

PHYSICAL VAPOR DEPOSITION APPARATUS

Field of the Invention

The present invention relates to the field of semiconductor manufacturing technology, in particular to a physical vapor deposition apparatus.

Background of the Invention

In a physical vapor deposition (PVD) sputtering device, typically a negative bias is applied to the sputtering target, such that the process gas such as Ar (argon) in the reaction chamber is excited into plasma, and the ions in the plasma are attracted to bombard the target, and thus the target material is sputtered and deposited on a wafer or substrate. Different applications (for example, semiconductor, solar, LED (light emitting diode), etc.) usually require different process parameters such as sputtering voltage and sputtering rate. Especially for a conductive film layer including ITO (indium tin oxide), AZO ((aluminum zinc oxide) or the like used in applications such as solar, LED and the like, a relatively low sputtering voltage is required for ensuring better process performance of the thin film formed by sputtering and deposition.

As described above, in the conventional physical vapor deposition apparatus, DC power is applied to the target by DC power source, so as to excite the gas into plasma, and a negative bias is applied to the target to attract ions in the plasma to bombard the target, such that the sputtered target material is deposited on a substrate carried by a base. However, the conventional physical vapor deposition apparatus may bring some problems in special applications (such as ITO sputtering in LED field). Firstly, direct current sputtering will produce a high voltage (e.g., of about several hundred volts) on the target, and generates a high DC bias voltage, for example, of about several tens of volts on the surface of the substrate. For the ITO sputtering in LED applications, high target voltage or high DC bias voltage will cause damage to the wafer or substrate. Moreover, under certain DC power, the density of plasma generated by direct current sputtering is relatively low, which results in a relatively low deposition rate.

In order to solve the problem of excessive sputtering bias, a sputtering manner in which both RF and DC are simultaneously supplied to the target is adopted in the present field. For example, in Chinese patent application No.200980143935.2, RF power is fed onto the target through a cylindrical electrode. However, a large coupling capacitance

exists between the cylindrical electrode and the outer wall of an enclosing unit, which causes the RF power to be partially lost due to the coupling capacitance, even makes it impossible to maintain stable plasma, and results in waste of the RF power.

Summary of the Invention

The present invention is proposed to solve at least one of the above technical problems in the prior art.

To this end, one object of the present invention is to provide a physical vapor deposition apparatus which, by changing the structure of electrode, is capable of performing uniform sputtering of the target without affecting the layout of the magnetron driving unit.

The physical vapor deposition apparatus according to an embodiment of the present invention comprises: a reaction chamber, which includes a top wall, a sputtering target and a substrate support unit, wherein the sputtering target is adjacent to the top wall, and the substrate support unit is disposed in the reaction chamber and opposite to the sputtering target; a DC power source coupled to the sputtering target; a RF power source, wherein an output of the RF power source is sequentially connected to a RF matching unit and a RF feeding unit, the RF feeding unit comprises a distribution ring and a plurality of distribution strips disposed along a circumferential direction of the distribution ring at intervals, the distribution ring is coupled to the sputtering target through the distribution strips, and the RF feeding unit is coupled to the RF power source through the distribution ring.

In the physical vapor deposition apparatus according to the embodiment of the present invention, by changing the structure of a feeding electrode, the influence on the magnetron driving unit can be reduced to the largest extent without affecting arrangement of the magnetron driving unit. In addition, by adopting the RF feeding unit with the distribution ring, the uniformity of the target sputtering can be maximized.

Furthermore, the physical vapor deposition apparatus according to the invention has the additional features as follows.

According to an embodiment of the present invention, a plurality of distribution rings are provided, the plurality of distribution rings are parallel to each other and are disposed at intervals along an axial direction of the distribution rings, two adjacent distribution rings are connected by the distribution strips.

According to an embodiment of the present invention, projection of the distribution ring on the radial cross-section thereof is circular in shape.

According to an embodiment of the present invention, the distribution strips are uniformly distributed along the circumferential direction of the distribution ring.

According to an embodiment of the present invention, cross-section of the distribution strip has a width larger than or equal to 5mm, and has a thickness larger than or equal to 0.1mm.

According to an embodiment of the present invention, the RF feeding unit is made of copper, silver or gold.

According to an embodiment of the present invention, each distribution strip has at least two distribution sections, and a connection section is connected between two adjacent distribution sections.

According to an embodiment of the present invention, the distribution section extends along the axial direction of the distribution ring.

According to an embodiment of the present invention, the distribution section extends obliquely with respect to the axial direction of the distribution ring inwardly or outwardly.

According to an embodiment of the present invention, the connection section extends parallel to a plane of the distribution ring.

According to an embodiment of the present invention, the connection section extends obliquely with respect to a plane of the distribution ring upwardly or downwardly.

According to an embodiment of the present invention, frequency of the RF power source is in the range of 2MHz to 27.12 MHz, and specifically is 2MHz, 13.56 MHz or 27.12 MHz.

According to an embodiment of the present invention, the physical vapor deposition apparatus further comprises: a variable reactance unit, the variable reactance unit is connected in series between the substrate support unit and ground for adjusting DC bias voltage on a substrate.

According to an embodiment of the present invention, the variable reactance unit is a variable capacitor, a variable inductor or a circuit comprising a variable capacitor and a variable inductor.

According to an embodiment of the present invention, the sputtering target is a metal oxide target.

According to an embodiment of the present invention, the metal oxide target is ITO (indium tin oxide) target or AZO (aluminum zinc oxide) target.

According to an embodiment of the present invention, in the ITO (indium tin oxide) target, content of tin oxide with respect to the overall indium tin oxide is in the range of 0.1% to 20%.

Additional aspects and advantages of the present invention will be given in part in the following description, part will become apparent from the following description, or be learned by practice of the present invention.

Brief Description of the Drawings

The above and/or additional aspects and advantages of the present invention will become apparent and readily appreciated from the description of the embodiments in conjunction with the following drawings. In the drawings:

Figure 1 is a schematic view of a physical vapor deposition apparatus provided by an embodiment of the present invention.

Figure 2 is a schematic view of a first embodiment of an electrode in the physical vapor deposition apparatus provided by an embodiment of the present invention.

Figure 3 is a schematic view of a second embodiment of the electrode in the physical vapor deposition apparatus provided by the embodiment of the present invention.

Figure 4 is a schematic view of a third embodiment of the electrode in the physical vapor deposition apparatus provided by the embodiment of the present invention.

Figure 5 is a schematic view of a fourth embodiment of the electrode in the physical vapor deposition apparatus provided by the embodiment of the present invention.

Figure 6 is a schematic view of a fifth embodiment of the electrode in the physical vapor deposition apparatus provided by the embodiment of the present invention.

Figure 7 is a schematic view of a sixth embodiment of the electrode in the physical vapor deposition apparatus provided by the embodiment of the present invention.

Figure 8 is a schematic view of a physical vapor deposition apparatus provided by another embodiment of the present invention.

Figures 9a to 9c are schematic views of a variable reactance unit in the physical vapor deposition apparatus as shown in FIG. 8.

Reference numerals:

1 reaction chamber	11 base
110 opening	12 sidewall
141 valve	142 gas source
144 conduit	2 back plate
21 insulating unit	22 top wall
3 substrate support unit	
4 shield case	40 shield space
5 magnetron	
61 RF feeding unit	610 variable capacitor
611 distribution ring	612 distribution strip
6121 distribution section	6122 connection section
62 RF power source	63 RF matching unit
71 DC power source	72 RF filter
8 variable reactance unit	
91 electrode	92 RF power source
93 matching unit	
100 physical vapor deposition apparatus	200 sputtering target
Y axis direction	

Detailed Description of the Embodiments

Embodiments of the present invention will be described in detail below, examples of the embodiments are shown in the accompanying drawings, in which throughout the description same or similar reference numerals denote same or similar components or components having the same or similar functions. The embodiments described with reference to the accompanying drawings are illustrative for explaining the present invention only and shall not be construed as limiting the present invention.

In the description of the present invention, it should be understood that the terms "above", "below", "left", "right", "top", "bottom", "inner", "outer", etc. refer to the orientation or positional relationship based on those shown in the drawings. Those terms are used merely for convenience and ease of description of the present invention, rather than indicating or implying that the device or component referred to must have a particular orientation, or be configured and operated in a particular orientation, and therefore it shall not be construed as limiting the present invention. In addition, the terms

“first”, “second” are merely illustrative, not to indicate or imply relative importance or implicitly specify the number of the indicated technical features. Thus, the technical features defined using “first”, “second” or the like may explicitly or implicitly include one or more of the features.

It should be noted that, unless otherwise specifically defined and limited in the present description, the terms “mount”, “couple”, “connection”, etc. should be understood in a generalized manner. For example, the connection may be a fixed connection, detachable connection or integral connection; it may be a mechanical connection or an electrical connection; it may be a direct connection, or an indirect connection through intermediate media, or the internal communication between two components. Those of ordinary skill in the art shall understand the specific meaning of the above terms in the present invention depending on specific circumstances. Also in the present invention, unless otherwise specifically defined and limited, a first feature is “above” or “below” a second feature” may include a case in which the first feature directly contacts with the second feature, and a case in which the first feature and the second feature do not directly contact with each other but through other feature(s) therebetween”.

The basic principles of the present invention is that, by changing the existing RF access technique, i.e., by changing the structure of the feeding electrode of the present invention (will be described in detail below), the affection on the magnetron driving unit is decreased to a minimum without changing arrangement of the magnetron driving unit. Besides, by using the RF feeding unit with the distribution ring, the uniformity of the target sputtering can be maximized. Hereinafter the present invention will be described in detail.

Physical vapor deposition apparatus

The above-described principles of the present invention will be described in detail below with reference to the accompanying drawings. As shown in Figure 1, according to an embodiment of the present invention, there is provided a physical vapor deposition apparatus 100, which is used for sputtering the sputtering target 200, and depositing the sputtered target material on a wafer or substrate (not shown).

As shown in Figure 1, the physical vapor deposition apparatus provided by the embodiment of the present invention includes a reaction chamber 1, a back plate 2, a substrate support unit 3, a shield case 4, a magnetron 5, a RF feeding unit 61, and a RF

power source 62.

The reaction chamber 1 is open at the top and has an opening 110 formed at the bottom, and the reaction chamber 1 is grounded.

The bottom surface of the back plate 2 forms the top wall 22 of the reaction chamber, a sputtering target 200 is disposed on the top wall 22. In practical applications, the sputtering target 200 and the back plate 2 may be fixedly connected by way of welding, and are communicated therebetween. The back plate 2 is provided at the top of the reaction chamber 1 through an insulating unit 21, and closes the top of the reaction chamber 1. The substrate support unit 3 is used for setting the substrate, and extends into the reaction chamber 1 through the opening 110, such that the substrate (not shown) is disposed opposite to the sputtering target 200. Optionally, the substrate support unit 3 may be an electrostatic chuck.

Optionally, as shown in Figure 1, the reaction chamber 1 further comprises a base 11 and a side wall 12, the opening 110 is formed on the base 11, and the base 11 is grounded. The side wall 12 is provided on the base 11, the reaction chamber 1 is defined by the base 11 and the side wall 12, the insulating unit 21 is provided between the top of the side wall 12 and the back plate 2, so that the back plate 2 is electrically insulated from the reaction chamber 1, and the sputtering target 200 fixed on the back plate 2 is thus insulated from ground.

As shown in Figure 1, the shield case 4 is made of metal material and is provided above the back plate 2 for electromagnetic shielding, and the shield case 4 and the back plate 2 define a shield space 40. The RF feeding unit 61 is provided within the shield case 4 and connected to the shield case 4, the lower end of the RF feeding unit 61 is connected to an edge of the back plate 2.

The RF power source 62 is connected to the RF feeding unit 61 through the RF matching unit 63, for transmitting RF power to the back plate 2, i.e., feeding RF power into the back part 2, so as to be coupled to the sputtering target 200. The RF matching unit 63 can maximize the RF power transmitted to the RF feeding unit 61. The structure of the RF feeding unit 61 will be described in detail below with reference to Figures 2 to 6.

As shown in Figure 1, the magnetron 5 is provided within the shield space 40 and at the top of the back plate 2. A gas source 142 provides, to the reaction chamber 1, process gas, such as argon, one or more oxygen-containing or nitrogen-containing gases. The

process gas can react with the sputtering material to form a film layer on the substrate. Process gas after the reaction and reaction by-products are exhausted from the reaction chamber 1 by a vacuum pump (not shown).

In operation, the gas source 142 supplies the process gas (e.g., argon) into the reaction chamber 1. The RF power source 62 applies RF power to the sputtering target 200 through the RF matching unit 63 and the RF feeding unit 61, so as to excite the argon gas in the reaction chamber 1 into plasma, and generate a negative bias voltage on the sputtering target 200. The negative bias voltage will attract argon ions to bombard the sputtering target 200, so that material of the sputtering target 200 is sputtered off, and deposited on a substrate or wafer on the substrate support unit 3.

As shown in Figure 1, the reaction chamber 1 may be controlled by a controller (not shown). The controller is usually designed for controlling the reaction chamber 1, and typically comprises a CPU (central processing unit) (not shown), memory (not shown) and supporting circuitry (i.e., I/O) (not shown). The CPU may be any type of computer processor used in industrial environments, the industrial environments are configured to control various system functions, substrate movement, etc., and monitor the process (e.g., temperature of the substrate support unit, the chamber process time, I/O signals, etc.). The memory is connected to the CPU, and may be one or more memories that are readily available, such as RAM (random access memory), ROM (read only memory), floppy disk, hard disk, or any other form of digital storage, local or remote storage. Software instructions and data may be coded and stored in the memory, for instructing the CPU to perform operation.

As shown in Figure 1, the physical vapor deposition apparatus 100 further comprises: a DC power source 71 provided in the vicinity of the shield case 4, and is connected to the back plate 2 through a DC connection strip (not shown), so as to apply DC power to the sputtering target 200. During the process, DC power and RF power are simultaneously supplied to the sputtering target 200 by the DC power source 71 and the RF power source 62, thus high-density plasma can be generated and the voltage on the target can be significantly reduced, thereby reducing possible damage to the substrate or wafer. Furthermore, the high-density plasma results in high particle flux, which increases the deposition rate significantly and therefore increases the process efficiency.

Furthermore, since the physical vapor deposition apparatus 100 adopting such double-source structure (the DC power source 71 and the RF power source 62), the

penetration performance of the material increases, whereby not only the conventional Cu target but also the target for forming ITO or AZO film can be sputtered, thus expanding the range of the applied materials for the physical vapor deposition apparatus 100.

In addition, it should be noted that when the physical vapor deposition apparatus according to the embodiment of the present invention 100 is used for sputtering the ITO target, the content of tin oxide in the target may range from 0.1% to 20%.

As shown in Figure 1, the physical vapor deposition apparatus 100 further comprises: a RF filter 72, which is provided between the DC power source 71 and the RF feeding unit 61 for filtering the RF power. Thus, on the premise that DC power is normally supplied, RF power is filtered from the DC loop between the DC power source 71 and the RF feeding unit 61, thus preventing the RF voltage from damaging the DC power source 71.

In the embodiment described above, the frequency of the RF power source 62 may be high frequency such as 2MHz, 13.56 MHz or 27.12 MHz. The RF power may be less than 3000 watts (W).

Optionally, in an embodiment of the present invention, the DC bias voltage on the substrate on the substrate support unit 3 may be adjusted by adjusting the ratio of the RF power from the RF power source 62 to the DC power from the DC power source 71. For example, the RF power from the RF power source 62 is 600W, while the DC power from the DC power source 71 is 100W, and in this case the bias voltage on the substrate is substantially zero, such that the substrate is prevented from being damaged.

In an example of the present invention, the substrate support unit 3 may be electrically floating. In another example of the present invention, the substrate support unit 3 may be grounded. In still another embodiment of the present invention, the physical vapor deposition apparatus 100 further includes an electrode 91 and RF power source 92. As shown in Figure 1, the electrode 91 is connected to the substrate support unit 3, the RF power source 92 is connected to the electrode 91 through a matching unit 93, so as to transmit RF power to the substrate support unit 3, thereby generating a radio frequency bias voltage.

Structure of electrode

The structure of the electrode of the above-described RF feeding unit 61 will be described in detail. As described above, RF power source 62 is connected to the RF feeding unit 61 through the RF matching unit 63, so as to transmit the RF power to the

edge of the back plate 2. By using the RF matching unit 63, on one hand the RF power transmitted to the RF feeding unit 61 can be maximized, and on the other hand the RF matching unit 63 itself and the RF power source 62 can be isolated from damage from other power source (such as DC power source) which may be connected to the sputtering target 200. The position at the central axis of the sputtering target 200 is usually occupied by a magnetron driving unit (not shown) and other components. Therefore, the RF power transmitted from the RF power source 62 can only be input through a position other than the central axis of the sputtering target 200, which results in non-uniform RF feeding, and thus affects the distribution uniformity of plasma finally produced in the reaction chamber 1.

To this end, the present invention adopts a feeding mode using the distribution ring 611. With the distribution ring 611, RF feeding changes from a point feeding mode to a surface feeding mode, thus uniform RF feeding is achieved.

In an embodiment of the present invention, as shown in FIG. 2 through FIG. 7, the RF feeding unit 61 comprises a distribution ring 611 and a plurality of distribution strips 612 disposed along the circumferential direction of the distribution ring 611 at intervals. The distribution ring 611 is coupled to the RF power source 62 through the RF matching unit 63, for example, as shown in Figure 2. Each distribution ring 612 is connected to the back plate 2 through the distribution strips 612, and thus coupled to the sputtering target (not shown). As shown in Figure 2, the projection of the distribution ring 611 on the radial cross-section thereof is circular in shape, thus the RF power can be distributed uniformly.

Of course, in order to produce more uniform plasma in the reaction chamber 1, RF feeding may be performed by means of multiple layers of distribution rings 611. As shown in Figure 3, the RF feeding unit 61 may comprise a plurality of distribution rings 611 (two layers of distribution ring 611 are shown in Figure 3). The plurality of distribution rings 611 are parallel to each other, and are disposed at intervals along the axial direction Y of the distribution ring 611. Two adjacent distribution rings 611 are connected by the distribution strips 612, and the distribution ring 611 closest to the sputtering target 200 is connected to the back plate 2 through the distribution strips 612, so as to be coupled to the sputtering target (not shown).

In feeding the RF power, the RF power is firstly input to the distribution ring 611 on the topmost layer, and is then fed, through the distribution strips 612, to the distribution

rings 611 below the distribution ring 611 on the topmost layer sequentially from top to bottom. Compared to the conventional cylindrical structure, the RF feeding structure of the present invention having a "nest" shape can distribute the RF power multiple times, thereby the RF feeding can become more uniform. Moreover, since the structure having the "nest" shape distributes the RF power multiple times, the RF power distribution becomes more uniform. Compared to the standing wave effect due to a relatively large number of high frequency components when the RF power is transmitted at a relatively short distance in a conventional solution, according to the present invention, the RF power can uniformly reach the sputtering target (not shown) after reaching the back plate 2, thus the sputtering target can be sputtered uniformly and the standing wave effect can be avoided.

It should be noted that, as compared to the conventional structure in which a conductive hollow cylindrical structure is adopted at the center of the sputtering target for applying RF power, the structure of the electrode of the present invention does not affect the arrangement of the magnetron driving unit, thereby the affection on the magnetron driving unit is decreased to a minimum. Besides, the uniformity of the target sputtering can be maximized without affecting the existing design.

In an example of the present invention, as shown in Figure 3, the projection of the distribution ring 611 on the radial cross-section (perpendicular to the axial direction of the distribution ring) thereof is rectangular in shape. Of course, the present invention is not limited thereto, in other examples of the present invention, the projection of the distribution ring 611 on the radial cross-section thereof may be of any shape such as circle (Figure 2), annularity or polygon having more than three sides, and any circumferential annular structure that can distribute RF power can be adopted. Of course, the shape of the projections is preferably circular.

According to an embodiment of the present invention, the number of the distribution strips 612 between two adjacent distribution rings 611 and the number of the distribution strips 612 between the sputtering target and the distribution ring 611 closest to the sputtering target may be different. As shown in Figure 3, the number of the distribution strips 612 between the distribution ring 611 on the top layer and the distribution ring 611 on the bottom layer is different from the number of the distribution strips 612 between the distribution ring 611 on the bottom layer and the back plate 2. It should be noted that the number of the distribution strips 612 is not particularly limited, as long as the RF

power can be evenly distributed.

Further, as shown in FIG. 3, the areas enclosed by the respective distribution rings 611 may gradually increase toward the sputtering target (not shown) along a vertical direction (i.e., the axial direction of the distribution ring), i.e., the closer a distribution ring 611 is to the sputtering target, the larger the area enclosed by the distribution ring 611 is. Thus, the distribution of RF power sequentially becomes even toward the sputtering target in the vertical direction. It should be noted that the term "vertical direction" refers to a direction along which the RF feeding unit 61 is mounted on the back plate 2; as shown in Figure 3, the vertical direction is the axial direction Y of the distribution ring 611.

In some examples of the present invention, each layer comprises at least three distribution strips 612 distributed evenly along the circumferential direction. Optionally, the distribution strip 612 is made of metal material, such as copper. Of course, the distribution strip 612 may also be made of other metal material such as aluminum, silver, gold, stainless steel, alloy or the like. Preferably, the distribution strip 612 has a width larger than or equal to 5mm, and has a thickness larger than or equal to 0.1mm.

In the following the structure of the RF feeding unit 61 will be further described with reference to Figure 4. In the example as shown in Figure 4, the projection of the distribution ring 611 on the radial cross-section thereof is a rectangular in shape. The RF feeding unit 61 includes four distribution strips 612 distributed evenly along the circumferential direction of the sputtering target (not shown). The upper ends of the four distribution strips 612 are connected to the rectangular distribution ring 611 respectively, and the lower ends of the four distribution strips 612 are connected to the edge of the back plate 2 evenly and at intervals. As such, RF power is transmitted to the distribution ring 611 through the RF matching unit 63, and is delivered evenly to the back plate 2 through the four distribution strips 612 and further to the sputtering target, resulting in a negative bias voltage on the sputtering target.

The exemplary structures of the distribution strip 612 will be described with reference to Figures 3 through 7. As shown in Figure 4, each distribution strip 612 has two distribution sections 6121 and one connection section 6122. The connection section 6122 is connected between two distribution sections 6121, and extends parallel to the plane of the distribution ring 611. Two ends of the connection section 6122 are respectively connected to one end of the two distribution sections 6121. The other end of the

distribution section 6121 close to the distribution ring 611 is connected to the distribution ring 611; and the other end of the distribution section 6121 close to the sputtering target 200 is connected to the back plate 2. Optionally, the connection section 6122 may extend obliquely with respect to the plane of the distribution ring 611 upwardly or downwardly, i.e., the extending direction of the connection section 6122 forms an acute angle with respect to the plane of the distribution ring 611, as long as the two ends of the connection section 6122 are connected to two adjacent distribution sections 6121, respectively.

According to an embodiment of the present invention, a plurality of distribution sections 6121 may extend along the axial direction (i.e., vertical direction) of the distribution ring 611 and toward the sputtering target (not shown). Optionally, as shown in Figures 5 and 6, the plurality of distribution sections 6121 may extend toward the sputtering target obliquely with respect to the axial direction of the distribution ring 611 inwardly or outwardly, i.e. the extending direction of the distribution section 6121 form an acute angle with respect to the axial direction of the distribution ring 611.

According to an embodiment of the present invention, as shown in Figure 7, each of the distribution strips 612 may have three or more distribution sections 6121, and accordingly there are multiple connection sections 6122. Each connection section 6122 have two ends connected between two adjacent distribution sections 6121, and extend parallel to the plane of the distribution ring 611. Optionally, the connection section 6122 may extend obliquely with respect to the plane of the distribution ring 611 upwardly or downwardly. The other end of the distribution section 6121 closest to the distribution ring 611 is connected to the distribution ring 611, the other end of the distribution section 6121 closest to the back plate 2 is connected to the sputtering target 200. With the above specific structure of the distribution strip 612, the uniformity of RF power distribution can be further improved.

Of course, in practical applications, each distribution strip 612 may not be segmented but have a continuous structure, and a plurality of distribution strips 612 extend from the distribution ring 611 to the sputtering target (not shown) along the axial direction of the distribution ring 611, and are parallel to each other. However, it should be noted that each distribution strip 612 may extend from the distribution ring 611 toward the sputtering target obliquely with respect to the axial direction of the distribution ring 611 outwardly or inwardly.

Adjustment of variable reactance unit

Hereinafter, means for adjusting variable reactance in the lower electrode of the physical vapor deposition apparatus 100 of the present invention will be described with reference to Figure 8. In an embodiment of the present invention, the physical vapor deposition apparatus 100 further includes a variable reactance unit 8. As shown in Figure 8, the variable reactance unit 8 is connected in series between the substrate support unit 3 and the ground for adjusting DC bias voltage on the substrate. Specifically, the variable reactance unit 8 may be a variable capacitor (as shown in Figure 9a), a variable inductor (as shown in Figure 9b) or a parallel circuit of a variable capacitor and a variable inductor (as shown in Figure 9c). In this case, since the substrate (not shown) on the substrate support unit 3 is part of the load of the plasma, the variable reactance unit 8 can be added thereon to adjust the potential of the substrate in the RF circuit, thereby adjusting the DC bias voltage on the substrate. For example, when the variable reactance unit 8 is a variable capacitor, the capacitance may be about 300 PF (picofarad), so that the DC bias voltage on the substrate is 0.

It should be noted that, in the physical vapor deposition apparatus 100, bombardment to the surface of the substrate may be adjusted by controlling the grounded reactance of the electrode, and thus the step coverage and properties of the deposited film and the like may be affected, said properties include grain size, film stress, crystal orientation, film density, roughness and film composition, etc. Therefore, the variable reactance unit 8 can be used for changing deposition rate, etching rate and the like. In an embodiment, by appropriately adjusting the grounded reactance of the electrode/substrate, the variable reactance unit 8 can facilitate deposition or etching, or prevent deposition or etching. The variable capacitor 610 is set for adjusting the impedance to the ground, thereby adjusting the interaction between the substrate and ions in the plasma during processing.

Process

The process of the physical vapor deposition apparatus according to an embodiment of the present invention will be described with reference to Figure 1 and Figure 8, and a case in which the RF power source 62 and the DC power source 71 both apply power to the sputtering target 200 is taken as an example. Compared to a case in which RF power is only applied, the combination of RF power source and DC power source allows lower

overall RF power during processing, thereby reducing the damage of plasma to the substrate and improving the device yield. Of course, the RF power source 62 may be used alone to apply RF power to the sputtering target 200.

In operation, supply of the process gas from the gas source 142 to the reaction chamber 1 may be controlled through a valve 141, for example, argon is supplied through conduit 144. The RF power source 62 applies RF power to the sputtering target 200 through the RF feeding unit 61, so as to excite the argon gas in the reaction chamber 1 into plasma; at the same time, the DC power source 71 also applies DC power to the sputtering target 200 through the RF feeding unit 61, and generates a negative bias voltage on the sputtering target 200. Since the RF feeding unit 61 of the present invention adopts a RF feeding structure in a "nest" shape, it can distribute the RF power multiple times, which enables the RF power and DC voltage to be uniformly applied to the sputtering target 200, thereby generating high-density plasma. As the sheath bias voltage of the plasma is inversely proportional to the density thereof, the negative bias voltage generated on the target is significantly reduced, thereby reducing damage to the substrate or wafer. In addition, high-density plasma results in high particle flux, and the deposition rate can be significantly increased, thereby increasing the process efficiency.

The above-described negative bias voltage applied to the sputtering target 200 may attract argon ions to bombard the sputtering target 200, the material of the sputtering target 200 is sputtered off and deposited on the substrate on the substrate support unit 3, thereby the process is completed.

At this time, by adjusting the ratio of RF power from the RF power source 62 to DC power from the DC power source 71 (as shown in Figure 1), or by adjusting the variable reactance unit 8 (as shown in Figure 8), the DC bias voltage on the substrate on the substrate support unit 3 can be adjusted.

Other components and operations of the physical vapor deposition apparatus according to the embodiments of the present invention are well known to those of ordinary skills in the art, and are not described in detail herein.

In the description of the present specification, description referring to the terms "an embodiment", "some embodiments", "illustrative embodiment", "example", "specific example", or "some examples" etc., means that the particular features, structures, materials, or characteristics described in conjunction with the embodiment or example are included in at least one embodiment or example of the present invention. In the

present specification, the illustrative representation of the above terms does not necessarily refer to the same embodiment or example. Furthermore, the particular features, structures, materials, or characteristics described may be combined in any one or more embodiments or examples in a suitable manner.

Although the embodiments of the present invention have been illustrated and described, those of ordinary skills in the art will appreciate that various changes, modifications, substitutions and variations can be made to these embodiments without departing from the principle and essence of the present invention, and the scope of the present invention is defined by the claims and equivalents thereof.

CLAIMS:

1. A physical vapor deposition apparatus, comprising:
 - a reaction chamber, which includes a top wall, a sputtering target and a substrate support unit, wherein the sputtering target is adjacent to the top wall, and the substrate support unit is disposed in the reaction chamber and opposite to the sputtering target;
 - a DC power source coupled to the sputtering target;
 - a RF power source, wherein an output of the RF power source is sequentially connected to a RF matching unit and a RF feeding unit, the RF feeding unit comprises a distribution ring and a plurality of distribution strips disposed along a circumferential direction of the distribution ring at intervals, the distribution ring is coupled to the sputtering target through the distribution strips, and the RF feeding unit is coupled to the RF power source through the distribution ring.
2. The physical vapor deposition apparatus according to claim 1, wherein a plurality of distribution rings are provided, the plurality of distribution rings are parallel to each other and are disposed at intervals along an axial direction of the distribution rings, two adjacent distribution rings are connected by the distribution strips.
3. The physical vapor deposition apparatus according to claim 1, wherein projection of the distribution ring on a radial cross-section thereof is circular in shape.
4. The physical vapor deposition apparatus according to claim 1, wherein the cross-section of the distribution strip has a width larger than or equal to 5mm, and has a thickness larger than or equal to 0.1mm.
5. The physical vapor deposition apparatus according to claim 1, wherein the RF feeding unit is made of copper, silver or gold.
6. The physical vapor deposition apparatus according to any one of claims 1-5, wherein each distribution strip has at least two distribution sections, and a connection section is connected between two adjacent distribution sections.

7. The physical vapor deposition apparatus according to claim 6, wherein the distribution section extends along the axial direction of the distribution ring.

8. The physical vapor deposition apparatus according to claim 6, wherein the distribution section extends obliquely with respect to the axial direction of the distribution ring inwardly or outwardly.

9. The physical vapor deposition apparatus according to claim 6, wherein the connection section extends parallel to a plane of the distribution ring.

10. The physical vapor deposition apparatus according to claim 6, wherein the connection section extends obliquely with respect to a plane of the distribution ring upwardly or downwardly.

11. The physical vapor deposition apparatus according to claim 1, wherein frequency of the RF power source is in the range of 2MHz to 27.12 MHz.

12. The physical vapor deposition apparatus according to claim 1, further comprising:
a variable reactance unit, which is connected in series between the substrate support unit and ground for adjusting a DC bias voltage on a substrate.

13. The physical vapor deposition apparatus according to claim 12, wherein the variable reactance unit is a variable capacitor, a variable inductor or a circuit comprising a variable capacitor and a variable inductor.

14. The physical vapor deposition apparatus according to claim 1, wherein the sputtering target is a metal oxide target.

15. The physical vapor deposition apparatus according to claim 14, wherein the metal oxide target is indium tin oxide target or aluminum zinc oxide target.

16. The physical vapor deposition apparatus according to claim 15, wherein content of

tin oxide in the indium tin oxide target is in the range of 0.1% to 20%.