plurality of gas outlets 201 are set on the gas spray

port 2 to form a gas outlet region for supplying process gas to the inside of the process chamber 1, as shown in FIG. 6A. The heating tray 3 is located below the gas spray port 2, and is used for carrying and heating the substrate w. The radio frequency source 9 is used for providing radio frequency power, forming a radio frequency electric field inside the process chamber 1, exciting process gas inside the process chamber 1 to dissociate into plasma gas, and the dissociated plasma gas performs thin film deposition on the substrate w.

The existing gas spray port 2 is an upper electrode, different from this existing gas spray port 2, the gas spray port 2 and the upper electrode 6 in the present embodiment are independently arranged, and the gas spray port 2 is an insulator. The upper electrode 6 is arranged below the gas spray port 2. The sizes of the upper and lower electrodes are the same or the difference is ± 10 mm. Meanwhile, the diameter of the lower electrode 12 is smaller than the diameter of the substrate w but not more than 15mm, so that a uniform radio frequency electric field can be formed between the upper and lower electrodes, that is, in the reaction region, and the thin film deposited on the substrate w can be more uniform. Considering that the process gas needs to be introduced into the reaction region, the upper electrode 6 needs to be configured as a meshed electrode, and the diameter of the gas outlet region of the gas spray port 2 needs to be greater than or equal to the diameter of the meshed electrode. In addition, in this embodiment, in order to ensure the stability of the gas flow in the process chamber 1, a circle of flow guide ring 5 is added to the side surface of the upper electrode 6, and the material of the flow guide ring 5 is preferably AlN or Al₂O₃.

Other arrangements of the present embodiment are the same as the arrangements of the first embodiment, and will not be repeatedly described here.

The present invention also provides the third embodiment of a thin film deposition apparatus. As shown in FIG. 5, a gas spray port 2 and an upper electrode in the third embodiment are independently provided, the gas spray port 2 is an insulator, and the bottom of the gas spray port 2 is formed with a groove. The gas outlets 201 of the gas spray port 2 is provided in the bottom groove, and at the same time, the upper electrode 6 is placed in the groove. The gas outlets 201 in the present embodiment may also be made of a metal material to play a role of heat conduction. Preferably, the gas spray port 2 completely wraps the sidewall of the upper electrode 6. Considering that the

process gas needs to be introduced into the reaction region, the upper electrode 6 needs to be arranged as a meshed electrode. The groove set by the gas spray port 2 may have a plurality of shapes, and the groove is preferably circular in order to better fit the upper electrode 6. In order to better wrap the sidewall of the upper electrode 6, the diameter of the groove is the same as the diameter of the upper electrode 6.

In this embodiment, the gas spray port 2 is configured as the insulator with the groove in the middle, and the electrode is placed in the groove, so in this case, the flow guide ring 5 is not needed, and the step protruding from the gas spray port 2 can realize the function of the flow guide ring 5 in the foregoing embodiments.

Referring to FIGS. 6A and 6B, the meshed electrode is disposed below the gas spray port 2, and the gas holes of the meshed electrode are communicated with the gas outlets of the gas spray port 2, which not only generates a uniform electric field with the lower electrode 12, but also effectively introduces the uniform process gas.

Other arrangements of the present embodiment are the same as the arrangements of the first embodiment, and will not be repeatedly described here.

The present invention also provides the fourth embodiment of a thin film deposition apparatus. The thin film deposition apparatus comprises a process chamber 1, a gas spray port 2, a heating tray 3 and a radio frequency source 9. Wherein, the process chamber 1 is used for performing a thin film deposition process on the substrate w, the gas spray port 2 is provided on the top wall of the process chamber 1, and a plurality of gas outlets 201 are set on the gas spray port 2 to form a gas outlet region for supplying process gas to the inside of the process chamber 1, as shown in FIG. 7A. The heating tray 3 is located below the gas spray port 2, and is used for carrying and heating a substrate w. The radio frequency source 9 is used for providing radio frequency power, forming a radio frequency electric field inside the process chamber 1, exciting process gas inside the process chamber 1 to dissociate into plasma gas, and the dissociated plasma gas performs thin film deposition on the substrate w.

In order to further ensure that the thin film on the substrate w is more uniform, the apparatus further comprises support rings 4 and a rotating lifting/lowering mechanism 8. The support rings 4 are used to support the substrate w and extend to the

outside of the substrate w. At the same time, the support rings 4 are insulators, and can not only support the substrate w, but also shield the electric field leakage of the lower electrode 12 to ensure that the electric field is not stretched and reacted.

In this embodiment, an insulating plate 7 is further provided below the gas spray port 2, and a plurality of gas holes 701 are set on the insulating plate 7, and the gas holes 701 are communicated with the gas outlets 201 of the gas spray port 2 for introducing process gas into the process chamber 1. In order to make the process gas introduced into the process chamber 1 more uniform, the number and hole diameter of the gas outlets 201 and the gas holes 701 on the gas spray port 2 are the same, and the positions correspond one to one.

In the prior art, an insulating coating is applied below the gas spray port 2 with a thickness less than 0.2mm, so as to reduce the reaction between the gas spray port 2 of the metal material and the gas and thereby generating thin film deposition. In the present invention, the insulating plate 7 with a certain thickness is selected, and the insulating plate 7 and the gas spray port 2 are not integrally formed, and the thickness of the insulating plate 7 is more than 0.2mm, and more preferably more than 5mm. In contrast to the function of the insulating coating in the prior art, the insulating plate 7 in the present invention is intended to deposit the thin film on the insulating plate 7 similar to the thin film on the substrate. Quartz and silicon can be added to the insulating plate 7, wherein, the quartz can be black quartz mixed with silicon powder, so that the heat absorption efficiency can be increased, the temperature of the insulating plate 7 can be increased, and the compactness of the film can be improved. Since the insulating plate 7 cannot block the alternating electric field, and the temperature of the insulating plate is also high due to the thermal insulation characteristic generated by the insulating plate, the thin film is deposited on the insulating plate 7, and the thickness of the thin film is compacter and close to the thin film deposited on the substrate, so the thin film is not easy to break and does not generate particulate matter. The surface of the insulating plate 7 may also be roughened mechanically or chemically to increase the adsorption force between the surface and the diameter of the thin film, increase the thickness of the deposited thin film and reduce the frequency of cleaning of the process chamber.

Referring to FIGS. 7A and 7B, the insulating plate 7 may be in contact with the

bottom surface of the gas spray port 2, or a gap may be left between the insulating plate 7 and the bottom surface of the gas spray port 2. FIG. 7A shows that the insulating plate 7 is configured to be in contact with the bottom surface of the gas spray port 2. Since the gas spray port 2 is made of metal, the thermal conductivity is better, the insulating plate 7 does not generate excessively high temperature and has better temperature uniformity, and the temperature is closer to the process temperature of the substrate, so that the thin film deposited on the insulating plate 7 is also closer to the thin film deposited on the substrate.

FIG. 7B shows that the insulating plate 7 is arranged so as to leave a gap 11 between the insulating plate 7 and the gas spray port 2, and the size of the gap 11 is between 0.1 and 2mm. In this embodiment, since the gap 11 is too small, the plasma that can enter the gap 11 is also small, and the plasma is completely or partially adsorbed by the insulating plate 7, so that deposition is not generated on the electrode or deposition is generated less. If the gap 11 is set too large, the insulating plate 7 will not have time to adsorb, and too much plasma will enter the gap 11, causing deposition on the electrode and increasing the cleaning frequency. Since there is a gap 11 between the gas spray port 2 and the insulating plate 7, and at the same time, it is not desirable for plasma to enter the gap 11 to react with the electrode or less plasma to enter the gap 11 to generate less reaction with the electrode, a circle of insulating ring may be used to wrap the gap to block the plasma from entering. Preferably, the insulating ring is integrally formed with the insulating plate 7, and the insulating plate 7 is directly designed so that the edge of the insulating plate 7 extends upward to form a U-shaped insulating cover to wrap the gap, so as to prevent the plasma from entering from both sides of the gap. The diameter of the U-shaped insulating cover is preferably greater than or equal to the diameter of the lower support rings, which can play the role of the flow guide ring in the foregoing embodiments, and only the portion of the U-shaped insulating cover opposite to the gas outlets 201 of the gas spray port is provided with gas holes 701.

In addition, the insulating plate 7 is preferably made of a material resistant to HF plasma cleaning such as sapphire or carbonization.

The thin film deposition apparatus of the present embodiment can reduce particles and cleaning frequency without cutting off the plasma in the process, and can realize

multi-layer film formation at one time.

The present invention has a specific and detailed disclosure of the related technology through the above embodiments and the description of the related drawings, so that those skilled in the art can carry out the related technology accordingly. The above-described embodiments are merely for illustrating the present invention, and are not intended to limit the present invention, and the scope of the present invention should be defined by the claims of the present invention. Changes in the number of elements described herein or replacements of equivalent elements should still fall within the scope of the present invention.

Meanwhile, the present invention uses specific words to describe embodiments of the present invention. Such as “one embodiment”, “an embodiment” and/or “some embodiments” means a certain feature, structure, or characteristic related to at least one embodiment of the present invention. Therefore, it should be emphasized and noted that “an embodiment” or “one embodiment” or “an alternative embodiment” mentioned twice or more at different positions in this specification do not necessarily refer to the same embodiment.

Similarly, it should be noted that in the foregoing description of the embodiments of the present invention, in order to simplify the formulation of the disclosure of the present invention and thereby facilitate the understanding of one or more embodiments of the present invention, multiple features may sometimes be combined into one embodiment, the accompanying drawings, or the description thereof. However, this method of disclosure does not mean that more features are required for the object of the present invention than the features mentioned in the claims. In fact, the features of the embodiments are less than all of the features of the single embodiment disclosed above.

What is claimed is:

1. A thin film deposition apparatus, comprising:

a process chamber, for performing thin film deposition;

a gas supply assembly, disposed on the top wall of the process chamber, for supplying process gas to the inside of the process chamber;

a heating tray, disposed below the gas supply assembly, for carrying and heating a substrate;

an upper electrode and a lower electrode, for forming a uniform electric field in the process chamber;

a radio frequency source, connected to the upper electrode and the lower electrode for providing radio frequency power, exciting process gas inside the process chamber to dissociate into plasma gas, and the plasma gas performing thin film deposition on the substrate;

wherein, the sizes of the upper electrode and the lower electrode are the same or different by $\pm 10\text{mm}$, and the diameter of the lower electrode is smaller than the diameter of the substrate, so that the uniform electric field is generated between the upper electrode and the lower electrode.

2. The thin film deposition apparatus according to claim 1, wherein the diameter difference between the lower electrode and the substrate is $\leq 15\text{mm}$.

3. The thin film deposition apparatus according to claim 1, wherein the diameter of the upper electrode and the diameter of the substrate are the same or different by $\pm 10\text{mm}$.

4. The thin film deposition apparatus according to claim 1, wherein the thin film deposition apparatus further comprises a support ring and a rotating mechanism, and the support ring is used for supporting the substrate.

5. The thin film deposition apparatus according to claim 4, wherein the support ring is an insulator.

6. The thin film deposition apparatus according to claim 5, wherein the rotating mechanism is used for controlling the heating tray to rotate relative to the substrate or for controlling the heating tray to rotate together with the substrate or for controlling the gas supply assembly to rotate relative to the substrate or for controlling the support ring and the substrate to rotate together.

7. The thin film deposition apparatus according to claim 5, wherein when the rotating mechanism controls the substrate to rotate, the gas supplied into the process chamber is inert gas.

8. The thin film deposition apparatus according to claim 7, wherein the inert gas is nitrogen.

9. The thin film deposition apparatus according to claim 7, wherein the temperature of the inert gas introduced is 200-500°C.

10. The thin film deposition apparatus according to claim 4, wherein when the rotating mechanism controls the substrate to rotate, the radio frequency source is in an on state.

11. The thin film deposition apparatus according to claim 4, wherein the thin film deposition apparatus further comprises a flow guide ring, and the flow guide ring wraps the sidewall of the upper electrode.

12. The thin film deposition apparatus according to claim 11, wherein the diameter of the flow guide ring is greater than or equal to the diameter of the support ring.

13. The thin film deposition apparatus according to claim 11, wherein the flow guide ring is an insulator.

14. The thin film deposition apparatus according to claim 13, wherein the material of the flow guide ring is AlN or Al₂O₃.

15. The thin film deposition apparatus according to claim 1, wherein the upper electrode and the gas supply assembly are integral.

16. The thin film deposition apparatus according to claim 1, wherein the gas supply assembly is an insulator, the upper electrode is positioned below the gas supply assembly, and the upper electrode is a meshed electrode.

17. The thin film deposition apparatus according to claim 1, wherein the gas supply assembly is an insulator with a groove at the bottom, and the gas outlets of the gas supply assembly are positioned in the groove, a meshed electrode is also embedded in the groove.

18. The thin film deposition apparatus according to claim 17, wherein the groove is the circular groove.

19. The thin film deposition apparatus according to claim 18, wherein the diameter of the circular groove is the same as the diameter of the meshed electrode.

20. A thin film deposition apparatus, comprising:

a process chamber, for performing thin film deposition;

a gas supply assembly, disposed on the top wall of the process chamber, for supplying process gas to the inside of the process chamber;

a heating tray, disposed below the gas supply assembly, for carrying and heating a substrate;

a radio frequency source, for providing radio frequency power, exciting process gas inside the process chamber to dissociate into plasma gas, the plasma gas performing thin film deposition on the substrate;

an insulating plate, located below the gas supply assembly, the insulating plate being provided with a plurality of gas holes for introducing process gas into the process chamber.

21. The thin film deposition apparatus according to claim 20, wherein the thickness of the insulating plate is above 0.2mm.

22. The thin film deposition apparatus according to claim 20, wherein the insulating plate is in contact with the bottom surface of the gas supply assembly.

23. The thin film deposition apparatus according to claim 22, wherein the diameter of the gas hole and the diameter of the gas outlet is the same.

24. The thin film deposition apparatus according to claim 22, wherein the number of the gas holes is greater than or equal to the number of the gas outlets.

25. The thin film deposition apparatus according to claim 22, wherein each gas outlet of the gas supply assembly has a gas hole on the insulating plate corresponding to the position of the gas outlet.

26. The thin film deposition apparatus according to claim 20, wherein a gap is left between the insulating plate and the gas supply assembly, and a circle of insulating ring is added on the outside of the gap.

27. The thin film deposition apparatus according to claim 26, wherein the insulating ring is the edge of the insulating plate extending upward to the sidewall that wraps the gas supply assembly.

28. The thin film deposition apparatus according to claim 26, wherein the gap between the insulating plate and the gas supply assembly is 0.1-2mm.

29. The thin film deposition apparatus according to claim 20, wherein the insulating plate is made of a material that does not react with HF.

30. The thin film deposition apparatus according to claim 29, wherein the insulating plate is made of sapphire or silicon carbide.

31. The thin film deposition apparatus according to claim 29, wherein quartz and silicon are added to the insulating plate material.

32. The thin film deposition apparatus according to claim 31, wherein the quartz is synthetic quartz mixed with silicon.

33. The thin film deposition apparatus according to claim 20, wherein the surface treatment of the insulating plate is the rough surface.

34. The thin film deposition apparatus according to claim 20, wherein the thin film deposition apparatus further comprises a support ring and a rotating mechanism, the support ring is used for supporting the substrate, and the rotating mechanism is used for controlling the substrate to rotate.