SUBSTRATE CARRYING DEVICE AND PLASMA PROCESSING EQUIPMENT

FIELD OF THE INVENTION

This invention relates to the technical field of microelectronics processing, and specifically, to a substrate carrying device and a plasma processing equipment.

BACKGROUND OF THE INVENTION

Plasma processing equipment is the commonly used equipment for processing a semiconductor device. During processes such as etching, sputtering, and chemical vapor deposition and so on, in order to improve the production efficiency of the plasma processing equipment and decrease the production cost thereof, a substrate carrying device (e.g. a tray) with a larger size is generally used to carry a plurality of processed workpieces, and is simultaneously transported to a reaction chamber, thus achieving a procedure that a plurality of processed workpieces are treated simultaneously.

Figure 1 is a structural diagram of a existing plasma processing equipment. As shown in Figure 1, the plasma processing equipment includes a reaction chamber 1 and a tray 3. A base 5 is arranged in the reaction chamber 1, an electrostatic chuck 4 is fixed on the base 5, and a plurality of substrate mounting locations 21 are arranged on an upper surface of the tray 3. The electrostatic chuck 4 adsorbs the tray 3 carrying a plurality of processed workpieces 2 to an upper surface of the electrostatic chuck 4 by an electrostatic attraction manner while adsorbing a plurality of processed workpieces 2 to a plurality of substrate mounting locations 21 of the tray 3. Furthermore, in an actual processing process, a plasma formed in the reaction chamber 1 easily facilitates the temperature of the processed workpiece 2 to be higher than the temperature needed by the process, and thus the temperature of the processed workpiece needs to be controlled. For the traditional temperature control manner, a heat exchange gas (e.g., helium gas or argon gas) blows a back surface (i.e., a lower surface of the processed workpiece 2) of the processed workpiece 2 to regulate the temperature of the processed workpiece 2 by means of the heat exchange gas.

Referring to Figure 2, it shows a top view of the tray of Figure 1. Specifically, each substrate mounting location 21 corresponding to the tray 3 is provided with one middle inlet passage, the middle inlet passage includes one central inlet hole 31 and a plurality of middle inlet holes 32.

Among others, the central inlet hole 31 is arranged at the center of the substrate mounting location 21; and the plurality of middle inlet holes 32 are uniformly arranged at a circumference taking the center of the substrate mounting location 21 as its center and taking one half of the radius of the substrate mounting location 21 as its radius. Referring to Figure 1 again, a gas passage 6 is arranged in the electrostatic chuck 4, a gas outlet end of the gas passage 6 is positioned at the upper surface of the electrostatic chuck 4 and in communication with each middle inlet passage in the tray 3; a gas inlet end of the gas passage 6 is connected with the gas source (not shown in the Figure 1) used for providing the heat exchange gas. During the process that the temperature of the processed workpiece 2 is regulated, the heat exchange gas enters into a gap between the substrate mounting location 21 and a lower surface of the corresponding processed workpiece 2 via the gas passage 6 and the middle inlet passage in the tray 3, to realize the heat exchange between the heat exchange gas and the processed workpiece 2.

In actual implementation, the above plasma processing equipment inevitably has the following problems: as the middle inlet hole 32 is positioned at the circumference taking the center of the substrate mounting location 21 as its center and taking one half of the radius of the substrate mounting location 21 as its radius, the diffusion radius of the heat exchange gas which diffuses from the middle inlet hole 32 to the periphery always cannot reach one half of the radius of the substrate mounting location 21, and thus the heat exchange gas from the middle inlet hole 32 usually cannot reach the peripheral region (e.g., the region extending from the edge of the substrate mounting location 21 to its center by 3mm-5mm) of the processed workpiece 2, thus causing worse heat exchange effect between the heat exchange gas and the peripheral region of the processed workpiece 2, which will cause that the temperature of the peripheral region of the processed workpiece 2 is different from that of the middle region thereof, and hence lead to worse temperature uniformity of the processed workpiece 2, thus lowering the process uniformity of the plasma processing equipment.

SUMMARY OF THE INVENTION

The invention aims at solving one of the technical problems in the prior art, and proposes a substrate carrying device and a plasma processing equipment, which can improve the heat exchange effect of the peripheral region of the processed workpiece, so that the temperature between the peripheral region of the processed workpiece and the middle region thereof can tend to be uniform, thus improving the process uniformity of the plasma processing equipment.

To realize the object of the invention, the invention provides a substrate carrying device for carrying a processed workpiece and regulating the temperature of the processed workpiece by

means of a heat exchange gas, wherein an upper surface of the substrate carrying device is provided with a plurality of substrate mounting locations, and heat-exchange gas inlet passages are arranged in the substrate carrying device corresponding to each substrate mounting location, so as to guide the heat exchange gas to the upper surface of the substrate mounting location. Among others, the heat-exchange gas inlet passages comprise peripheral inlet passages and middle inlet passages, wherein gas inlets of the peripheral inlet passages and the middle inlet passages are all in communication with an external gas source; and gas outlets of the peripheral inlet passages are arranged in the peripheral region of the upper surface of the substrate mounting location; gas outlets of the middle inlet passages are arranged in the middle region of the upper surface of the substrate mounting location.

For each substrate mounting location, a plurality of gas outlets of the peripheral inlet passages and a plurality of gas outlet of the middle inlet passage are arranged as hole-shaped structures, and the plurality of gas outlets of the peripheral inlet passages and the plurality of gas outlets of the middle inlet passages are arranged into at least one ring uniformly along the peripheral direction of the substrate mounting location, respectively.

For each substrate mounting location, its peripheral region and/or its middle region form a groove which is concave from the upper surface of the substrate carrying device, and the gas outlets of the peripheral inlet passages and the gas outlets of the middle inlet passages are positioned at a bottom surface or a side surface of the groove.

The groove extends along the peripheral direction of the substrate mounting location and is closed to be in a ring-shape.

The total area of the gas outlets of the peripheral inlet passages is less than that of the gas outlets of the middle inlet passages.

The diameter of the gas outlet of the peripheral inlet passage is less than that of the gas outlet of the middle inlet passage.

The diameter of the gas outlet of the peripheral inlet passage is one third to two thirds of that of the gas outlets of the middle inlet passage.

The diameter of the gas outlets of the middle inlet passages is 0.6mm-1mm.

The number of the gas outlets of the peripheral inlet passages is equal to that of the gas outlets of the middle inlet passages.

Along the radial direction of the substrate mounting location, the distance between the gas outlets of the peripheral inlet passages at the outermost side and an edge of the substrate mounting location is 2mm-5mm.

The gas outlets of the plurality of middle inlet passages are arranged into one ring, and their positions in the radial direction of the substrate mounting location are at one half of the radius of the

substrate mounting location.

The heat-exchange gas inlet passages also comprise a central inlet passage, a gas inlet of the central inlet passage is in communication with the external gas source, and a gas outlet of the central inlet passage is arranged in the middle place of the upper surface of the substrate mounting location.

On the other hand, the invention also provides a plasma processing equipment comprising a reaction chamber, a gas source, a clamping device positioned in the reaction chamber and a substrate carrying device positioned on the clamping device, wherein the substrate carrying device is used for carrying a processed workpiece and regulating the temperature of the processed workpiece by means of a heat exchange gas provided by the gas source. The substrate carrying device adopts any one of the above mentioned substrate carrying devices, and the heat-exchange gas inlet passages in the substrate carrying device are in communication with the gas source.

A first gas path and a second gas path which are independent with each other are arranged in the clamping device. An outlet end of the first gas path extends to an upper surface of the clamping device and is solely in communication with the middle inlet passages; and an inlet end of the first gas path is in communication with the gas source. The outlet end of the second gas path extends to the upper surface of the clamping device and is solely in communication with the peripheral inlet passages; an inlet end of the second gas path is in communication with the gas source.

The gas source comprises a first gas source and a second gas source, and a first gas path and a second gas path which are independent with each other are arranged in the clamping device. An outlet end of the first gas path extends to an upper surface of the clamping device and is solely in communication with the middle inlet passages; and the inlet end of the first gas path is in communication with the first gas source. The outlet end of the second gas path extends to the upper surface of the clamping device and is solely in communication with the peripheral inlet passages; the inlet end of the second gas path is in communication with the second gas source.

A gas path is arranged in the clamping device, the outlet end of the gas path extends to the upper surface of the clamping device and is in communication with the middle inlet passages and the peripheral inlet passages, respectively; and the inlet end of the gas path is in communication with the gas source, the gas source supplies the heat exchange gas to the middle inlet passages and the peripheral inlet passages via the gas path at the same time.

A pressure flow controller or a mass flow controller is arranged at the upstream of the gas outlets of the peripheral inlet passages and the upstream of the gas outlets of the middle inlet passages.

The pressure flow controller is used for regulating the amount of the heat exchange gas flowing through the middle inlet passages; the mass flow controller is used for regulating the

amount of the heat exchange gas flowing through the peripheral inlet passages.

The invention has the following advantageous effects.

For the substrate carrying device provided by the invention, the gas outlets of the peripheral inlet passages are arranged at the peripheral region of each substrate mounting location, so that the heat exchange gas can be diffused to the peripheral region of the upper surface of the substrate mounting location via the gas outlets of the peripheral inlet passage, and thus the heat exchange effect of the peripheral region of the substrate mounting region can be improved, so that, during the process, the temperature between the peripheral region of the processed workpiece and the middle region thereof can tend to be uniform, thus improving the process uniformity of the plasma processing equipment.

As one preferable technical solution, the total area of the gas outlets of the peripheral inlet passages is less than that of the gas outlets of the middle inlet passages, so that more heat exchange gas is diffused in the middle region with bigger area via the gas outlets of the middle inlet passages while reducing the flow amount of the heat exchange gas flowing through the gas outlets of the peripheral inlet passages, so that the heat exchange gas which is diffused to the outside of the substrate mounting location via the gas outlets of the peripheral inlet passages can be reduced, thus avoiding the adverse effects on process results due to excessive heat-exchange gas leaked in the reaction chamber.

The plasma processing equipment provided by the invention, with the above substrate carrying device provided by the invention, can improve the temperature uniformity of the processed workpiece, thus improving the uniformity of the plasma processing process.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and/or additional aspects and advantages of the invention can become apparent and easily understood from the description of the embodiments with reference to the drawings as below, wherein:

Figure 1 is a structural diagram of existing plasma processing equipment;

Figure 2 is a top view of a tray in Figure 1;

Figure 3 is a sectional view of a substrate carrying device provided by an embodiment of the invention;

Figure 4 is a top view of a first form of a substrate mounting location which can be adopted by a substrate carrying device shown in Figure 3;

Figure 5 is a top view of a second form of a substrate mounting location which can be adopted by a substrate carrying device shown in Figure 3;

Figure 6 is a sectional view of a substrate carrying device provided by another embodiment of the invention;

Figure 7 is a partial top view of one form of a substrate mounting location which can be adopted by a substrate carrying device shown in Figure 6;

Figure 8 is a structural diagram of plasma processing equipment provided by a first embodiment of the invention;

Figure 9A is a structural diagram of a clamping device applied into the plasma processing equipment shown in Figure 8;

Figure 9B is a structural diagram of another clamping device applied into the plasma processing equipment shown in Figure 8;

Figure 10 is a structural diagram of a plasma processing equipment provided by a second embodiment of the invention; and

Figure 11 is a structural diagram of a plasma processing equipment provided by a third embodiment of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The invention substantially provides a substrate carrying device, wherein a plurality of substrate mounting locations are arranged on an upper surface of the substrate carrying device, and heat-exchange gas inlet passages are arranged in the substrate carrying device corresponding to each substrate mounting location, so as to guide the heat exchange gas to the upper surface of the substrate mounting location; the heat-exchange gas inlet passage includes peripheral inlet passages and middle inlet passages, gas inlets of the peripheral inlet passages and the middle inlet passages are all in communication with an external gas source, gas outlets of the peripheral inlet passages are arranged in the peripheral region of the upper surface of the substrate mounting location, and the gas outlets of the middle inlet passages are arranged at the middle region of the upper surface of the substrate mounting location, to regulate the temperature of a borne processed workpiece by means of the heat exchange gas during the process.

To enable those skilled in the art to better understand the technical solution of the invention, the substrate carrying device and plasma processing equipment provided by embodiments of the invention are described in details with reference to the accompanying figures.

Figure 3 is a sectional view of the substrate carrying device provided by an embodiment of the invention. Figure 4 is a top view of a first form of the substrate mounting location which can be adopted by the substrate carrying device shown in Figure 3. Referring to Figure 3 and Figure 4, the substrate carrying device 20 is used for carrying the processed workpiece 21 and regulating the

temperature of the processed workpiece 21 by means of a heat exchange gas. The substrate carrying device 20 includes a plurality of substrate mounting locations 201; during the process, the processed workpiece 21 is arranged on the substrate mounting location 201 accordingly; and in the embodiment, each substrate mounting location 201 is arranged as the shape of a groove, and the processed workpiece 21 is arranged in the groove. With the groove, the position where the processed workpiece 21 is on the substrate carrying device 20 can be defined, so that the displacement of the processed workpiece 21 with respect to the substrate carrying device 20 can be avoided. It's necessary to note that in actual implementation, the substrate mounting location 201 is not limited to be arranged as the shape of the groove but can be arranged as the shape of a convex plate, wherein the processed workpiece 21 is borne by the convex plate to define the position of the processed workpiece 21 on the substrate carrying device 20. It can be understood that the substrate mounting location 201 is arranged as the shape of the groove to better facilitate the defining of the position of the processed workpiece 21.

Furthermore, corresponding to each substrate mounting location 201, the heat-exchange gas inlet passages are arranged in the substrate carrying device 20, and the heat exchange gas (e.g., helium gas or argon gas and so on) flows into a gap between the upper surface of each substrate mounting location 201 and a lower surface of the processed workpiece 21 corresponding to it, thereby realizing the heat exchange between the heat exchange gas and the processed workpiece 21 to regulate the temperature of the processed workpiece 21. Specifically, the heat-exchange gas inlet passages include a central inlet passage, a middle inlet passage and an peripheral inlet passage, wherein the gas inlets of the central inlet passage, the peripheral inlet passage and the middle inlet passage are all in communication with an external heat-exchange gas source, the gas outlet of the central inlet passage is arranged at the central position of the upper surface of the substrate mounting location 201; the gas outlets of the peripheral inlet passages are arranged in the region close to the edge of the upper surface of the substrate mounting location 201 (hereinafter referred to as the peripheral region of the upper surface of the substrate mounting location); and the gas outlet of the middle inlet passage is arranged in the middle region between the center position and the peripheral region of the upper surface of the substrate mounting location 201 (hereinafter referred to as the middle region of the upper surface of the substrate mounting location).

The gas outlet of the central inlet passages and the gas outlets of the middle inlet passages are all arranged as hole-shaped structures, as shown as a central inlet hole 23 and middle inlet holes 24 in Figure 3 and Figure 4, respectively. Among others, there is one central inlet hole 23, and its center and the center of the substrate mounting location 201 are coincided, the heat exchange gas is diffused in the central region 231 of the substrate mounting location 201 via the central inlet hole 23, wherein the so-called central region 231 is the region where the heart exchange gas can be diffused

around via the central inlet hole 23. There are a plurality of middle inlet holes 24, the plurality of middle inlet holes 24 are arranged into one ring uniformly along the circumference of the substrate mounting location 201, there is a certain distance between the adjacent middle inlet holes 24, and the diameter of each middle inlet hole may be 0.6mm-1mm. The heat exchange gas is diffused in the middle region 241 via the middle inlet hole 24. In the embodiment, the diameter of the substrate mounting location 201 is 2 cuns （a Chinese unit of length, 1 cun≈3.33cm） to correspond to the processed workpiece 21 with the diameter of 2 cuns, there can be 6-10 middle inlet holes 24, these middle inlet holes 24 are arranged into one ring along the circumferential direction of the substrate mounting location 201, and the distance between the center of the middle inlet hole 24 and the center of the substrate mounting location 201 is about one half of the radius of the substrate mounting location 201; that is to say, the center of each middle inlet hole 24 is arranged on a circumference taking the center of the substrate mounting location 201 as its center and taking one half of the radius of the substrate mounting location 201 as its radius (e.g., about 30mm).

In addition, the diameter of the central inlet hole 23 can be equal to or different from the diameter of the middle inlet hole 24, and furthermore, if the heat exchange gas from the middle inlet hole 24 can be diffused to the center region 231, the central inlet hole 23 can be omitted.

The peripheral inlet passages are arranged at the peripheral region of the upper surface of the substrate mounting location 201, so that the heat exchange gas can be diffused to the peripheral region via the peripheral inlet passages, thereby improving the heat exchange effect of the processed workpiece 21 at the peripheral region of the substrate mounting location 201 during the process, facilitating the temperature of the peripheral region of the processed workpiece 21 and the middle region thereof to tend to be uniform, and further improving the uniformity of a plasma processing process.

In the embodiment, the gas outlets of the peripheral inlet passages are arranged as the hole-shaped structures, as shown as the peripheral inlet hole 25 in Figure 3 and Figure 4. There are a plurality of peripheral inlet holes 25, these peripheral inlet holes 25 are arranged into one ring uniformly along the circumferential direction of the substrate mounting location 201, and there is a certain distance between the adjacent peripheral inlet holes 25. In the radial direction of the substrate mounting location 201, the distance D between the gas outlet of the peripheral inlet passage and the edge of the substrate mounting location 201 is 2mm-5mm; that is to say, the distance D between the center of each peripheral inlet hole 25 and the edge of the substrate mounting location 201 is 2mm-5mm. The heat exchange gas is diffused in the peripheral region 251 via the peripheral inlet hole 25. In addition, when the diameter of the processed workpiece 21 is 2 cuns, the radius of the circumference on which a plurality of peripheral inlet holes 25 are positioned may be 40mm-48mm, there can be 12-16 peripheral inlet holes 25.

Preferably, the total area of the gas outlets of the peripheral inlet passages is less than that of the gas outlets of the middle inlet passages, so that more heat exchange gas is diffused in the middle region with bigger area via the gas outlets of the middle inlet passages while reducing the flow amount of the heat exchange gas flowing through the gas outlets of the peripheral inlet passages, so that the heat exchange gas which is diffused to the outside of the substrate mounting location 201 via the gas outlets of the peripheral inlet passages can be reduced, thus avoiding the adverse effects on process results due to too much amount of the heat exchange gas leaked in the reaction chamber. For example, when the number of the peripheral inlet holes 25 is equal to that of the middle inlet holes 24, the diameter of the peripheral inlet holes 25 can be less than that of the middle inlet holes 24, to reduce the flow amount of the heat exchange gas flowing through the peripheral inlet holes 25 and to further control the leakage amount of the heat exchange gas leaked to the outside of the substrate mounting location 201 to be within a reasonable scope. Preferably, the diameter of the peripheral inlet holes 25 is made to be one third to two thirds of the diameter of the middle inlet holes 24; and more preferably, the diameter of the middle inlet holes 24 is 0.6mm-1mm.

Referring to Figure 5, it is a top view of a second form of a substrate mounting location which can be adopted by a substrate carrying device shown in Figure 3. In the embodiment, the diameter of the processed workpiece 21 borne by the substrate mounting location 201 is 4 cuns, the number of the middle inlet holes 24 on the substrate mounting location 201 is more than that shown in the embodiment shown in Figure 4, a plurality of middle inlet holes 24 can be arranged on two circumferences taking the center of the substrate mounting location 201 as their centers and having different radiuses; and furthermore, the number of the middle inlet holes 24 arranged on the same circumference and the distance between the two circumferences can be determined according to the diameter of the middle inlet holes 24 and the diffusing radius of the heat exchange gas diffusing around via the middle inlet holes 24.

It can be easily understood that with the increase of the size of the processed workpiece 21 (for example, its diameter is 4 cuns, 6 cuns or more), the number of the middle inlet holes 24 on the substrate mounting location 201 can be increased, these middle inlet holes 24 can also be arranged into two rings or more than two rings along the circumferential direction of the substrate mounting location 201; and the distances between the centers of the middle inlet holes 24 in different rings and the centers of the substrate mounting location 201 are different, so as to diffuse the heat exchange gas to each position of the upper surface of the substrate mounting location 201 more rapidly and uniformly. Similarly, with the increase of the size of the processed workpiece 21, the number of the peripheral inlet holes 25 is also increased correspondingly, and the peripheral inlet holes 25 can also be arranged into two rings or more than two rings along the circumferential direction of the substrate mounting location 201; for example, when the diameter of the processed

workpiece 21 is 4 cuns, there can be 20-24 peripheral inlet holes 25.

It shall be pointed out that although the gas outlets of the peripheral inlet passages and the gas outlets of the middle inlet passages are all arranged as a plurality of hole-shaped structures in the above embodiments, and the plurality of hole-shaped structures are arranged into at least one ring uniformly along the circumferential direction of the substrate mounting location, the invention is not limited to this, and in actual implementation, the gas outlets of the peripheral inlet passages and/or the middle inlet passages can also be arranged as follows: that is to say, for each substrate mounting location, its peripheral region and/or its middle region form a groove of the gas outlet which is concave from the upper surface of the substrate carrying device, the gas outlets of the peripheral inlet passages and the gas outlets of the middle inlet passages are positioned at a bottom surface of the corresponding gas outlet groove, to guide the heat exchange gas into the gas groove to carry out the heat exchange with the processed workpiece borne by the substrate mounting location, as shown in Figure 6 and Figure 7.

Referring to Figure 6 and Figure 7, Figure 6 is a sectional view of a substrate carrying device provided by another embodiment of the invention, and Figure 7 is a partial top view of one form of a substrate mounting location which can be adopted by a substrate carrying device shown in Figure 6. The structures and functions of the substrate carrying device and the substrate mounting location shown in this embodiment are similar to those in the embodiments shown in the above Figure 3 and Figure 4, the difference of these two embodiments only lies in the followings: in this embodiment, for each substrate mounting location, its peripheral region 251 forms a groove 252 of the gas outlets of the peripheral inlet passages which is concave from the upper surface of the substrate carrying device, outlet holes 25 of the peripheral inlet passages are positioned at the bottom surface of the groove 252 of the gas outlets of the peripheral inlet passages, to guide the heat exchange gas into the groove 252 of the gas outlets; furthermore, the middle region 241 of the substrate mounting location 201 is provided with a groove 242 of the gas outlets of the middle inlet passages which is concave from the upper surface of the substrate carrying device, outlet holes 24 of the middle inlet passages are positioned at the bottom surface of the groove 242 of the gas outlets of the middle inlet passages, to guide the heat exchange gas into the groove 242 of the gas outlets.

Hence, the heat exchange gas into the groove 252 of the gas outlets of the peripheral inlet passages and the heat exchange gas into the groove 242 of the gas outlets of the middle inlet passages can flow along the circumferential direction of the substrate mounting location 201, so that the heat exchange gas is diffused in the grooves 242 and 252 of the gas outlets more uniformly, so that during the process, the temperature of the processed workpiece 21 corresponding to the regions of the grooves 242 and 252 of the gas outlets tends to be uniform, thus further improving the uniformity of the plasma processing process. Furthermore, as the heat exchange gas can flow in the

grooves 242 and 252 of the gas outlets and be diffused uniformly, the number of the outlet holes 25 of the peripheral inlet passages/the outlet holes 24 of the middle inlet passages in the substrate carrying equipment is not limited; for example, only one outlet hole 25 of the peripheral inlet passage/only one outlet hole 24 of the middle inlet passage can facilitate the heat exchange gas to be uniformly diffused in the groove 242 of the gas outlet/the groove 252 of the gas outlet; furthermore, when the number of the outlet holes 25 of the peripheral inlet passages/the number of the outlet holes 24 of the middle inlet passages is relatively less, the inner structure of the substrate carrying device can be more simple.

It can be understood that although the groove of the gas outlet in this embodiment is arranged to extend along the circumferential direction of the substrate mounting location and is closed in a ring shape; in the actual application, the groove of the gas outlet can also be arranged in other shapes, might not extend along the circumferential direction of the substrate mounting location and might not be closed in a ring shape; therefore, the heat exchange gas can enter into the groove of the gas outlet via the outlet hole at its bottom surface and is evenly diffused therein, while the uniformity of the heat exchange gas can be optimized. In addition, the arrangement positions of the outlet holes 24/25 arranged in the groove 242/252 of the gas outlet can also be at a side wall of the groove 242/252 of the gas outlet.

It can be further understood that the laying out rules and position relation of the groove of the gas outlets of the peripheral inlet passages and the groove of the gas outlets of the middle inlet passages in the radial direction of the substrate mounting location, and the arranging rules of the gas outlets of the peripheral inlet passages and the gas outlets of the middle inlet passages are all similar with the description of the embodiments shown in the above Figure 3 –Figure 5, and thus they will not be repeated any more here. Additionally, it can be understood that the upper surface of the substrate mounting location described in the invention includes the surface of the substrate mounting location carrying the processed workpiece, the bottom surface or side surface of the groove of the gas outlets of the peripheral inlet passages, and the bottom surface or side surface of the groove of the gas outlets of the middle inlet passages.

As another technical solution, the invention also provides a plasma processing equipment. Referring to Figure 8, it is a structural diagram of plasma processing equipment provided by the first embodiment of the invention, wherein the substrate carrying device is a tray. As shown in Figure 8, the plasma processing equipment includes the reaction chamber 100, the gas source 28, a clamping device 26 positioned in the reaction chamber 100 and the tray 20 positioned on the clamping device 26. The tray 20 is used for carrying the processed workpiece 21 and for regulating the temperature of the processed workpiece 21 by means of the heat exchange gas provided by the gas source 28; additionally, the tray 20 can improve the uniformity of the temperature of the

processed workpiece 21 during the process, by adopting the structure form of the substrate carrying device provided by the previous embodiments of the invention, thereby improving the uniformity of the process results.

In this embodiment, a first gas path 41 and a second gas path 42 which are independent with each other is arranged in the clamping device 26 (as Figure 8 is a sectional view, the projections of the first gas path 41 and the second gas path 42 which are not in communication with each other actually are overlapped), wherein an outlet end of the first gas path 41 extends to an upper surface of the clamping device 26 and is solely in communication with the middle inlet passages of the tray 20; an inlet end of the first gas path 41 is in communication with the gas source 28; an outlet end of the second gas path 42 extends to the upper surface of the clamping device 26 and is solely in communication with the peripheral inlet passages of the tray 20; an inlet end of the second gas path 42 is in communication with the gas source 28; and the gas source 28 supplies the heat exchange gas to the middle inlet passages and the peripheral inlet passages of the tray 20 via the first gas path 41 and the second gas path 42 at the same time.

In this embodiment, the plasma processing equipment furtther includes a pressure flow controller 43 and a mass flow controller 44. The pressure flow controller 43 is used for regulating the flow amount of the heat exchange gas flowing through the middle inlet passage of the tray 20, to ensure the gas pressure between the upper surface of the substrate mounting location 201 and the lower surface of the processed workpiece 21 corresponding to it to be fixed at a predetermined gas pressure value; the predetermined gas pressure value is the allowable maximum value of the gas pressure between the substrate mounting location 201 and the lower surface of the corresponding processed workpiece 21 when a leakage amount of the heat exchange gas (i.e., the leakage amount of the heat exchange gas which is in the gas between the substrate mounting location 201 and the lower surface of the corresponding processed workpiece 21 and is leaked to the reaction chamber 100) does not exceed its safety threshold value. The so-called safety threshold value is the maximum leakage amount of the heat exchange gas which is allowed to be leaked into the reaction chamber 100 under the premise that the process results are not influenced. For example, the pressure flow controller 43 controls the flow amount of the helium gas in the middle inlet passages of the tray 20, so that the gas pressure between the substrate mounting location 201 and the lower surface of the corresponding processed workpiece 21 meets the requirement that the leakage amount of the helium gas is less than 8sccm under the conditions of the helium gas pressure of 8 torrs.

The mass flow controller 44 is used for regulating the amount of the heat exchange gas flowing through the peripheral inlet passages of the tray 20, and an edge of the processed workpiece 21 can be facilitated to be continuously filled with the heat exchange gas (e.g., the helium gas), to

ensure that the heat exchange gas which enters into a gap between the substrate mounting location 201 and the lower surface of the corresponding processed workpiece 21 via the peripheral inlet passages of the tray 20 can carry out the heat exchange with the peripheral region of the processed workpiece 21 under the premise that its leakage amount is not exceed the safety threshold value so that the heat exchange effect of the peripheral region of the processed workpiece 21 can be improved, thus further effectively controlling the temperature of the edge of the processed workpiece 21.

In this embodiment, the clamping device 26 and the tray 20 as well as the tray 20 and the processed workpiece 21 are both fixed together therebetween by an electrostatic attraction manner. Specifically, referring to Figure 9A, it is a structural diagram of the clamping device applied for the plasma processing equipment shown in Figure 8. The clamping device 26 includes the electrostatic chuck and a DC power supply, wherein the electrostatic chuck includes a chuck body, the chuck body is made of a conductive material, the surface of which is wrapped with an insulating material, the conductive material is taken as an electrode of the chuck body and connected to the ground; the tray 20 is made of the conductive material, the surface of which is wrapped with the insulating material, to ensure that the tray 20 is not etched by the plasma in the reaction chamber 100; the conductive material is taken as the electrode of the tray and is electrically connected with the DC power supply, the electrostatic adsorption force is generated between the tray 20 and the chuck body as well as between the tray 20 and the processed workpiece 21 after they are powered on; that is to say, the electrostatic adsorption force is generated between the tray 20 and the chuck body and the electrostatic adsorption force is generated between the tray 20 and the processed workpiece 21, so that the tray 20 adsorbs the processed workpiece 21 to its substrate mounting location 201 while the chuck body can adsorb the tray 20 to its upper surface.

In the actual application, the chuck body can also be made of the insulating material in which the chuck electrode is embedded; similarly, the tray 20 can also be made of the insulating material in which the tray electrode is embedded.

It needs to be noted that although the clamping device 26 and the tray 20 as well as the tray 20 and the processed workpiece 21 are both fixed together by the electrostatic attraction manner in this embodiment, the invention is not limited to this; in the actual application, only the tray 20 and the processed workpiece 21 can be fixed together by the electrostatic attraction manner while the clamping device 26 and the tray 20 are fixed together by a mechanical fixture manner, for example, as shown in Figure 9B. Referring to Figure 9B, it is a structural diagram of another clamping device applied for the plasma processing equipment shown in Figure 8. The clamping device includes a mechanical chuck and the DC power supply, wherein the mechanical chuck fixes the tray 20 to its upper surface by the mechanical fixture manner; for example, the mechanical chuck can include a

base for carrying the processed workpice 21 and a tooling such as a mechanical clamp, a compression ring and so on for fixing the processed workpiece 21 to the base; the tray 20 is made of the conductive material the surface of which is wrapped with the insulating material, the conductive material is taken as the electrode of the tray and is electrically connected with the DC power supply; the electrostatic attraction is generated between the tray 20 and the processed workpiece 21 after they are powered on, so that the processed workpiece 21 is fixed to the substrate mounting location 201 of the tray 20. It is easily understood that the tray 20 can also be made of the insulating material in which the tray electrode is embedded.

Additionally, in the actual application, the tray 20 and the processed workpiece 21 can also be fixed together by the mechanical fixture manner or the like; in fact, the fixture manner of the tray 20 is not needed to be limited as long as the tray 20 can fix the processed workpiece 21 to its upper surface.

Referring to Figure 10, it is a structural diagram of the plasma processing equipment provided by the second embodiment of the invention. Compared with the first embodiment, the plasma processing equipment provided by this embodiment also includes a reaction chamber 100, a gas source 28, a clamping device 26 positioned in the reaction chamber 100, a tray 20 positioned on the clamping device 26, a pressure flow controller 43 and a mass flow controller 44. As the functions and connection relation of the above devices or apparatuses have been described in the first embodiment, they will not be repeated any more here. Only the differences between this embodiment and the first embodiment are described in details in the following.

Specifically, in this embodiment, the gas source further includes a first gas source 45 and a second gas source 46; and the first gas path 41 and the second gas path 42 which are independent with each other are also arranged in the clamping device 26, the outlet end of the first gas path 41 extends to the upper surface of the clamping device 26 and is solely in communication with the middle inlet passages of the tray 20; the inlet end of the first gas path 41 is in communication with the first gas source 45; the outlet end of the second gas path 42 extends to the upper surface of the clamping device 26 and is solely in communication with the peripheral inlet passages of the tray 20; the inlet end of the second gas path 42 is in communication with the second gas source 46; during the process, the first gas source 45 supplies solely the heat exchange gas to the middle inlet passages of the tray 20 via the first gas path 41; and the second gas source 46 supplies solely the heat exchange gas to the peripheral inlet passages of the tray 20 via the second gas path 42.

Referring to Figure 11, it is a structural diagram of the plasma processing equipment provided by the third embodiment of the invention. Compared with the second embodiment, the plasma processing equipment provided by the third embodiment also includes a reaction chamber 100, a gas source 28, a clamping device 26 positioned in the reaction chamber 100 and a tray 20

positioned on the clamping device 26. As the functions and connection relation of the above devices or the apparatuses have been described in the first and the second embodiments, they will not be repeated any more here. Only the differences between this embodiment and the first and the second embodiments are described in details in the followings.

Specifically, in this embodiment, the gas path 27 is arranged in the clamping device 26, the outlet end of the gas path 27 extends to the upper surface of the clamping device 26 and is in communication with the middle inlet passages and the peripheral inlet passages of the tray 20, respectively; the inlet end of the gas path 27 is in communication with the gas source 28; and the gas source 28 supplies the heat exchange gas to the middle inlet passages and the peripheral inlet passages of the tray 20 via the gas path 27 at the same time.

It shall be noted that in the actual application, a pressure flow controller or a mass flow controller can also be arranged on one of the gas source and the gas path of the plasma processing equipment in this embodiment, to regulate the flow amount of the heat exchange gas flowing through the middle inlet passages and the peripheral inlet passages as a whole; that is to say, to regulate the flow amount of the heat exchange gas flowing through the middle inlet passages and the peripheral inlet passages at the same time.

It shall be further pointed out that, to control the flow amount of the heat exchange gas flowing through the middle inlet passages and the peripheral inlet passages, the pressure flow controller or the mass flow controller can be arranged at any position of the upstream of the gas outlets of the peripheral inlet passages and the upstream of the gas outlets of the middle inlet passages. The so-called upstream of the gas outlets of the peripheral inlet passages and the so-called upstream of the gas outlets of the middle inlet passages respectively indicate any position between the gas source and the gas outlets of the peripheral inlet passages as well as between the gas source and the gas outlets of the middle inlet passages.

It can be understood that the above embodiments are only illustrative embodiments adopted to explain the principles of the present invention while the present invention is not limited to this. For those skilled in the art, various variations and improvements can be made without departing from the spirit and essence of the invention and these variations and improvements are considered to be within the protection scope of the invention.

CLAIMS

What is claimed is:

1. A substrate carrying device for carrying a processed workpiece and regulating the temperature of the processed workpiece by means of a heat exchange gas, wherein an upper surface of the substrate carrying device is provided with a plurality of substrate mounting locations, and a heat-exchange gas inlet passage is arranged in the substrate carrying device corresponding to each substrate mounting location so as to guide the heat exchange gas to an upper surface of the substrate mounting location, the substrate carrying device being characterized in that: the heat-exchange gas inlet passage comprises a peripheral inlet passage and a middle inlet passage, gas inlets of the peripheral inlet passage and the middle inlet passage are all in communication with an external gas source,

a gas outlet of the peripheral inlet passage is arranged in a peripheral region of the upper surface of the substrate mounting location, and a gas outlet of the middle inlet passage is arranged in the middle region of the upper surface of the substrate mounting location.

2. The substrate carrying device according to claim 1, characterized in that, for each substrate mounting location, a plurality of gas outlets of the peripheral inlet passages and a plurality of gas outlet of the middle inlet passages are arranged as hole-shaped structures, and the plurality of gas outlets of the peripheral inlet passages and the plurality of gas outlets of the middle inlet passages are arranged into at least one ring uniformly along the peripheral directions of the substrate mounting locations, respectively.

3. The substrate carrying device according to claim 1 or 2, characterized in that, for each substrate mounting location, its peripheral region and/or its middle region is formed with a groove which is concave from the upper surface of the substrate carrying device, and the gas outlets of the peripheral inlet passages and the gas outlets of the middle inlet passages are positioned on a bottom surface or a side surface of the groove.

4. The substrate carrying device according to claim 3, characterized in that, the groove extends along the peripheral direction of the substrate mounting location and is closed in a ring shape.

5. The substrate carrying device according to claim 1, characterized in that, the total area of the gas outlets of the peripheral inlet passages is less than that of the gas outlets of the middle inlet passages.

6. The substrate carrying device according to claim 1, characterized in that, the diameter of the gas outlet of the peripheral inlet passage is less than that of the gas outlet of the middle inlet

passage.

7. The substrate carrying device according to claim 6, characterized in that, the diameter of the gas outlet of the peripheral inlet passage is one third to two thirds of that of the gas outlet of the middle inlet passage.

8. The substrate carrying device according to claim 7, characterized in that, the diameter of the gas outlet of the middle inlet passage is 0.6mm-1mm.

9. The substrate carrying device according to any one of claims 6-8, characterized in that, the number of the gas outlets of the peripheral inlet passages is equal to that of the gas outlets of the middle inlet passages.

10. The substrate carrying device according to claim 1, characterized in that, along the radial direction of the substrate mounting location, the distance between the gas outlet of the peripheral inlet passage at the outermost side and an edge of the substrate mounting location is 2mm-5mm.

11. The substrate carrying device according to claim 2, characterized in that, the plurality of gas outlets of the middle inlet passages are arranged into one ring, and their positions in the radial direction of the substrate mounting location are at one half of the radius of the substrate mounting location.

12. The substrate carrying device according to claim 1, characterized in that, the heat-exchange gas inlet passage also comprise a central inlet passage, wherein a gas inlet of the central inlet passage is in communication with the external gas source, and a gas outlet of the central inlet passage is arranged in the middle of the upper surface of the substrate mounting location.

13. A plasma processing equipment comprising a reaction chamber, a gas source, a clamping device positioned in the reaction chamber, and a substrate carrying device positioned on the clamping device, wherein the substrate carrying device is configured to carry a processed workpiece and regulate the temperature of the processed workpiece by means of a heat exchange gas provided by the gas source, the plasma processing equipment being characterized in that, the substrate carrying device adopts the substrate carrying device according to any one of claims 1-12, and the heat-exchange gas inlet passage in the substrate carrying device is in communication with the gas source.

14. The plasma processing equipment according to claim 13, characterized in that, a first gas path and a second gas path which are independent with respect to each other are arranged in the clamping device, wherein

an outlet end of the first gas path extends to an upper surface of the clamping device and is solely in communication with the middle inlet passages; an inlet end of the first gas path is in communication with the gas source,

an outlet end of the second gas path extends to the upper surface of the clamping device and is solely in communication with the peripheral inlet passages, and an inlet end of the second gas path is in communication with the gas source.

15. The plasma processing equipment according to claim 13, characterized in that, the gas source comprises a first gas source and a second gas source, and a first gas path and a second gas path which are independent with respect to each other are arranged in the clamping device, wherein

an outlet end of the first gas path extends to an upper surface of the clamping device and is solely in communication with the middle inlet passages, an inlet end of the first gas path is in communication with the first gas source; and

an outlet end of the second gas path extends to the upper surface of the clamping device and is solely in communication with the peripheral inlet passages, and an inlet end of the second gas path is in communication with the second gas source.

16. The plasma processing equipment according to claim 13, characterized in that, gas paths are arranged in the clamping device, an outlet end of the gas path extends to the upper surface of the clamping device and are in communication with the middle and peripheral inlet passages, respectively; the inlet ends of the gas paths are in communication with the gas source, and the gas source supplies the heat exchange gas to the middle and peripheral inlet passages via the gas paths at the same time.

17. The plasma processing equipment according to any one of claims 13-16, characterized in that, a pressure flow controller or a mass flow controller is arranged at the upstream of the gas outlet of the peripheral inlet passage and the upstream of the gas outlet of the middle inlet passage.

18. The plasma processing equipment according to claim 17, characterized in that, the pressure flow controller is configured to regulate the amount of the heat-exchange gas flowing through the middle inlet passages; and

the mass flow controller is configured to regulate the amount of the heat-exchange gas flowing through the peripheral inlet passages.