

ELECTROSTATIC CHUCK AND SEMICONDUCTOR PROCESSING APPARATUS

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TECHNICAL FIELD

[0001] The present disclosure relates to the field of semiconductor manufacturing, and in particular, to an electrostatic chuck and a semiconductor processing apparatus.

BACKGROUND

10 [0002] An Electrostatic Chuck (ESC for short) is configured to support a wafer by electrostatic adsorption, so as to prevent movement and misalignment of the wafer during the process. In the process, a back-blowing gas under certain pressure needs to be introduced into a gap between the electrostatic chuck and the wafer for improving a capability of the electrostatic chuck to transfer heat to the wafer and avoiding vacuum
15 insulation, so that a capability of the electrostatic chuck to control a temperature of the wafer can be improved; and in addition, the electrostatic chuck can apply a radio frequency bias voltage to the wafer.

[0003] The electrostatic chuck is generally placed in a vacuum chamber. Taking a Physical Vapor Deposition (PVD) device as an example, when the wafer is transferred in
20 the vacuum chamber of the PVD device and placed on the electrostatic chuck, the vacuum chamber in a background vacuum state (a background vacuum degree is generally in the order of 10^{-8} Torr or 10^{-9} Torr). At this time, the gap between the wafer and the electrostatic chuck is in a vacuum insulation state, and the electrostatic chuck cannot control the temperature of the wafer, so the back-blowing gas needs to be
25 introduced into the gap between the wafer and the electrostatic chuck and needs to be maintained under a certain pressure (e.g., 1Torr to 20Torr). The back-blowing gas can transfer heat between the electrostatic chuck and the wafer, thereby enabling the temperature control capability of the electrostatic chuck.

[0004] Electrostatic chucks can be classified into a Coulomb-type electrostatic chuck
30 and a Johnsen-Rahbek effect type (J-R type) electrostatic chuck. The Coulomb-type

electrostatic chuck works on a principle of producing electrostatic adsorption on the wafer by electrostatic attraction generated between an electrode and the wafer, and the J-R type electrostatic chuck works on a principle of producing electrostatic adsorption on the wafer by electrostatic attraction generated between an upper surface of the electrostatic chuck and the wafer. In order to improve heat transfer efficiency, gas channels are generally disposed on the upper surface of the electrostatic chuck, so as to facilitate diffusion of the back-blowing gas to different positions of the wafer through the gas channels. Since a distance from an electrode in the Coulomb-type electrostatic chuck to the wafer is relatively small, a thickness of a dielectric layer above the electrode is too thin to dispose the gas channels; while a distance from an electrode in the J-R type electrostatic chuck to the wafer is relatively large, and a thickness of a dielectric layer above the electrode is relatively thick, which allows disposing the gas channel.

[0005] However, for the J-R type electrostatic chuck, with the existing gas channel structure, only after the back-blowing gas is introduced for a long time (100s or more), stability and uniformity of a back-blowing pressure can meet requirements of the process, that is, a PVD process can be started. Considering that the time of the PVD process is generally in a range of 20s to 100s, the J-R type electrostatic chuck equipped with the existing gas channel structure results in low equipment production capacity, and cannot be applied to industrial production.

SUMMARY

[0006] In order to solve at least one technical problem in the prior art, the present disclosure provides an electrostatic chuck and a semiconductor processing apparatus, which can effectively shorten ventilation time of a back-blowing gas while ensuring that a back-blowing pressure meets stability and uniformity requirements, thereby improving equipment production capacity.

[0007] For achieving the objective of the present disclosure, there is provided an electrostatic chuck applied to a semiconductor processing apparatus, including a chuck body, an upper surface of the chuck body is provided with a protrusion structure, a central gas inlet, and a gas channel structure, the protrusion structure is located in a non-gas channel region of the upper surface of the chuck body, is configured to bear a

wafer, and is provided with a bearing surface for bearing the wafer, and a preset distance is provided between the bearing surface and the upper surface of the chuck body; the gas channel structure includes an annular gas channel, a primary gas channel group, and a secondary gas channel group, the annular gas channel is located at an edge of the upper surface of the chuck body, and is configured to define a heat exchange region on an inner side of the annular gas channel; the primary gas channel group and the secondary gas channel group are both distributed in the heat exchange region, the primary gas channel group surrounds the central gas inlet, and the secondary gas channel group surrounds the primary gas channel group; the primary gas channel group is respectively communicated with the central gas inlet and the secondary gas channel group, and is configured to be capable of increasing a speed of delivering a back-blowing gas flowing out of the central gas inlet to the secondary gas channel group; and the secondary gas channel group is respectively communicated with the primary gas channel group and the annular gas channel, and is configured to enable the back-blowing gas to be uniformly distributed at different positions of the heat exchange region.

[0008] Optionally, a ratio of an area of an orthographic projection of the primary gas channel group on the upper surface of the chuck body to an area of a specified region of the upper surface of the chuck body is less than or equal to 50%, and the area of the specified region is an area of a circle which takes a center of the upper surface as a center of circle and has a specified diameter.

[0009] Optionally, the specified diameter is less than or equal to 50mm.

[0010] Optionally, the primary gas channel group includes a plurality of primary gas channels uniformly distributed along a circumferential direction of the central gas inlet, and each of the primary gas channels is arranged along a radial direction of the central gas inlet, a gas inlet end of each of the primary gas channels is communicated with the central gas inlet, and a gas outlet end of each of the primary gas channels is communicated with the secondary gas channel group.

[0011] Optionally, a width of the primary gas channels is greater than or equal to 0.5mm and less than or equal to 3mm; a depth of the primary gas channels is greater than or equal to 0.1mm and less than or equal to 0.4mm; and a number of the primary gas channels is greater than or equal to nine and less than or equal to twenty.

[0012] Optionally, the secondary gas channel group includes one stage of sub-gas channel group including a plurality of secondary gas channels, the gas outlet end of each

of the primary gas channels is communicated with a gas inlet end of at least one secondary gas channel, and a plurality of secondary gas channels communicated with a same primary gas channel extend from a gas outlet end of the primary gas channel in different directions away from the central gas inlet; or, the secondary gas channel group includes multiple stages of sub-gas channel groups which are surrounded in sequence in a direction away from the central gas inlet, each stage of sub-gas channel group includes a plurality of secondary gas channels, the gas outlet end of each of the primary gas channels is communicated with a gas inlet end of at least one secondary gas channel in an adjacent stage of sub-gas channel group, and a plurality of secondary gas channels communicated with a same primary gas channel extend from a gas outlet end of the primary gas channel in different directions away from the central gas inlet; a gas outlet end of each secondary gas channel of an upstream stage is communicated with a gas inlet end of at least one secondary gas channel of an adjacent downstream stage, and a plurality of secondary gas channels of a downstream stage communicated with a same secondary gas channel of an upstream stage extend from a gas outlet end of the secondary gas channel of the upstream stage in different directions away from the central gas inlet.

[0013] Optionally, a width of the secondary gas channels is greater than or equal to 0.5mm and less than or equal to 3mm; a depth of the secondary gas channels is greater than or equal to 0.1mm and less than or equal to 0.4mm; and a number of the secondary gas channels is greater than or equal to nine and less than or equal to one hundred.

[0014] Optionally, the secondary gas channel group includes two stages of sub-gas channel groups, which are a stage-1 gas channel group and a stage-2 gas channel group respectively, the stage-1 gas channel group includes a plurality of first secondary gas channels, the gas outlet end of each of the primary gas channels is communicated with gas inlet ends of three first secondary gas channels, and among every three first secondary gas channels communicated with a same primary gas channel, one of the three first secondary gas channels in the middle is coaxial with the primary gas channel, and two of the three first secondary gas channels on both sides are symmetrically distributed relative to the one of the three first secondary gas channels in the middle; and gas outlet ends of any two adjacent first secondary gas channels communicated with different primary gas channels converge to form a first common gas outlet end; and the stage-2 gas channel group includes a plurality of second secondary gas channels, and among

every three first secondary gas channels communicated with a same primary gas channel, a gas outlet end of one of the three first secondary gas channels in the middle is communicated with gas inlet ends of two second secondary gas channels, and each first common gas outlet end is communicated with gas inlet ends of two second secondary gas channels; and gas outlet ends of any two adjacent second secondary gas channels, one of which is communicated with a gas outlet end of a first secondary gas channel and the other of which is communicated with a first common gas outlet end, converge to form a second common gas outlet end, and all second common gas outlet ends are communicated with the annular gas channel.

[0015] Optionally, the secondary gas channel group further includes a plurality of transition gas channels, gas inlet ends of all the transition gas channels are communicated with all the second common gas outlet ends in one-to-one correspondence, and gas outlet ends of all the transition gas channels are communicated with the annular gas channel.

[0016] Optionally, a diameter of an annular center line of the annular gas channel is greater than or equal to 270mm and less than or equal to 290mm; a radial width of the annular gas channel is greater than or equal to 0.5mm and less than or equal to 3mm; and a depth of the annular gas channel is greater than or equal to 0.1mm and less than or equal to 0.4mm.

[0017] Optionally, the protrusion structure includes a plurality of protrusions uniformly distributed in the non-gas channel region, and a ratio of a total area of orthographic projections of the plurality of protrusions on the upper surface of the chuck body to an area of the upper surface of the chuck body is greater than or equal to 2% and less than or equal to 10%.

[0018] Optionally, the preset distance is greater than or equal to 2 μ m and less than or equal to 10 μ m.

[0019] As the other technical solution, the present disclosure further provides a semiconductor processing apparatus, including a process chamber and an electrostatic chuck disposed in the process chamber, and the electrostatic chuck adopts the above electrostatic chuck provided in the present disclosure.

[0020] The present disclosure has the following beneficial effects.

[0021] In the electrostatic chuck provided in the present disclosure, the gas channel structure includes the annular gas channel, the primary gas channel group, and the

secondary gas channel group, and the annular gas channel is located at the edge of the upper surface of the chuck body, and is configured to define the heat exchange region on the inner side of the annular gas channel, so as to ensure that a gas pressure in the heat exchange region is not affected by a pressure in the chamber and ensure stability of the gas pressure, thereby enabling normal heat exchange of the back-blowing gas; the primary gas channel group and the secondary gas channel group are both distributed in the heat exchange region, and the primary gas channel group surrounds the central gas inlet, is respectively communicated with the central gas inlet and the secondary gas channel group, and is configured to be capable of increasing the speed of delivering the back-blowing gas flowing out of the central gas inlet to the secondary gas channel group, so that it can be ensured that the back-blowing gas diffuses all around from the central gas inlet quickly; and the secondary gas channel group surrounds the primary gas channel group, is respectively communicated with the primary gas channel group and the annular gas channel, and is configured to enable the back-blowing gas to be uniformly distributed at different positions of the heat exchange region. The primary gas channel group plays a major role in making the back-blowing pressure quickly meet the stability requirement, and the secondary gas channel group plays a major role in making the back-blowing gas quickly meet the uniformity requirement. Thus, by using the primary gas channel group together with the secondary gas channel group, the ventilation time of the back-blowing gas can be effectively shortened while ensuring that the back-blowing pressure meets the stability and uniformity requirements, so that the equipment production capacity can be improved.

[0022] By adopting the electrostatic chuck provided in the present disclosure, the semiconductor processing apparatus provided in the present disclosure can shorten the ventilation time of the back-blowing gas while ensuring that the back-blowing pressure meets the stability and uniformity requirements, thereby improving the equipment production capacity.

BRIEF DESCRIPTION OF DRAWINGS

[0023] FIG. 1 is a cross-sectional side view of an electrostatic chuck according to a first embodiment of the present disclosure;

[0024] FIG. 2 is a top view of a gas channel structure of the electrostatic chuck according to the first embodiment of the present disclosure;

[0025] FIG. 3 is another top view of a gas channel structure of the electrostatic chuck according to the first embodiment of the present disclosure;

5 [0026] FIG. 4 is a top view of a gas channel structure of an electrostatic chuck according to a second embodiment of the present disclosure;

[0027] FIG. 5 is an overall top view of an electrostatic chuck according to a third embodiment of the present disclosure;

[0028] FIG. 6 is a partial top view of the electrostatic chuck shown in FIG. 5;

10 [0029] FIG. 7 is a comparison chart of average gas pressure-time curves of the electrostatic chuck provided in the third embodiment of the present disclosure and an electrostatic chuck in the prior art; and

[0030] FIG. 8 is a comparison chart of gas pressure-wafer position curves of the electrostatic chuck provided in the third embodiment of the present disclosure and the
15 electrostatic chuck in the prior art.

DETAIL DESCRIPTION OF EMBODIMENTS

[0031] In order to enable those of ordinary skill in the art to better understand the technical solutions of the present disclosure, an electrostatic chuck and a semiconductor
20 processing apparatus provided in the present disclosure are described in detail below with reference to the drawings.

First Embodiment

[0032] Referring to FIG. 1, the present embodiment provides an electrostatic chuck 1, including a chuck body 11 provided therein with an electrode 12 which is electrically
25 connected to a direct-current power apply for supplying power to a wafer. In general, a portion of the chuck body 11 above the electrode 12 is a dielectric layer, and a portion of the chuck body 11 below the electrode 12 is a base. The dielectric layer and the base are both made of a ceramic material, and the electrode 12 may be embedded inside the ceramic material by sintering.

30 [0033] The electrostatic chuck 1 provided in the present embodiment is a J-R type electrostatic chuck, and works on a principle of producing an adsorption effect on a wafer 2 by electrostatic attraction generated between an upper surface 111 of the chuck

body 11 and the wafer 2. On this basis, in the present embodiment, the upper surface 111 of the chuck body 11 is provided with a protrusion structure, a central gas inlet, and a gas channel structure. The protrusion structure includes a plurality of protrusions 13 uniformly distributed in a non-gas channel region (a region beyond the central gas inlet and the gas channel structure), a bearing surface formed by the plurality of protrusions 13 is configured to bear the wafer 2, and a preset distance (i.e., a height of the protrusions 13) is provided between the bearing surface and the upper surface 111 of the chuck body 11. The preset distance is such set that sufficiently large electrostatic attraction can be generated between the upper surface 111 of the chuck body 11 and the wafer 2, so as to ensure no movement or misalignment of the wafer 2 in the process.

[0034] The following formula is the Coulomb's Law Formula:

$$F = \frac{KQq}{r^2}$$

where F is the electrostatic attraction; K is the Coulomb constant, Q is a charge amount of the upper surface 111, q is a charge amount of a lower surface of the wafer 2, and r is a distance between the lower surface of the wafer 2 and the upper surface 111 of the chuck body 11 (for the J-R type electrostatic chuck).

[0035] As can be seen from the Coulomb's Law Formula, the electrostatic attraction F is inversely proportional to a square of the distance r, and therefore, the magnitude of the electrostatic attraction F mainly depends on the magnitude of the distance r, and the smaller the distance r, the larger the electrostatic attraction F. In addition, the electrostatic attraction F is proportional to the charge amount Q of the upper surface 111, and therefore, the larger the area of the region of the upper surface 111 beyond the protrusion structure and the gas channel structure, the larger the electrostatic attraction F.

[0036] Based on the above principle, optionally, the preset distance between the bearing surface formed by the plurality of protrusions 13 and the upper surface 111 of the chuck body 11 is greater than or equal to 2μm and less than or equal to 10μm. By setting the preset distance within such range, it can be ensured that the insufficient electrostatic attraction F, which is caused by the overlarge preset distance and may cause movement or misalignment of the wafer 2 in the process, is avoided; and it can also be ensured that deterioration of a heat conduction capability of a back-blowing gas, which is caused by the preset distance being smaller than a mean free path of molecules of the back-blowing

gas introduced between the wafer 2 and the upper surface 111 in the process and may affect a temperature control capability of the electrostatic chuck, is avoided.

[0037] In addition, optionally, a ratio of a total area of orthographic projections of the protrusions 13 on the upper surface 111 of the chuck body 11 to an area of the upper surface 111 is greater than or equal to 2% and less than or equal to 10%. By setting the ratio within such range, it can be ensured that the insufficient area of the upper surface 111, which is caused by the overlarge ratio and may cause the insufficient charge amount Q of the upper surface 111 and further cause the insufficient electrostatic attraction F, is avoided; and it can also be ensured that the wafer 2 being not uniformly and stably supported due to the too small ratio is avoided.

[0038] In some alternative embodiments, the plurality of protrusions 13 may be uniformly arranged on a plurality of circles in the non-gas channel region which have different radii and take a center of the upper surface 111 as a center of circle, such as the arrangement of the plurality of protrusions 13 shown in FIG. 5. Alternatively, the plurality of protrusions 13 may be arranged in an array in the non-gas channel region, for example, the array is a rectangular array or an array in any other shape. The number of the plurality of protrusions 13 and the arrangement thereof are not particularly limited in the present disclosure.

[0039] In some alternative embodiments, the protrusions 13 may be made of a TAC (hydrogen-free diamond-like coating) material with a Filtered Cathodic Vacuum Arc (FCVA) method. The protrusions made with such method have good wear resistance and can resist a high temperature, thereby prolonging service life of the electrostatic chuck.

[0040] In some alternative embodiments, a distance between the electrode 12 and the upper surface 111 of the chuck body 11 is greater than or equal to 0.5mm and less than or equal to 2mm. By setting the distance within such range, better electrostatic attraction F can be generated.

[0041] Referring to FIG. 2, the central gas inlet 112 is located at the center of the upper surface 111 of the chuck body 11, and is configured to introduce the back-blowing gas between the upper surface 111 and the wafer 2 to realize heat exchange therebetween, thereby realizing temperature control of the electrostatic chuck.

[0042] Referring to FIG. 2, the gas channel structure includes an annular gas channel 31, a primary gas channel group, and a secondary gas channel group. The annular gas channel 31 is located at an edge of the upper surface 111 of the chuck body 11, and is

configured to define a heat exchange region (including an inner ring region 111a and an outer ring region 111b) on an inner side of the annular gas channel 31. Since an edge region 111c of the upper surface 111 of the chuck body 11 is communicated with an interior of a chamber, a gas pressure may suddenly drop in the edge region 111c, which keeps the back-blowing gas from performing heat exchange in the edge region 111c. In such case, with the annular gas channel 31, it can be ensured that a gas pressure in the heat exchange region (including the inner ring region 111a and the outer ring region 111b) on the inner side of the annular gas channel 31 is not affected by a pressure in the chamber, and stability of the gas pressure can also be ensured, thereby enabling normal heat exchange of the back-blowing gas.

[0043] In some alternative embodiments, a diameter of an annular center line of the annular gas channel 31 is greater than or equal to 270mm and less than or equal to 290mm, and is preferably 280mm; a radial width of the annular gas channel 31 is greater than or equal to 0.5mm and less than or equal to 3mm, and is preferably 2mm; and a depth of the annular gas channel 31 is greater than or equal to 0.1mm and less than or equal to 0.4mm, and is preferably 0.2mm. The above ranges of the diameter of the annular center line, the radial width, and the depth of the annular gas channel 31 can not only ensure that an area of the heat exchange region is enlarged as much as possible, but also ensure that the gas pressure in the heat exchange region on the inner side of the annular gas channel 31 is not affected by the pressure in the chamber, so that the stability of the gas pressure can be ensured, thereby enabling the normal heat exchange of the back-blowing gas.

[0044] Both the primary gas channel group and the secondary gas channel group are distributed in the heat exchange region, the primary gas channel group surrounds the central gas inlet 112, such as in the inner ring region 111a shown in FIG. 2; and the secondary gas channel group surrounds the primary gas channel group, such as in the outer ring region 111b shown in FIG. 2. The primary gas channel group is respectively communicated with the central gas inlet 112 and the secondary gas channel group, and is configured to be capable of increasing a speed of delivering the back-blowing gas flowing out of the central gas inlet 112 to the secondary gas channel group, so that it can be ensured that the back-blowing gas diffuses all around from the central gas inlet 112, that is, a diffusion speed of the back-blowing gas can be increased. The primary gas

channel group plays a major role in making a back-blowing pressure quickly meet a stability requirement.

[0045] The primary gas channel group is located in the inner ring region 111a close to the central gas inlet 112, and a gas pressure at the central gas inlet 112 is higher than gas pressures in the other regions. Therefore, if an area of an orthographic projection of the primary gas channel group on the upper surface 111 of the chuck body 11 is too large, a gas pressure in the inner ring region 111a is likely to be relatively high, resulting in a “bulging” phenomenon of the wafer in the inner ring region. In order to solve such problem, a ratio of the area of the orthographic projection of the primary gas channel group on the upper surface 111 of the chuck body 11 to an area R of a specified region is less than or equal to 50%, the area R of the specified region is an area of a circle which takes the center of the upper surface 111 as a center of circle and has a specified diameter, that is, the specified region is a region within an outer edge of the inner ring region 111a. Optionally, the specified diameter is less than or equal to 50mm, for example, the specified diameter is 50mm. Certainly, the area of the orthographic projection of the primary gas channel group on the upper surface 111 of the chuck body 11 should not be too small, so as to ensure that the back-blowing gas can quickly diffuse all around from the central gas inlet 112 to make the back-blowing pressure quickly meet the stability requirement.

[0046] In some alternative embodiments, the primary gas channel group includes a plurality of primary gas channels 32 uniformly distributed along a circumferential direction of the central gas inlet 112, and each primary gas channel 32 is arranged along a radial direction of the central gas inlet 112 to minimize a path along which the back-blowing gas flows to the outer ring region 111b, so as to ensure that the back-blowing gas can diffuse all around from the central gas inlet 112 quickly. Moreover, a gas inlet end of each primary gas channel 32 is communicated with the central gas inlet 112, and a gas outlet end of each primary gas channel 32 is communicated with the secondary gas channel group. The back-blowing gas flowing out from the central gas inlet 112 diffuses all around simultaneously through all the primary gas channels 32, and flows into the secondary gas channel group.

[0047] In some alternative embodiments, the area of the orthographic projection of the primary gas channel group on the upper surface 111 of the chuck body 11 may be adjusted by setting the number, width, depth and other parameters of the primary gas

channels 32. For example, the width of the primary gas channels 32 is greater than or equal to 0.5mm and less than or equal to 3mm, and is preferably 2mm; the depth of the primary gas channels 32 is greater than or equal to 0.1mm and less than or equal to 0.4mm, and is preferably 0.2mm; and the number of the primary gas channels 32 is greater than or equal to nine and less than or equal to twenty, and is preferably ten. For example, fifteen primary gas channels 32 are shown in FIG. 2. By setting the number, width, and depth of the primary gas channels 32 within those ranges, it can be ensured that the gas pressure in the inner ring region 111a is not made too high due to the overlarge area of the orthographic projection of the primary gas channel group on the upper surface 111 of chuck body 11, which may cause the “bulging” phenomenon of the wafer in the inner ring region; and it can also be ensured that the area of the orthographic projection of the primary gas channel group on the upper surface 111 of the chuck body 11 is big enough to enable the back-blowing gas to quickly diffuse all around from the central gas inlet 112, thereby making the back-blowing pressure quickly meet the stability requirement.

[0048] It should be noted that the primary gas channel group is not limited to the above structure adopted in the present embodiment, and may adopt any other structure in practical applications as long as the back-blowing pressure can quickly meet the stability requirement.

[0049] The secondary gas channel group is respectively communicated with the primary gas channel group and the annular gas channel 31, and is configured to enable the back-blowing gas to be uniformly distributed at different positions of the heat exchange region (including the inner ring region 111a and the outer ring region 111b), that is, the secondary gas channel group may enable the back-blowing gas to diffuse quickly and uniformly. The secondary gas channel group plays a major role in making the back-blowing gas quickly meet a uniformity requirement. Thus, by using the primary gas channel group together with the secondary gas channel group, ventilation time of the back-blowing gas can be effectively shortened while ensuring that the back-blowing pressure meets the stability and uniformity requirements, so that equipment production capacity can be increased.

[0050] It should be noted that the primary and secondary gas channel groups may function to guide diffusion of the back-blowing gas due to a larger distance between a gas channel region where the primary and secondary gas channel groups are located and

a wafer surface and a smaller distance between the non-gas channel region of the upper surface 111 and the wafer surface. Moreover, both the primary gas channel group and the secondary gas channel group are communicated with the non-gas channel region, so that the back-blowing gas may further diffuse to the non-gas channel region after flowing
5 along the primary gas channel group and the secondary gas channel group in sequence, and finally the whole heat exchange region may be filled with the back-blowing gas, thereby realizing a uniform and stable gas pressure between the heat exchange region and the wafer surface.

[0051] In some alternative embodiments, the secondary gas channel group includes one
10 stage of sub-gas channel group. As shown in FIG. 2, the one stage of sub-gas channel group is located in the outer ring region 111b and includes a plurality of secondary gas channels 33, the gas outlet end of each primary gas channel 32 is communicated with gas inlet ends of two secondary gas channels 33, and every two secondary gas channels 33 communicated with a same primary gas channel 32 extend from the gas outlet end of the
15 primary gas channel 32 in different directions away from the central gas inlet 112. For example, as shown in FIG. 2, every two secondary gas channels 33 communicated with a same primary gas channel 32 extend in directions away from the central gas inlet 112 and away from each other, and are finally communicated with the annular gas channel 31. With every two secondary gas channels 33 used as two branches of a same primary gas
20 channel 32, the back-blowing gas flowing out of the primary gas channel 32 may further diffuse from the gas outlet end of the primary gas channel 32 in different directions away from the central gas inlet 112, so that the back-blowing gas can quickly meet the uniformity requirement.

[0052] It should be noted that the number of the secondary gas channel 33
25 communicated with a same primary gas channel 32 may be one in practical applications, in which case, the different secondary gas channels 33 may be communicated with each other, which may also enable the back-blowing gas to quickly meet the uniformity requirement. Alternatively, the number of the secondary gas channels 33 communicated with a same primary gas channel 32 may be three or more, for example, as shown in FIG.
30 3, the number of the secondary gas channels 33 communicated with a same primary gas channel 32 may be three. The number of the secondary gas channels 33 communicated with a same primary gas channel 32 may be freely set according to specific needs.

[0053] In some alternative embodiments, a width of the secondary gas channels 33 is greater than or equal to 0.5mm and less than or equal to 3mm, and is preferably 2mm; a depth of the secondary gas channels 33 is greater than or equal to 0.1mm and less than or equal to 0.4mm, and is preferably 0.2mm; and the number of the secondary gas channels 33 is greater than or equal to nine and less than or equal to one hundred, and is preferably twenty. By setting the width, depth and number of the secondary gas channels 33 within those ranges, an effect of enabling the back-blowing gas to quickly meet the uniformity requirement can be effectively produced.

[0054] It should be further noted that the secondary gas channels 33 are not limited to straight channels, and may be channels in any other shape such as curved channels or zigzag channels, which is not particularly limited in the present disclosure.

Second Embodiment

[0055] Referring to FIG. 4, the electrostatic chuck provided in the present embodiment differs from the electrostatic chuck provided in the first embodiment only in that: the secondary gas channel group has a different structure and is additionally provided with a plurality of transition gas channels 34. Only the difference between the present embodiment and the first embodiment is described in detail below.

[0056] Specifically, as shown in FIG. 4, an annular transition region 111d is further set between the outer ring region 111b and the annular gas channel 31 on the upper surface 111 of the chuck body 11. On this basis, the secondary gas channel group includes one stage of sub-gas channel group which is located in the outer ring region 111b and includes a plurality of secondary gas channels 33, the gas outlet end of each primary gas channel 32 is communicated with the gas inlet ends of two secondary gas channels 33, and every two secondary gas channels 33 communicated with a same primary gas channel 32 extend from the gas outlet end of the primary gas channel 32 in different directions away from the central gas inlet 112. For example, as shown in FIG. 2, every two secondary gas channels 33 communicated with a same primary gas channel 32 extend in directions away from the central gas inlet 112 and away from each other. Moreover, gas outlet ends of any two adjacent secondary gas channels 33 communicated with different primary gas channels 32 converge to form a common gas outlet end A, so that the two secondary gas channels 33 may be communicated with each other, thereby further improving the efficiency with which the back-blowing gas quickly meets the uniformity requirement.

[0057] Moreover, the secondary gas channel group further includes a plurality of transition gas channels 34 located in the annular transition region 111d, gas inlet ends of all the transition gas channels 34 are communicated with all the common gas outlet ends A in one-to-one correspondence, and gas outlet ends of all the transition gas channels 34 are communicated with the annular gas channel 31. With the transition gas channels 34, the plurality of secondary gas channels 33 communicated with each other may be further communicated with the annular gas channel 31.

[0058] It should be noted that the transition gas channels 34 may be omitted in practical applications, that is, without setting the annular transition region 111d, the common gas outlet ends A directly extend to the position of the annular gas channel 31 and is communicated with the annular gas channel 31.

[0059] The other structures and functions of the electrostatic chuck provided in the present embodiment are the same as those of the electrostatic chuck provided in the first embodiment, and thus will not be repeated here.

Third Embodiment

[0060] As a preferred embodiment, referring to FIG. 5 and FIG. 6, the electrostatic chuck provided in the present embodiment differs from the electrostatic chucks provided in the first and second embodiments only in that: the secondary gas channel group has a different structure. Only the difference between the present embodiment and the first and second embodiments is described in detail below.

[0061] As shown in FIG. 5 and FIG. 6, the secondary gas channel group includes two stages of sub-gas channel groups, which are surrounded in sequence in a direction away from the central gas inlet 112 and are located in the outer ring region. The two stages of sub-gas channel groups are a stage-1 gas channel group and a stage-2 gas channel group, respectively. The stage-1 gas channel group includes a plurality of first secondary gas channels 33a, and the stage-2 gas channel group includes a plurality of second secondary gas channels 33b.

[0062] The gas outlet end of each primary gas channel 32 is communicated with gas inlet ends of three first secondary gas channels 33a. Among every three first secondary gas channels communicated with a same primary gas channel 32, the first secondary gas channel 331 in the middle is coaxial with the primary gas channel 32, and the two first secondary gas channels 332 on both sides are symmetrically distributed relative to the first secondary gas channel 331 in the middle. Moreover, gas outlet ends of any two

adjacent first secondary gas channels 332 communicated with different primary gas channels 32 converge to form a first common gas outlet end A1. Among every three first secondary gas channels communicated with a same primary gas channel 32, a gas outlet end of the first secondary gas channel 331 in the middle is communicated with gas inlet ends of two second secondary gas channels 33b, and each first common gas outlet end A1 is communicated with gas inlet ends of two second secondary gas channels 33b. Furthermore, gas outlet ends of any two adjacent second secondary gas channels 33b, one of which is communicated with the gas outlet end of a first secondary gas channel 331 and the other of which is communicated with a first common gas outlet end A1, converge to form a second common gas outlet end A2, in other words, the gas outlet ends of any two adjacent second secondary gas channels 33b communicated with different gas outlet ends (including the gas outlet end of the first secondary gas channel 331 in the middle and the first common gas outlet end A1) converge to form a second common gas outlet end A2, and all second common gas outlet ends A2 are communicated with the annular gas channel 31.

[0063] Optionally, the secondary gas channel group further includes a plurality of transition gas channels 34, gas inlet ends of all the transition gas channels 34 are communicated with all the second common gas outlet ends A2 in one-to-one correspondence, and gas outlet ends of all the transition gas channels 34 are communicated with the annular gas channel 31.

[0064] The gas channel structure adopted in the electrostatic chuck shown in FIG. 5 is taken as an example in the following experiments, with specific parameters including: the widths of the primary gas channels 32, the secondary gas channels 33, the annular gas channel 31, and the transition gas channels 34 are all 2mm; the number of the primary gas channels 32 is fifteen; the total number of the secondary gas channels is sixty; and the diameter of the annular center line of the annular gas channel 31 is 280mm.

[0065] FIG. 7 is a comparison chart of average gas pressure-time curves of the electrostatic chuck provided in the third embodiment of the present disclosure and the electrostatic chuck in the prior art. As shown in FIG. 7, when an average gas pressure reaches the line B1, the magnitude of the average gas pressure is considered to meet a process requirement; and when the average gas pressure reaches the line B2, the stability of the average gas pressure is considered to meet a process requirement, and at this time,

a PVD process can be started. In general, a value of B1 is 90% of a value of B2. The curve S1 is an average gas pressure-time curve of the electrostatic chuck in the prior art; and the curve S2 is an average gas pressure-time curve of the electrostatic chuck provided in the third embodiment of the present disclosure. It can be seen from comparison that the time point t2 (100s or more) corresponding to an intersection of the curve S1 and the line B1 is greater than the time point t1 (about 12s) corresponding to an intersection of the curve S2 and the line B1, that is, the electrostatic chuck provided in the third embodiment of the present disclosure can reach the line B1 and the line B2 faster than the electrostatic chuck in the prior art. Thus, it can be demonstrated that the electrostatic chuck provided in the present embodiment can effectively shorten the ventilation time of the back-blowing gas while ensuring that the back-blowing pressure meets the stability requirement.

[0066] FIG. 8 is a comparison chart of gas pressure-wafer position curves of the electrostatic chuck provided in the third embodiment of the present disclosure and the electrostatic chuck in the prior art. As shown in FIG. 8, the curve S1 is a gas pressure-wafer position curve of the electrostatic chuck in the prior art; and the curve S2 is a gas pressure-wafer position curve of the electrostatic chuck provided in the third embodiment of the present disclosure. It can be seen from comparison that the magnitude of a gas pressure shown by the curve S1 gradually decreases from a center position (150mm) of a wafer to edge positions of the wafer, the highest gas pressure at the center position is about 680Pa, the lowest gas pressure at the edge positions is about 340Pa, and the uniformity of the gas pressure is poor. As shown by the curve S2, a gas pressure at the center position (150mm) of the wafer and gas pressures at the edge positions of the wafer differ slightly and are all about 680Pa. Thus, it can be demonstrated that the electrostatic chuck provided in the present embodiment can effectively improve the stability of the back-blowing pressure.

[0067] It should be noted that the third embodiment is merely a preferred embodiment, and the present disclosure is not limited thereto. In practical applications, the secondary gas channel group may further include three or more stages of sub-gas channel groups which are surrounded in sequence in a direction away from the central gas inlet 112, in which case, the gas outlet end of each primary gas channel 32 is communicated with a gas inlet end of at least one secondary gas channel in the adjacent stage of sub-gas channel group, and a plurality of secondary gas channels communicated with a same

primary gas channel 32 extend from the gas outlet end of the primary gas channel 32 in different directions away from the central gas inlet 112; a gas outlet end of each secondary gas channel of an upstream stage is communicated with a gas inlet end of at least one secondary gas channel of an adjacent downstream stage, and a plurality of secondary gas channels of a downstream stage communicated with a same secondary gas channel of an upstream stage extend from a gas outlet end of the secondary gas channel of the upstream stage in different directions away from the central gas inlet 112.

[0068] The other structures and functions of the electrostatic chuck provided in the present embodiment are the same as those of the electrostatic chucks provided in the first and second embodiments, and thus will not be repeated here.

[0069] In summary, by using the primary gas channel group together with the secondary gas channel group, the electrostatic chuck provided in each of the above embodiments of the present disclosure can shorten the ventilation time of the back-blowing gas while ensuring that the back-blowing pressure meets the stability and uniformity requirements, thereby improving the equipment production capacity.

[0070] As the other technical solution, an embodiment of the present disclosure further provides a semiconductor processing apparatus, including a process chamber and an electrostatic chuck disposed in the process chamber, and the electrostatic chuck adopts the electrostatic chuck provided in each of the above embodiments of the present disclosure.

[0071] By adopting the electrostatic chuck provided in the embodiments of the present disclosure, the semiconductor processing apparatus provided in the embodiment of the present disclosure can shorten the ventilation time of the back-blowing gas while ensuring that the back-blowing pressure meets the stability and uniformity requirements, thereby improving the equipment production capacity.

[0072] It should be understood that the above embodiments are merely exemplary embodiments adopted to illustrate the principle of the present disclosure, and the present disclosure is not limited thereto. Various modifications and improvements can be made by those of ordinary skill in the art without departing from the spirit and essence of the present disclosure, and those modifications and improvements are also considered to fall within the scope of the present disclosure.

What is claimed is:

1. An electrostatic chuck applied to a semiconductor processing apparatus, comprising a chuck body, wherein an upper surface of the chuck body is provided with a protrusion structure, a central gas inlet, and a gas channel structure, the protrusion structure is located in a non-gas channel region of the upper surface of the chuck body, and is provided with a bearing surface for bearing a wafer, and a preset distance is provided between the bearing surface and the upper surface of the chuck body;

the gas channel structure comprises an annular gas channel, a primary gas channel group, and a secondary gas channel group, the annular gas channel is located at an edge of the upper surface of the chuck body, and is configured to define a heat exchange region on an inner side of the annular gas channel; the primary gas channel group and the secondary gas channel group are both distributed in the heat exchange region, the primary gas channel group surrounds the central gas inlet, and the secondary gas channel group surrounds the primary gas channel group;

the primary gas channel group is respectively communicated with the central gas inlet and the secondary gas channel group, and is configured to be capable of increasing a speed of delivering a back-blowing gas flowing out of the central gas inlet to the secondary gas channel group; and

the secondary gas channel group is respectively communicated with the primary gas channel group and the annular gas channel, and is configured to enable the back-blowing gas to be uniformly distributed at different positions of the heat exchange region.

2. The electrostatic chuck of claim 1, wherein a ratio of an area of an orthographic projection of the primary gas channel group on the upper surface of the chuck body to an area of a specified region of the upper surface of the chuck body is less than or equal to 50%, and the area of the specified region is an area of a circle which takes a center of the upper surface as a center of circle and has a specified diameter.

3. The electrostatic chuck of claim 2, wherein the specified diameter is less

than or equal to 50mm.

4. The electrostatic chuck of any one of claims 1 to 3, wherein the primary gas channel group comprises a plurality of primary gas channels uniformly distributed along a circumferential direction of the central gas inlet, and each of the primary gas channels is arranged along a radial direction of the central gas inlet, a gas inlet end of each of the primary gas channels is communicated with the central gas inlet, and a gas outlet end of each of the primary gas channels is communicated with the secondary gas channel group.

5. The electrostatic chuck of claim 4, wherein a width of the primary gas channels is greater than or equal to 0.5mm and less than or equal to 3mm; a depth of the primary gas channels is greater than or equal to 0.1mm and less than or equal to 0.4mm; and a number of the primary gas channels is greater than or equal to nine and less than or equal to twenty.

6. The electrostatic chuck of claim 4, wherein the secondary gas channel group comprises one stage of sub-gas channel group comprising a plurality of secondary gas channels, the gas outlet end of each of the primary gas channels is communicated with a gas inlet end of at least one secondary gas channel, and a plurality of secondary gas channels communicated with a same primary gas channel extend from a gas outlet end of the primary gas channel in different directions away from the central gas inlet; or,

the secondary gas channel group comprises multiple stages of sub-gas channel groups which are surrounded in sequence in a direction away from the central gas inlet, each stage of sub-gas channel group comprises a plurality of secondary gas channels, the gas outlet end of each of the primary gas channels is communicated with a gas inlet end of at least one secondary gas channel in an adjacent stage of sub-gas channel group, and a plurality of secondary gas channels communicated with a same primary gas channel extend from a gas outlet end of the primary gas channel in different directions away from the central gas inlet; a gas outlet end of each secondary gas channel of an upstream stage is communicated with a gas inlet end of at least one secondary gas channel of an adjacent downstream stage, and a plurality of

secondary gas channels of a downstream stage communicated with a same secondary gas channel of an upstream stage extend from a gas outlet end of the secondary gas channel of the upstream stage in different directions away from the central gas inlet.

5 7. The electrostatic chuck of claim 6, wherein a width of the secondary gas channels is greater than or equal to 0.5mm and less than or equal to 3mm; a depth of the secondary gas channels is greater than or equal to 0.1mm and less than or equal to 0.4mm; and a number of the secondary gas channels is greater than or equal to nine and less than or equal to one hundred.

10 8. The electrostatic chuck of claim 6, wherein the secondary gas channel group comprises two stages of sub-gas channel groups, which are a stage-1 gas channel group and a stage-2 gas channel group respectively, the stage-1 gas channel group comprises a plurality of first secondary gas channels, the gas outlet end of each of the
15 primary gas channels is communicated with gas inlet ends of three first secondary gas channels, and among every three first secondary gas channels communicated with a same primary gas channel, one of the three first secondary gas channels in the middle is coaxial with the primary gas channel, and two of the three first secondary gas channels on both sides are symmetrically distributed relative to the one of the three
20 first secondary gas channels in the middle; and gas outlet ends of any two adjacent first secondary gas channels communicated with different primary gas channels converge to form a first common gas outlet end; and

the stage-2 gas channel group comprises a plurality of second secondary gas channels, and among every three first secondary gas channels communicated with a
25 same primary gas channel, a gas outlet end of one of the three first secondary gas channels in the middle is communicated with gas inlet ends of two second secondary gas channels, and each first common gas outlet end is communicated with gas inlet ends of two second secondary gas channels; and gas outlet ends of any two adjacent second secondary gas channels, one of which is communicated with a gas outlet end
30 of a first secondary gas channel and the other of which is communicated with a first common gas outlet end, converge to form a second common gas outlet end, and all second common gas outlet ends are communicated with the annular gas channel.

9. The electrostatic chuck of claim 8, wherein the secondary gas channel group further comprises a plurality of transition gas channels, gas inlet ends of all the transition gas channels are communicated with all the second common gas outlet ends in one-to-one correspondence, and gas outlet ends of all the transition gas channels are communicated with the annular gas channel.

10. The electrostatic chuck of any one of claims 1 to 3, wherein a diameter of an annular center line of the annular gas channel is greater than or equal to 270mm and less than or equal to 290mm; a radial width of the annular gas channel is greater than or equal to 0.5mm and less than or equal to 3mm; and a depth of the annular gas channel is greater than or equal to 0.1mm and less than or equal to 0.4mm.

11. The electrostatic chuck of claim 1, wherein the protrusion structure comprises a plurality of protrusions uniformly distributed in the non-gas channel region, and a ratio of a total area of orthographic projections of the plurality of protrusions on the upper surface of the chuck body to an area of the upper surface of the chuck body is greater than or equal to 2% and less than or equal to 10%.

12. The electrostatic chuck of claim 1 or 11, wherein the preset distance is greater than or equal to 2 μ m and less than or equal to 10 μ m.

13. A semiconductor processing apparatus, comprising a process chamber and an electrostatic chuck disposed in the process chamber, wherein the electrostatic chuck adopts the electrostatic chuck of any one of claims 1 to 12.