BEARING APPARATUS AND SEMICONDUCTOR PROCESSING DEVICE

FIELD OF THE INVENTION

The present invention relates to the field of semiconductor device manufacture, and specifically relates to a bearing apparatus and a semiconductor processing device.

BACKGROUND

During processes of fabricating an integrated circuit (IC) and a microelectromechanical system (MEMS), especially during processes for performing plasma etching, physical vapor deposition (PVD), chemical vapor deposition (CVD) and the like, a bearing apparatus is generally used to bear and heat a to-be-processed workpiece such as a wafer or the like, and also provide a direct current (DC) bias voltage to the to-be-processed workpiece and control temperature at a surface of the to-be-processed workpiece.

Fig. 1 is a schematic structural diagram of a typical bearing apparatus bearing a wafer. As illustrated in Fig. 1, the bearing apparatus includes an electrostatic chuck 11, an edge assembly, and a mounting fastener 16. The electrostatic chuck 11 fixes a wafer 12 onto an upper surface thereof by way of electrostatic adsorption, and a temperature control means is provided in the electrostatic chuck 11 to control the temperature of the wafer 12. The edge assembly is provided around an outer circumferential wall of the electrostatic chuck 11 and includes a focusing ring 13, a base ring 14 and an insulation ring 15 sequentially stacked from up to down, wherein the insulation ring 15 is fastened on the mounting fastener 16 to support the electrostatic chuck 11 and is made of an insulation material to electrically insulate the electrostatic chuck 11 from the mounting fastener 16; the focusing ring 13 is used for confining plasma within a circular area encircled by the focusing ring 13; and the base ring 14 is used for supporting the focusing ring 13 and protecting the outer circumferential wall of the electrostatic chuck 11 from being etched by the plasma.

In practical applications, however, the following problems inevitably exist in the above-described bearing apparatus.

After entering an era of 32-22 nanotechnology, high-k gate dielectric and metal-oxide-semiconductor (MOS) device having a metal gate electrode are brought into processes for fabricating ICs, and uniformity (3σ) in lengths of gate electrodes of transistors among wafers is reduced from 3 nm for the 45-nm node to 1.56 nm for the 32-nm node, which means that requirements for the process uniformity are significantly increased. However, a central temperature control unit is provided in a central area inside the electrostatic chuck 11 with a certain distance away from an edge of the electrostatic chuck, and, due to the fact that the wafer 12 has a diameter larger than that of the upper surface of the electrostatic chuck, the edge of the wafer 12 will go beyond the edge of the electrostatic chuck 11 when the wafer 12 and electrostatic chuck 11 are coaxially provided, resulting in that the temperature control means has difficulty in controlling the temperature at the edge of the wafer, which causes a temperature difference between the edge area and the central area of the wafer. Thus, it can be found that, as for some processes (e.g., processes of 32-22 nanotechnology), requirements for the temperature uniformity of the edge area and the central area of a wafer cannot be satisfied by simply relying on the electrostatic chuck to control the temperature of the wafer.

SUMMARY

The present invention is intended to solve at least one of technical problems in the prior art, and provides a bearing apparatus and a semiconductor processing device, which can adjust temperature of an edge area of a to-be-processed workpiece, so that temperature difference between an edge area and a central area of a wafer can be compensated and thus the process uniformity can be improved.

To achieve an object of the present invention, there is provided a bearing apparatus including an electrostatic chuck, a central temperature control unit and an edge assembly, wherein the central temperature control unit is provided in the electrostatic chuck and configured to adjust temperature of a central area of a to-be-processed workpiece supported by the electrostatic chuck, and the edge assembly is provided around an outer circumferential wall of the electrostatic chuck

and includes a focusing ring, a base ring and an insulation ring sequentially stacked from up to down. The bearing apparatus further includes an edge temperature control unit, which is provided in the edge assembly and configured to adjust temperature of an edge area of the to-be-processed workpiece by way of heat exchange.

Preferably, the edge temperature control unit includes at least one heat exchange channel provided in the edge assembly and around the electrostatic chuck in a circumferential direction of the electrostatic chuck, the at least one heat exchange channel being configured to accommodate a flowable heat exchange medium therein.

Preferably, the edge temperature control unit includes one heat exchange channel, which is provided in the base ring or the focusing ring, and has an inlet and an outlet both connected with a medium source for providing the heat exchange medium; or, the edge temperature control unit includes two heat exchange channels connected with each other, wherein the two heat exchange channels are provided in the base ring and the focusing ring, respectively, and the heat exchange channel provided in the base ring has an inlet and an outlet connected with the medium source for providing the heat exchange medium; and

the edge assembly further comprises two guiding channels, one of which is connected between the inlet of the heat exchange channel and an output tube of the medium source to allow them to communicate with each other, and the other of which is connected between the outlet of the heat exchange channel and an input tube of the medium source to allow them to communicate with each other.

Preferably, in a case where the base ring is provided with the heat exchange channel therein, two columnar extension parts are formed, on a lower surface of the base ring, correspondingly to the inlet and the outlet of the heat exchange channel, each columnar extension part penetrates the insulation ring in a thickness direction of the insulation ring, and the guiding channels are configured as channels penetrating respective columnar extension parts along axes of the columnar extension parts and connected with the heat exchange channel.

Preferably, a temperature sensing through hole penetrating the insulation ring in the thickness direction of the insulation ring is provided in the insulation ring, and

the bearing apparatus further includes an edge temperature detection unit, which is configured to detect temperature of the base ring, which is to be used as the temperature of the edge area of the to-be-processed workpiece, through the temperature sensing through hole.

Preferably, in a case where the edge temperature control unit includes one heat exchange channel provided in the focusing ring, two columnar extension parts are formed, on a lower surface of the focusing ring, correspondingly to the inlet and the outlet of the heat exchange channel, each columnar extension part penetrates the base ring and the insulation ring in a thickness direction of the base ring, and the guiding channels are configured as channels penetrating respective columnar extension parts along axes of the columnar extension parts and connected with the heat exchange channel.

Preferably, a first temperature sensing through hole penetrating the base ring in the thickness direction of the base ring is provided in the base ring, a second temperature sensing through hole penetrating the insulation ring in a thickness direction of the insulation ring is provided in the insulation ring, and the first and second temperature sensing through holes are coaxially provided; and

the bearing apparatus further includes an edge temperature detection unit, which is configured to detect temperature of the focusing ring, which is to be used as the temperature of the edge area of the to-be-processed workpiece, through the first and second temperature sensing through holes.

Preferably, in a case where the base ring is provided with the heat exchange channel therein, the base ring consists of an upper ring body and a lower ring body butted against each other; and/or, in a case where the focusing ring is provided with the heat exchange channel therein, the focusing ring consists of an upper ring body and a lower ring body butted against each other;

an annular groove is formed on a lower surface of the upper ring body, and the annular groove is closed by an upper surface of the lower ring body to form into a closed channel serving as the heat exchange channel when the upper ring body and the lower ring body are butted against each other; or,

an annular groove is formed on the upper surface of the lower ring body, and the annular groove is closed by the lower surface of the upper ring body to form into a closed channel serving as the heat exchange channel when the upper ring body and the lower ring body are butted against each other; or,

each of two annular grooves is formed on corresponding one of the lower surface of the upper ring body and the upper surface of the lower ring body, and the two annular grooves jointly form a closed channel serving as the heat exchange channel when the upper ring body and the lower ring body are butted against each other.

Preferably, the heat exchange channel is obtained by performing a primary sintering separately on the upper ring body and the lower ring body, then performing a secondary sintering on the upper and lower ring bodies together, and butting the upper ring body against the lower ring body; or

the heat exchange channel is obtained by performing one sintering on the upper and lower ring bodies and butting the upper ring body against the lower ring body.

Preferably, the bearing apparatus further includes a central temperature detection unit and a control unit, wherein

the central temperature detection unit is configured to detect temperature of the electrostatic chuck, which is to be used as the temperature of the central area of the to-be-processed workpiece, and send the detected temperature to the control unit; and

the control unit is configured to receive the temperature of the edge area of the to-be-processed workpiece sent from the edge temperature detection unit and the temperature of the central area of the to-be-processed workpiece sent from the central temperature detection unit, and calculate a temperature difference between the edge area and the central area and send a control signal to the central temperature control unit and/or the edge temperature control unit according to the temperature difference, and the central temperature control unit and/or the edge temperature control unit compensates the temperature of the edge area and/or the temperature of the central area according to the control signal.

Preferably, the edge temperature detection unit includes a contact type temperature sensor or a non-contact type temperature sensor.

Preferably, a radial distance between an inner sidewall of the heat exchange channel and the outer circumferential wall of the electrostatic chuck is less than or equal to than 3 mm.

Preferably, the inlet and the outlet of the heat exchange channel are symmetrically arranged in a radial direction of the heat exchange channel.

As another technical solution, the present invention further provides a semiconductor processing device including a reaction chamber and a bearing apparatus provided in the reaction chamber, wherein the bearing apparatus is used for bearing a to-be-processed workpiece and adjusting the temperature of the to-be-processed workpiece, and is the above bearing apparatus provided in the present invention.

The present invention has beneficial effects as follows.

In the bearing apparatus provided by the present invention, the edge temperature control unit is provided in an edge assembly thereof, and can adjust the temperature of the edge area of the to-be-processed workpiece by heat exchange. Therefore, with the bearing apparatus provided by the present invention, the defect that the central temperature control unit provided in the electrostatic chuck is not capable of adjusting the temperature of the edge area of the to-be-processed workpiece can be remedied, so that the temperature difference between the edge area and the central area of the to-be-processed workpiece can be compensated to improve the temperature uniformity of the edge area and the central area of the to-be-processed workpiece, thereby improving the process uniformity. In addition, in the present invention, the structure of the edge assembly can be improved by a simple manufacturing method without any modification to the electrostatic chuck. In other words, in the present invention, a bearing apparatus capable of improving the process uniformity can be obtained by the simple manufacturing method.

Similarly, in the semiconductor processing device provided by the present invention, the above-described bearing apparatus provided by the present invention may be adopted to adjust the temperature of the edge area of the to-be-processed workpiece, so the temperature difference between the edge area and the central area of

the to-be-processed workpiece can be compensated, and thus the process uniformity can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic structural diagram of a typical bearing apparatus bearing a wafer;

Fig. 2A is a cross-sectional diagram of a bearing apparatus bearing a to-be-processed workpiece according to a first embodiment of the present invention, taken along a plane where an axis of the bearing apparatus is located;

Fig. 2B is an enlarged view of area I in Fig. 2A;

Fig. 2C is a cross-sectional diagram of the insulation ring shown in Fig. 2A, taken along line A-A;

Fig. 2D is a partial view of a cross section of the bearing apparatus bearing the to-be-processed workpiece according to the first embodiment of the present invention, taken along a plane where both the axis of the bearing apparatus and an axis of a temperature sensing through hole are located;

Fig. 3A is a partial view of a cross section of a bearing apparatus bearing a to-be-processed workpiece according to a second embodiment of the present invention, taken along a plane where both the axis of the bearing apparatus and an axis of a columnar extension part are located;

Fig. 3B is a partial view of a cross section of the bearing apparatus bearing the to-be-processed workpiece according to the second embodiment of the present invention, taken along a plane where both the axis of the bearing apparatus and an axis of a first temperature sensing through hole are located;

Fig. 4A is a partial view of a cross section of a bearing apparatus bearing a to-be-processed workpiece according to a third embodiment of the present invention, taken along a plane where both the axis of the bearing apparatus and an axis of a columnar extension part are located; and

Fig. 4B is a partial view of a cross section of the bearing apparatus bearing the to-be-processed workpiece according to the third embodiment of the present invention,

taken along a plane where both the axis of the bearing apparatus and an axis of a temperature sensing through hole are located.

Here, reference numerals are as follows:

bearing apparatus 100, electrostatic chuck 101, edge assembly 102, mounting fastener 27, workpiece to be processed 22, coolant channel 21, focusing ring 23, base ring 24, insulation ring 25, heat exchange channel 241, medium source 103, columnar extension part 242, sealing element 26, guiding channel 243, temperature sensing through hole 251, edge temperature detection unit 104, heat exchange channel 231, bearing apparatus 200, columnar extension part 232, first temperature sensing through hole 244, second temperature sensing through hole 251, and sealing element 28.

DETAILED DESCRIPTION

To make those skilled in the art better understand technical solutions of the present invention, a bearing apparatus and a semiconductor processing device provided by the present invention will be described in detail below in conjunction with the accompanying drawings.

Fig. 2A is a cross-sectional diagram of a bearing apparatus bearing a to-be-processed workpiece according to a first embodiment of the present invention, taken along a plane where an axis of the bearing apparatus is located. Fig. 2B is an enlarged view of area I in Fig. 2A. Referring to Figs. 2A and 2B together, the bearing apparatus 100 includes an electrostatic chuck 101, a central temperature control unit, an edge assembly 102, an edge temperature control unit and a mounting fastener 27. The electrostatic chuck 101 is configured to bear a to-be-processed workpiece 22 by way of electrostatic adsorption. In this embodiment, the central temperature control unit includes a coolant channel 21 provided within the electrostatic chuck 101, through which cooling liquid is introduced to adjust temperature of a central area of the to-be-processed workpiece 22. It needs to be set forth that the central temperature control unit is provided in a central area inside the electrostatic chuck 101 with a certain distance away from an edge of the electrostatic chuck 101, and, due to the fact that the to-be-processed workpiece 22 has a diameter larger than that of an upper

surface of the electrostatic chuck 101, the edge of the to-be-processed workpiece 22 goes beyond the edge of the electrostatic chuck 101 when the to-be-processed workpiece 22 and electrostatic chuck 101 are coaxially provided, which makes it difficult for the central temperature control unit to control the temperature of the edge area of the to-be-processed workpiece 22. Accordingly, the central area of the to-be-processed workpiece 22 refers to an area in which temperature adjustment can be achieved by the central temperature control unit.

In practical applications, other temperature control means may also be adopted as the central temperature control unit, as long as it can adjust the temperature of the central area of the to-be-processed workpiece 22 to meet specific process requirements. For example, in a case where the to-be-processed workpiece needs to be cooled, the central temperature control unit may be a temperature control means such as the above-described cooling liquid channel, a cooling gas channel, or the like, which makes the to-be-processed workpiece reach a predetermined cooling temperature; in a case where the to-be-processed workpiece needs to be heated, the central temperature control unit may be a temperature control means such as an armoured heating tube or the like, which makes the to-be-processed workpiece reach a predetermined heating temperature.

The edge assembly 102 is provided around an outer circumferential wall of the electrostatic chuck 101 and includes a focusing ring 23, a base ring 24 and an insulation ring 25 sequentially stacked from up to down. Here, the focusing ring 23 is made of quartz and has an inner circumferential wall whose cross section along a radial direction is of a step shape, and generally, an upper-step surface of the step is slightly higher than the upper surface of the to-be-processed workpiece 22, such that a boundary is formed around the to-be-processed workpiece 22 and thus plasma is confined within an area enclosed by the boundary. The base ring 24 is made of insulation material such as ceramics or the like and used for supporting the focusing ring 23 and protecting the outer circumferential wall of the electrostatic chuck 101 from being etched by the plasma. The insulation ring 25 is fastened on the mounting fastener 27 to support the electrostatic chuck 11, and is made of insulation material

such as Al_2O_3 ceramics or the like, which electrically insulates the electrostatic chuck 101 from the mounting fastener 27.

As described above, the edge of the to-be-processed workpiece 22 goes beyond the edge of the electrostatic chuck 101 while the edge assembly 102 is provided around the electrostatic chuck 101, so the edge area of the to-be-processed workpiece 22 is supported by the edge assembly 102. The edge temperature control unit is provided in the edge assembly 102 to adjust the temperature of the edge area of the to-be-processed workpiece 22 by way of heat exchange. In other words, heat generated by the edge temperature control unit is transferred to the edge area of the to-be-processed workpiece 22 through the edge assembly 102; or, heat from the edge area of the to-be-processed workpiece 22 is absorbed by the edge temperature control unit through the edge assembly 102. It needs to be set forth that, in order to ensure realization of the heat conduction of the edge assembly 102, shapes and dimensions of inner circumferential walls of the focusing ring 23 and the base ring 24 are matched well with the shape and dimension of the outer circumferential wall of the electrostatic chuck 101, so that the edge assembly 102 may make better contact with the to-be-processed workpiece 22, thereby achieving fast transfer of heat.

A structure of the edge temperature control unit adopted in this embodiment will be described in detail below. Specifically, the edge temperature control unit includes one heat exchange channel 241 provided in the base ring 24 and around the electrostatic chuck 101 in a circumferential direction of the electrostatic chuck 101, the heat exchange channel 241 being configured to accommodate therein a flowable heat exchange medium, such as heat exchange gas, heat exchange liquid, or the like, which adjusts the temperature of the edge area of the to-be-processed workpiece 22. More specifically, the heat exchange channel 241 has an inlet and an outlet in communication with a medium source 103 providing the heat exchange medium, and the edge assembly further includes two guiding channels 243, one of which is connected between the inlet of the heat exchange channel 241 and an output tube of the medium source 103 to make the two communicate with each other, the other of which is connected between the outlet of the heat exchange channel 241 and an input

tube of the medium source 103 to make the two communicate with each other, In this way, the heat exchange channel 241, the medium source 103, and the two guiding channels 243 in the edge assembly jointly constitute a circulation system of heat exchange medium. It need to be noted that, in the present invention, both the inlet and the outlet of the heat exchange channel are defined by taking the heat exchange channel as a reference, and specifically, the inlet refers to an entrance through which heat exchange medium flows into the heat exchange channel, and the outlet refers to an exit through which heat exchange medium flows out of the heat exchange channel; both the input tube and the output tube of the medium source are defined by taking the medium source as a reference, and specifically, the input tube refers to a tube through which heat exchange medium flows into the medium source, and the output tube refers to a tube through which heat exchange medium flows out of the medium source. The heat exchange medium flows into the heat exchange channel 241 through the inlet thereof, flows along the heat exchange channel 241, and at last flows out of the heat exchange channel 241 through the outlet thereof.

Preferably, the inlet and the outlet of the heat exchange channel 241 are symmetrically arranged in a radial direction of the heat exchange channel 241, such that heat exchange medium flowing into the heat exchange channel 241 is divided into two parts which flow along two respective branches of the heat exchange channel 241 to the outlet, the two respective branches having a same length, and thus the two parts have substantially identical flow rates and can collect at the outlet and drain out simultaneously, thereby achieving uniform heat exchange.

In this embodiment, two columnar extension parts 242 are formed, on a lower surface of the base ring 24, correspondingly to the inlet and the outlet of the heat exchange channel 241, and each columnar extension part 242 penetrates the insulation ring 25 in the thickness direction of the insulation ring 25 and extends to the underneath of the insulation ring 25 to be respectively connected, in a sealing manner, with the input tube and the output tube of the medium source 103 for providing heat exchange medium. The guiding channels 243 are configured as channels penetrating the columnar extension parts 242 along the axes of the columnar extension parts 242

and connected with the heat exchange channel 241, such that one of the guiding channels 243 is connected between the inlet of the heat exchange channel 241 and the output tube of the medium source 103 to make them communicate with each other, and the other of the guiding channels 243 is connected between the outlet of the heat exchange channel 241 and the input tube of the medium source 103 to make them communicate with each other. In addition, a sealing element 26 may be provided between an outer circumferential wall of each columnar extension part 242 and a through hole of the insulation ring 25 provided for the columnar extension part 242 to pass through, so as to seal a gap between the two.

With the help of the two columnar extension parts 242, the heat exchange channel 241 can be communicated with the input and output tubes of the medium source 103, and thus a circular flow of heat exchange medium can be implemented. In addition, with the help of the columnar extension parts 242, the guiding channel 243 may have no gap between the base ring 24 and the insulation ring 25 and thus there is no need to seal the gap between the base ring 24 and the insulation ring 25, so the structure of the bearing apparatus 100 can be simplified. In practical applications, the columnar extension part 242 and the base ring 24 may be manufactured integrally; or, the columnar extension part 242 and the base ring 24 may be manufactured separately and then fixedly connected to each other by adhering, sintering, or the like.

By the method of adjusting the temperature of the edge area of the to-be-processed workpiece 22 using the edge temperature control unit, the defect that the central temperature control unit provided in the electrostatic chuck 101 is not capable of adjusting the temperature of the edge area of the to-be-processed workpiece 22 can be remedied, compensation for the temperature difference between the edge area and the central area of the to-be-processed workpiece 22 can be achieved, and thus the process uniformity can be improved. Furthermore, in the bearing apparatus provided in the embodiments of the present invention, only the structure of the edge assembly 102 is improved without any modification to the electrostatic chuck 101, and, during the manufacture, the columnar extension part 242 and the base ring 24 may be manufactured by a relatively simple method such as the

above-described integral manufacture, so the process uniformity can be improved by means of simple modification to the device.

Preferably, as shown in Fig. 2B, a radial distance D between an inner sidewall of the heat exchange channel 241 and the outer circumferential wall of the electrostatic chuck 101 is no larger than 3 mm, so as to improve at least the heat transfer rate between the heat exchange channel 241 and the edge area of the to-be-processed workpiece 22 and ensure that the adjustment to temperature is controllable.

Fig. 2C is a cross-sectional diagram of the insulation ring shown in Fig. 2A, taken along line A-A. As shown in Fig. 2C, in this embodiment, a temperature sensing through hole 25, penetrating the insulation ring 25 in the thickness direction thereof, is provided in the insulation ring 25 and serves as a detection hole for detecting temperature of the base ring 24. Fig. 2D is a partial view of a cross section of the bearing apparatus bearing the to-be-processed workpiece in this embodiment, taken along a plane where both the axis of the bearing apparatus and an axis of the temperature sensing through hole are located. Referring to Figs. 2C and 2D, the bearing apparatus 100 further includes an edge temperature detection unit 104 configured to detect the temperature of the base ring 24, which is to be used as the temperature of the edge area of the to-be-processed workpiece 22, through the temperature sensing through hole 251.

In this embodiment, the edge temperature detection unit 104 adopts a non-contact type temperature sensor such as an infrared temperature sensor, which is installed in such a manner that the infrared temperature sensor is inserted into the temperature sensing through hole 251 with the probe of the infrared temperature sensor facing the lower surface of the base ring 24. In practical applications, the edge temperature detection unit 104 may also adopt a contact type temperature sensor such as a surface-mounted temperature sensor, which is installed in such a manner that the probe of the sensor passes through the temperature sensing through hole 251 and contacts the lower surface of the base ring 24. As shown in Fig. 2D, in order to improve the accuracy of temperature detection by the edge temperature detection unit 104, a sealing element 28 is provided between the edge temperature detection unit 104

and the temperature sensing through hole, such that the probe of the edge temperature detection unit 104 may be located in a hermetic space to be prevented from being affected by temperature outside the temperature sensing through hole.

Preferably, the bearing apparatus 100 further includes a central temperature detection unit and a control unit. The central temperature detection unit is configured to detect the temperature of the electrostatic chuck 101 and send it to the control unit as the temperature of the central area of the to-be-processed workpiece 22; at the same time, the above-described edge temperature detection unit 104 detects the temperature of the base ring 24, and sends it to the control unit as the temperature of the edge area of the to-be-processed workpiece 22. The control unit is configured to receive the temperature of the edge area of the to-be-processed workpiece 22 sent from the edge temperature detection unit and the temperature of the central area of the to-be-processed workpiece 22 sent from the central temperature detection unit, calculate a temperature difference between the edge area and the central area and send a control signal to the central temperature control unit and/or the edge temperature control unit 104 according to the temperature difference. The central temperature control unit and/or the edge temperature control unit 104 compensates the temperature of the edge area and/or the temperature of the central area according to the control signal, so that the temperature of the edge area of the to-be-processed workpiece 22 and the temperature of the central area of the to-be-processed workpiece 22 can tend to be uniform, and thereby the process uniformity can be improved. As such, the bearing apparatus 100 provided in the embodiments of the present invention can accurately control the temperature of the to-be-processed workpiece 22.

A manufacturing method of the base ring 24 and the heat exchange channel 241 therein will be described in detail below. Specifically, the base ring 24 preferably consists of an upper ring body and a lower ring body butted against each other, wherein an annular groove is formed on a lower surface of the upper ring body, and is closed by an upper surface of the lower ring body to form into a closed channel serving as the insulation ring 241 when the upper ring body and the lower ring body are butted against each other. Alternatively, an annular groove is formed on the upper

surface of the lower ring body, and is closed by the lower surface of the upper ring body to form into a closed channel serving as the heat exchange channel 241 when the upper ring body and the lower ring body are butted against each other. Alternatively, each of two annular grooves is formed on corresponding one of the lower surface of the upper ring body and the upper surface of the lower ring body, and the two annular grooves jointly form a closed channel serving as the heat exchange channel 241 when the upper ring body and the lower ring body are butted against each other. In other words, the base ring 24 has a split structure having upper and lower bodies, and the annular groove for forming the heat exchange channel 241 may be provided on upper and/or lower surfaces of the two split bodies, and it facilitates processing of the inner structure of the base ring 24, i.e., the heat exchange channel 241 and the inlet and outlet thereof. In addition, the base ring 24 may be manufactured by using the following two methods. The first method is first performing a primary sintering separately on the upper ring body and the lower ring body, then performing a secondary sintering on the two together, and obtaining the heat exchange channel 241 by butting the upper ring body against the lower ring body. Here, the purpose of the secondary sintering is to reduce the difficulty in processing the heat exchange channel 241. The second method is only performing one sintering on the upper and lower ring bodies, and obtaining the heat exchange channel 241 by butting the upper ring body against the lower ring body.

It needs to be set forth that, in this embodiment, the heat exchange channel 241 and the input tube/output tube of the medium source 103 are made connected through the two columnar extension parts 242 having the channels 243 provided therein. However, the present invention is not limited thereto. In practical applications, it is also possible to omit the two columnar extension parts and simply provide two guiding channels in the base ring 24 and the insulation ring 25. Upper ends of the two guiding channels are both connected to the heat exchange channel 241 and lower ends thereof are connected to the input tube or the output tube of the medium source 103, respectively, such that the heat exchange channel 241 and the input tube /output tube of the medium source 103 communicate with each other. In this case, the input and

output tubes of the medium source 103 should be directly connected, in a sealing manner, with the guiding channels, and further, it is also necessary to perform a sealing process between the base ring and the insulation ring to ensure that the heat exchange medium will not be leaked out from a gap therebetween.

Fig. 3A is a partial view of a cross section of a bearing apparatus bearing a to-be-processed workpiece according to a second embodiment of the present invention, taken along a plane where the axis of the bearing apparatus is located. In terms of an area shown in the partial view, Fig. 3A corresponds to Fig. 2B described above. Referring to Fig. 3A, the bearing apparatus 200 provided in this embodiment is different from the first embodiment only in that the heat exchange channel 231 is provided in the focusing ring 23, and other structures and functions of the bearing apparatus 200 are the same as those of the bearing apparatus 100 in the first embodiment described above, and the description thereof is not repeated. Hereinafter, only the specific implementation of the heat exchange channel 231 provided in the focusing ring 23 will be described in detail.

Specifically, two columnar extension parts 232 are formed, on a lower surface of the focusing ring 23, correspondingly to the inlet and the outlet of the heat exchange channel 231, and each columnar extension part 232 penetrates the base ring 24 and the insulation ring 25 in the thickness direction of the base ring 24 and extends to the underneath of the insulation ring 25. The above guiding channels 233 are configured as channels penetrating the columnar extension parts 232 along the axes of the columnar extension parts 232 and connected with the heat exchange channel 231. One of the columnar extension parts 232 is connected in a sealing manner with the input tube of the medium source 103 providing the heat exchange medium, and the inlet of the heat exchange channel 231 and the output tube of the medium source 103 are made connected with the help of the guiding channel 233 therein; the other one of the columnar extension parts 232 is connected in a sealing manner with the output tube of the medium source 103, and the outlet of the heat exchange channel 231 and the input tube of the medium source 103 are made connected with the help of the guiding channel 233 therein.

In addition, a sealing element 26 may be provided between the outer circumferential wall of each columnar extension part 232 and a through hole of the insulation ring 25 provided for the columnar extension part 232 to pass through, so as to seal a gap therebetween. The heat exchange channel 231 is provided in the focusing ring 23 so that the heat exchange channel 231 can be closer to the edge of the to-be-processed workpiece 22, and thus the heat transfer rate can be further improved and the temperature of the central area of the to-be-processed workpiece 22 and the temperature of the edge area of the to-be-processed workpiece 22 can become uniform more quickly.

Similar to the first embodiment, in the second embodiment of the present invention, it is possible to omit the two columnar extension parts and form through holes in the focusing ring 23, the base ring 24 and the insulation ring 25. The through holes in the focusing ring 23, the base ring 24 and the insulation ring 25 communicate with each other and serve as the guiding channel on their own, and the input and output tubes of the medium source 103 are directly connected, in a sealing manner, with lower ends of the guiding channels, and at the same time, a sealing process is performed between the focusing ring 23 and the base ring 24 and between the base ring 24 and the insulation ring 25 to ensure that the heat exchange medium will not be leaked out from a gap between the focusing ring 23 and the base ring 24 or between the base ring 24 and the insulation ring 25.

Referring to Fig. 3B, in the second embodiment of the present invention, a first temperature sensing through hole 244 penetrating the base ring 24 in the thickness direction of the base ring 24 is provided in the base ring 24, a second temperature sensing through hole 251 penetrating the insulation ring 25 in the thickness direction of the insulation ring 25 is provided in the insulation ring 25, and the first and second temperature sensing through holes 244 and 251 are coaxially provided to serve as a detection hole for detecting the temperature of the focusing ring 23. With the reference to Fig. 3B, the bearing apparatus 200 further includes an edge temperature detection unit 104, which is configured to detect the temperature of the focusing ring 23 through the first and second temperature sensing through holes 244 and 251, and

send the temperature to the control unit as the temperature of the edge area of the to-be-processed workpiece 22. A sealing element 28 is provided between the edge temperature detection unit 104 and the second temperature sensing through hole 251 to improve the accuracy of temperature detection by the edge temperature detection unit 104.

In addition, the heat exchange channel 231 may be formed in the focusing ring 23 in the same way as that in the first embodiment described above, description of which is not repeated herein.

Fig. 4A is a partial view of a cross section of a bearing apparatus bearing a to-be-processed workpiece according to a third embodiment of the present invention, taken along a plane where the axis of the bearing apparatus is located. In terms of an area shown in the partial view, Fig. 4A corresponds to Fig. 2B described above. Referring to Fig. 4A, the bearing apparatus 200 provided in this embodiment is different from the first embodiment only in that the edge temperature control unit includes two heat exchange channels (231, 241) communicating with each other, i.e., a heat exchange channel 231 provided in the focusing ring 23, and a heat exchange channel 241 provided in the base ring 24. In this case, similarly to the first embodiment, the heat exchange channel 241 provided in the base ring 24 has an inlet and an outlet connected with the medium source 103 supplying the heat exchange medium, and two guiding channels 243 are also provided in the edge assembly 102, one of which is connected between the inlet of the heat exchange channel 241 and the output tube of the medium source 103 to make them communicate with each other, and the other of which is connected between the outlet of the heat exchange channel 241 and the input tube of the medium source 103 to make them communicate with each other. Thus, the two heat exchange channel (231, 241), the medium source, and the two guiding channels 243 in the edge assembly jointly constitute a circulation system of heat exchange medium. The specific implementation of forming the two guiding channels 243 in the edge assembly is the same as that in the first embodiment described above, and other structures and functions of the bearing apparatus 200 are the same as those of the bearing apparatus 100 in the first embodiment described

above, and the description thereof is not repeated. Hereinafter, only the specific connection mode of the two heat exchange channels (231, 241) provided in the edge assembly 102 will be described.

The two heat exchange channels (231, 241) may be connected through two connection holes 234, one of which may have a location corresponding to the location of the inlet of the heat exchange channel 241 and the other of which may have a location corresponding to the location of the outlet of the heat exchange channel 241, such that the heat exchange medium can quickly flow into the heat exchange channel 231 in the focus ring 23 after flowing into the heat exchange channel 241 in the base ring 24, and thus the temperature of the edge area of the to-be-processed workpiece 22 can be adjusted quickly. When the two heat exchange channels (231, 241) are connected through the connection hole 234, it is necessary to perform a sealing process between the focus ring 23 and the base ring 24 to ensure that the heat exchange medium will not be leaked out from a gap between the focus ring 23 and the base ring 24.

The radial distance D of the inner sidewall of each of the heat exchange channels (231, 241) and the outer circumferential wall of the electrostatic chuck 101 is no larger than 3 mm so as to improve at least the heat transfer rate between the heat exchange channel and the edge area of the to-be-processed workpiece 22.

In addition, similarly to the first embodiment, the temperature sensing through hole 251 penetrating the insulating ring 25 in the thickness direction of the insulating ring 25 is provided in the insulating ring 25 and serves as a detection hole for detecting the temperature of the base ring 24. Referring to Fig. 4B, the bearing apparatus 100 further includes an edge temperature detection unit 104 for detecting the temperature of the base ring 24 through the temperature sensing through hole 251, and a sealing element 28 is provided between the edge temperature detection unit 104 and the temperature sensing through hole 251. Temperatures of the edge area of the to-be-processed workpiece 22, the focus ring 23 and the base ring 24 can tend to be uniform by continuous conduction of heat. Therefore, the temperature of the base ring 24 can be regarded as the temperature of the edge area of the to-be-processed

workpiece 22 and the edge temperature detection unit 104 sends the detected temperature to the control unit. By providing heat exchange channels in both the focusing ring 23 and the base ring 24, more heat exchange medium can be introduced to adjust the temperature of the edge of the to-be-processed workpiece 22, thereby further improving the heat transfer rate.

In addition, the heat exchange channel 241 may be formed in the base ring 24 in the same way as that in the first embodiment, and the heat exchange channel 231 may be provided in the focusing ring 23 in the same way as that in the first embodiment described above, descriptions of which are not repeated herein.

It needs be set forth that, in the first, second and third embodiments described above, one heat exchange channel 241 is provided in the base ring 24, the so-called "one heat exchange channel 241" is not intended to only refer to a single the heat exchange channel 241, but may also refer to one group of heat exchange channels, as long as the one group of heat exchange channels are provided in the base ring. Similarly, the expression that "one heat exchange channel 231 is provided in the focusing ring 23" may also refer to that one group of heat exchange channels are provided in the focusing ring 23.

It needs be set forth that, in the first, second and third embodiments described above, the heat exchange channel(s) is provided in the edge assembly 102, and the temperature of the edge area of the to-be-processed workpiece 22 is adjusted by introducing heat exchange medium into the heat exchange channel, but the present invention is not limited thereto. In practical applications, any other temperature control means may also be used as the edge temperature control unit to exchange heat with the edge assembly 102, and indirectly adjust the temperature of the edge area of the to-be-processed workpiece 22.

As described above, in the bearing apparatus provided in the above embodiments of the present invention, an edge temperature control unit is provided in an edge assembly thereof, and can adjust the temperature of the edge area of the to-be-processed workpiece by way of heat exchange. Therefore, with the bearing apparatus provided by the present invention, the defect that the central temperature

control unit provided in the electrostatic chuck is not capable of adjusting the temperature of the edge area of the to-be-processed workpiece can be remedied, so that the temperature difference between the edge area and the central area of the to-be-processed workpiece can be compensated to improve the temperature uniformity of the edge area and the central area of the to-be-processed workpiece, thereby improving the process uniformity. In addition, in the embodiments of the present invention, the structure of the edge assembly can be improved by a simple manufacturing method without any modification to the electrostatic chuck. In other words, in the present invention, a bearing apparatus capable of improving the process uniformity can be obtained by the simple manufacturing method.

As another technical solution, the present invention further provides a semiconductor processing device including a reaction chamber and a bearing apparatus provided in the reaction chamber, wherein the bearing apparatus is used for bearing a to-be-processed workpiece and adjusting the temperature of the to-be-processed workpiece. Further, the bearing apparatus may be the bearing apparatus provided in the above-described embodiments of the present invention.

In the semiconductor processing device provided in the embodiments of the present invention, the bearing apparatus provided in the above embodiments of the present invention may be adopted to adjust the temperature of the edge area of the to-be-processed workpiece, so the temperature difference between the edge area and the central area of the wafer can be compensated, and thus the process uniformity can be improved.

It can be understood that the foregoing implementations are merely exemplary implementations used for describing the principle of the present invention, but the present invention is not limited thereto. Those of ordinary skill in the art may make various variations and improvements without departing from the spirit and essence of the present invention, and these variations and improvements shall also fall into the protection scope of the present invention.

CLAIMS:

1. A bearing apparatus, comprising an electrostatic chuck, a central temperature control unit and an edge assembly, wherein

the central temperature control unit is provided in the electrostatic chuck and configured to adjust temperature of a central area of a to-be-processed workpiece supported by the electrostatic chuck;

the edge assembly is provided around an outer circumferential wall of the electrostatic chuck and comprises a focusing ring, a base ring and an insulation ring sequentially stacked from up to down; and

the bearing apparatus further comprises an edge temperature control unit provided in the edge assembly and configured to adjust temperature of an edge area of the to-be-processed workpiece by way of heat exchange.

2. The bearing apparatus according to claim 1, wherein the edge temperature control unit comprises at least one heat exchange channel provided in the edge assembly and around the electrostatic chuck in a circumferential direction of the electrostatic chuck, the at least one heat exchange channel being configured to accommodate a flowable heat exchange medium therein.

3. The bearing apparatus according to claim 2, wherein the heat exchange channel is provided in the base ring or the focusing ring, and has an inlet and an outlet connected with a medium source for providing the heat exchange medium; or, the edge temperature control unit comprises two heat exchange channels connected with each other, which are provided in the base ring and the focusing ring, respectively, and the heat exchange channel provided in the base ring has an inlet and an outlet connected with the medium source for providing the heat exchange medium; and

the edge assembly further comprises two guiding channels, one of which is connected between the inlet of the heat exchange channel and an output tube of the medium source to allow them to communicate with each other, and the other of which

is connected between the outlet of the heat exchange channel and an input tube of the medium source to allow them to communicate with each other.

4. The bearing apparatus according to claim 3, wherein, in a case where the base ring is provided with the heat exchange channel therein, two columnar extension parts are formed, on a lower surface of the base ring, correspondingly to the inlet and the outlet of the heat exchange channel, each columnar extension part penetrates the insulation ring in a thickness direction of the insulation ring, and the guiding channels are configured as channels penetrating respective columnar extension parts along axes of the columnar extension parts and connected with the heat exchange channel.

5. The bearing apparatus according to claim 4, wherein a temperature sensing through hole penetrating the insulation ring in the thickness direction of the insulation ring is provided in the insulation ring, and

the bearing apparatus further comprises an edge temperature detection unit, which is configured to detect temperature of the base ring, which is to be used as the temperature of the edge area of the to-be-processed workpiece, through the temperature sensing through hole.

6. The bearing apparatus according to claim 3, wherein, in a case where the edge temperature control unit comprises one heat exchange channel provided in the focusing ring, two columnar extension parts are formed, on a lower surface of the focusing ring, correspondingly to the inlet and the outlet of the heat exchange channel, each columnar extension part penetrates the base ring and the insulation ring in a thickness direction of the base ring, and the guiding channels are configured as channels penetrating respective columnar extension parts along axes of the columnar extension parts and connected with the heat exchange channel.

7. The bearing apparatus according to claim 6, wherein a first temperature sensing through hole penetrating the base ring in the thickness direction of the base

ring is provided in the base ring, a second temperature sensing through hole penetrating the insulation ring in a thickness direction of the insulation ring is provided in the insulation ring, and the first and second temperature sensing through holes are coaxially provided; and

the bearing apparatus further comprises an edge temperature detection unit, which is configured to detect temperature of the focusing ring, which is to be used as the temperature of the edge area of the to-be-processed workpiece, through the first and second temperature sensing through holes.

8. The bearing apparatus according to claim 3, wherein, in a case where the base ring is provided with the heat exchange channel therein, the base ring consists of an upper ring body and a lower ring body butted against each other; and/or, in a case where the focusing ring is provided with the heat exchange channel therein, the focusing ring consists of an upper ring body and a lower ring body butted against each other;

an annular groove is formed on a lower surface of the upper ring body, and the annular groove is closed by an upper surface of the lower ring body to form into a closed channel serving as the heat exchange channel when the upper ring body and the lower ring body are butted against each other; or,

an annular groove is formed on the upper surface of the lower ring body, and the annular groove is closed by the lower surface of the upper ring body to form into a closed channel serving as the heat exchange channel when the upper ring body and the lower ring body are butted against each other; or,

each of two annular grooves is formed on corresponding one of the lower surface of the upper ring body and the upper surface of the lower ring body, and the two annular grooves jointly form a closed channel serving as the heat exchange channel when the upper ring body and the lower ring body are butted against each other.

9. The bearing apparatus according to claim 8, wherein the heat exchange channel is obtained by performing a primary sintering separately on the upper ring

body and the lower ring body, then performing a secondary sintering on the upper and lower ring bodies together, and butting the upper ring body against the lower ring body; or,

the heat exchange channel is obtained by performing one sintering on the upper and lower ring bodies and butting the upper ring body against the lower ring body.

10. The bearing apparatus according to claim 5 or 7, wherein the bearing apparatus further comprises a central temperature detection unit and a control unit,

the central temperature detection unit is configured to detect temperature of the electrostatic chuck, which is to be used as the temperature of the central area of the to-be-processed workpiece; and

the control unit is configured to receive the temperature of the edge area of the to-be-processed workpiece sent from the edge temperature detection unit and the temperature of the central area of the to-be-processed workpiece sent from the central temperature detection unit, and calculate a temperature difference between the edge area and the central area and send a control signal to the central temperature control unit and/or the edge temperature control unit according to the temperature difference, and the central temperature control unit and/or the edge temperature control unit compensates the temperature of the edge area and/or the temperature of the central area according to the control signal.

11. The bearing apparatus according to claim 5 or 7, wherein the edge temperature detection unit comprises a contact type temperature sensor or a non-contact type temperature sensor.

12. The bearing apparatus according to any one of claims 2 to 11, wherein a radial distance between an inner sidewall of the heat exchange channel and the outer circumferential wall of the electrostatic chuck is no larger than 3 mm.

13. The bearing apparatus according to claim 3, wherein the inlet and the outlet

of the heat exchange channel are symmetrically arranged in a radial direction of the heat exchange channel.

14. A semiconductor processing device, comprising a reaction chamber, and the bearing apparatus according to any one of claims 1 to 13 provided in the reaction chamber, the bearing apparatus being used for bearing the to-be-processed workpiece and adjusting temperature of the to-be-processed workpiece.