

GAS MIXING DEVICE AND SEMICONDUCTOR PROCESS APPARATUS

TECHNICAL FIELD

5 [0001] The present disclosure relates to the field of semiconductor manufacturing, and in particular, to a gas mixing device and a semiconductor process apparatus.

BACKGROUND

10 [0002] At present, an Atomic Layer Deposition (ALD) apparatus has been widely used in a semiconductor chip manufacturing process, and gas-related systems of the ALD apparatus mainly include a gas intake system, a gas mixing system, a gas distribution system, and a gas discharge system and the like. The ALD process mainly adopts pulse gas intake as a gas intake manner, so as to realize deposition of a monoatomic film on a surface of a wafer layer by layer.

15 [0003] Specifically, a gas intake method of the ALD process using two source gases includes:

step 1, introducing a diluent gas (e.g., nitrogen) into a process chamber to purge pipelines and the chamber;

20 step 2, introducing a mixed gas of a first source gas and the diluent gas into the process chamber;

step 3, stopping introducing the first source gas, and introducing the diluent gas into the process chamber;

step 4, introducing a mixed gas of a second source gas and the diluent gas into the process chamber; and

25 step 5, stopping introducing the second source gas, and introducing the diluent gas into the process chamber.

[0004] The steps 2 to 5 are circularly performed.

30 [0005] In a process of performing the steps 2 to 5, a mixing device is needed to fully mix the source gases and the diluent gas (or a carrier gas for the source gases), so as to make the mixed gas uniform in concentration; and then the mixed gas is quickly dispersed with

the gas distribution system (e.g., a spray device) and uniformly blown to the surface of the wafer to form a film through chemical reaction. How to mix the gases quickly and uniformly is crucial to shortening gas mixing time and improving performance and production capacity.

5 [0006] However, an existing gas mixing device adopts a pressure holding method to promote the flow of the gases in a horizontal direction. With such method, serious flow blockage, large flow resistance, and low gas mixing efficiency are caused, and totally uniform mixing of the gases can be hardly achieved, resulting in poor uniformity. Thus, the existing gas mixing device is not suitable for an operating condition with a high gas
10 mixing requirement.

SUMMARY

[0007] The present disclosure aims to solve at least one technical problem in the prior art, and provides a gas mixing device and a semiconductor process apparatus, which can not
15 only shorten gas mixing time and increase gas mixing efficiency, but also effectively improve mixing uniformity and product performance.

[0008] In order to achieve the objective of the present disclosure, there is provided a gas mixing device applied to a semiconductor process apparatus, including a gas mixing component, a first gas intake pipeline, and a second gas intake pipeline; the gas mixing
20 component being provided therein with a first gas intake passage, a second gas intake passage, and an annular gas mixing passage, wherein

a gas inlet end of the first gas intake passage and a gas inlet end of the second gas intake passage are communicated with a gas outlet end of the first gas intake pipeline and a gas outlet end of the second gas intake pipeline, respectively; a gas outlet end of
25 the first gas intake passage and a gas outlet end of the second gas intake passage are both communicated with the annular gas mixing passage; and a gas outlet end of the annular gas mixing passage is configured to be communicated with a process chamber of the semiconductor process apparatus; and

a gas outgoing direction of the first gas intake passage and a gas outgoing direction of
30 the second gas intake passage are set to enable gases, which respectively flow into the annular gas mixing passage from the gas outlet end of the first gas intake passage and the

gas outlet end of the second gas intake passage, to rotationally flow in a same direction along a circumferential direction of the annular gas mixing passage when being mixed.

[0009] Optionally, the first gas intake passage includes a plurality of first dispersion holes uniformly distributed along the circumferential direction of the annular gas mixing passage, a connecting line between an orthographic projection of a gas outlet end of each of the first dispersion holes on a radial section of the annular gas mixing passage and a center of the radial section is a first connecting line, a connecting line between an orthographic projection of a gas inlet end of each of the first dispersion holes on the radial section and the center of the radial section is a second connecting line, and an included angle is formed between the first connecting line and the second connecting line.

[0010] Optionally, the second gas intake passage includes a plurality of second dispersion holes uniformly distributed along the circumferential direction of the annular gas mixing passage, a connecting line between an orthographic projection of a gas outlet end of each of the second dispersion holes on the radial section of the annular gas mixing passage and the center of the radial section is a third connecting line, a connecting line between an orthographic projection of a gas inlet end of each of the second dispersion holes on the radial section and the center of the radial section is a fourth connecting line, and an included angle is formed between the third connecting line and the fourth connecting line; and

the second dispersion holes and the first dispersion holes are staggered from each other in an axial direction of the annular gas mixing passage.

[0011] Optionally, the first gas intake passage further includes a first annular sub-passage and a first connecting sub-passage, and the first annular sub-passage is disposed around the annular gas mixing passage on an outer side of the annular gas mixing passage; and the plurality of first dispersion holes are located between the first annular sub-passage and the annular gas mixing passage, the gas inlet end of each of the first dispersion holes is communicated with the first annular sub-passage, and the gas outlet end of each of the first dispersion holes is communicated with the annular gas mixing passage; and

two ends of the first connecting sub-passage are communicated with the first annular sub-passage and the gas outlet end of the first gas intake pipeline, respectively; and a gas outgoing direction of the first connecting sub-passage is set to enable a gas flowing into

the first annular sub-passage to flow rotationally, and a flow direction of the gas in the first annular sub-passage is the same as a flow direction of a gas in the annular gas mixing passage.

[0012] Optionally, the second gas intake passage further includes a second annular sub-passage and a second connecting sub-passage, and the second annular sub-passage is disposed around the annular gas mixing passage on an inner side of the annular gas mixing passage; and the plurality of second dispersion holes are located between the second annular sub-passage and the annular gas mixing passage, the gas inlet end of each of the second dispersion holes is communicated with the second annular sub-passage, and the gas outlet end of each of the second dispersion holes is communicated with the annular gas mixing passage; and

the second connecting sub-passage and the first connecting sub-passage are staggered from each other in the axial direction of the annular gas mixing passage; two ends of the second connecting sub-passage are communicated with the second annular sub-passage and the gas outlet end of the second gas intake pipeline, respectively; and a gas outgoing direction of the second connecting sub-passage is set to enable a gas flowing into the second annular sub-passage to flow rotationally, and a flow direction of the gas in the second annular sub-passage is the same as the flow direction of the gas in the annular gas mixing passage.

[0013] Optionally, an orthographic projection of an axis of the first connecting sub-passage on the radial section of the gas mixing component coincides with any one radial direction on the radial section, or is parallel with the any one radial direction, or forms an included angle with the any one radial direction; and

an orthographic projection of an axis of the second connecting sub-passage on the radial section of the gas mixing component coincides with any one radial direction on the radial section, or is parallel with the any one radial direction, or forms an included angle with the any one radial direction.

[0014] Optionally, the gas mixing device further includes a third gas intake pipeline and an on-off valve disposed on the third gas intake pipeline; and

the gas mixing component is further provided therein with a third gas intake passage, which is located above the annular gas mixing passage; and a gas inlet end of the third gas intake passage is communicated with a gas outlet end of the third gas intake pipeline,

and a gas outlet end of the third gas intake passage is communicated with at least one of the first annular sub-passage and the second annular sub-passage.

[0015] Optionally, the third gas intake passage includes a plurality of third dispersion holes uniformly distributed along the circumferential direction of the annular gas mixing passage, a gas inlet end of each of the third dispersion holes is communicated with the gas outlet end of the third gas intake pipeline, and a gas outlet end of each of the third dispersion holes is communicated with the first annular sub-passage or the second annular sub-passage; or

the third gas intake passage includes two gas hole groups, each of the two gas hole groups includes a plurality of third dispersion holes uniformly distributed along the circumferential direction of the annular gas mixing passage, the plurality of third dispersion holes in one of the two gas hole groups have gas inlet ends communicated with the gas outlet end of the third gas intake pipeline, and gas outlet ends communicated with the first annular sub-passage; and the plurality of third dispersion holes in the other of the two gas hole groups have gas inlet ends communicated with the gas outlet end of the third gas intake pipeline, and gas outlet ends communicated with the second annular sub-passage.

[0016] Optionally, the on-off valve includes a valve body and a valve plate, the valve body is connected between the third gas intake pipeline and the gas mixing component, and a connecting passage is provided in the valve body, and is respectively communicated with the gas outlet end of the third gas intake pipeline and the gas inlet end of the third gas intake passage; and

the valve plate is movably disposed in the connecting passage, and is configured to open or close the connecting passage, and the valve plate is provided with at least one through hole for allowing a gas with a flow less than or equal to a preset flow to pass through the through hole.

[0017] Optionally, the third gas intake passage further includes a third connecting sub-passage, a gas inlet end of the third connecting sub-passage is communicated with the gas outlet end of the third gas intake pipeline, and a gas outlet end of the third connecting sub-passage is communicated with gas inlet ends of the plurality of third dispersion holes; and

a flow guide protrusion is provide on a surface of the gas mixing component which is opposite to the gas outlet end of the third gas intake pipeline, a surface of the flow guide

protrusion which is opposite to the gas outlet end of the third gas intake pipeline is an arc-shaped convex surface, and the flow guide protrusion is configured to guide a gas flowing into the third connecting sub-passage to the gas inlet ends of the plurality of third dispersion holes.

5 [0018] Optionally, a converging passage is further provided below the annular gas mixing passage in the gas mixing component, and includes a third annular sub-passage and a vertical sub-passage, a gas inlet end of the third annular sub-passage is communicated with the gas outlet end of the annular gas mixing passage, a gas outlet end of the third annular sub-passage is communicated with a gas inlet end of the vertical
10 sub-passage, and both an inner diameter and an outer diameter of the third annular sub-passage decrease from the annular gas mixing passage to the vertical sub-passage; and

a gas outlet end of the vertical sub-passage is configured to be communicated with the process chamber of the semiconductor process apparatus.

15 [0019] As another technical solution, the present disclosure further provides a semiconductor process apparatus, including a process chamber, wherein the semiconductor process apparatus further includes the gas mixing device provided in the present disclosure, which is configured to introduce a mixed gas into the process chamber.

20 [0020] Optionally, the process chamber includes a cavity, and a cover plate and a spray device which are disposed at a top of the cavity, and the spray device is located below the cover plate; wherein

the gas mixing component is disposed on the cover plate, the cover plate is provided with a first gas inlet corresponding to the gas outlet end of the annular gas mixing
25 passage, and a flow guide plug is provided in the first gas inlet, and is provided with a plurality of straight through holes for changing a flow direction of the mixed gas flowing through the flow guide plug to a vertical downward direction.

[0021] Optionally, the plurality of straight through holes include a plurality of first straight through holes and a plurality of second straight through holes, and the plurality
30 of first straight through holes are arranged in at least one circle around an axis of the flow guide plug; and

among the plurality of first straight through holes in an outermost circle, at least one second straight through hole is arranged in a gap between every two adjacent first

straight through holes, and a radial section area of the second straight through hole is less than a radial section area of each of the first straight through holes.

[0022] Optionally, the plurality of straight through holes include one first straight through hole having a circular radial section, and one or more second straight through holes having ring-shaped radial sections; and

the one or more second straight through holes surround the first straight through hole, and a plurality of second straight through holes are nested with each other; and each of the one or more second straight through holes is provided with at least one reinforcing rib extending along a radial direction of each of the one or more second straight through holes, and the at least one reinforcing rib is respectively connected to an inner circumferential wall and an outer circumferential wall of each of the one or more second straight through holes along the radial direction of each of the one or more second straight through holes.

[0023] Optionally, a conical passage is disposed at a surface of the cover plate which is opposite to the spray device, an upper end of the conical passage is communicated with the first gas inlet, a lower end of the conical passage is communicated with a second gas inlet of the spray device, and an inner diameter of the conical passage increases from the first gas inlet to the second gas inlet.

[0024] The present disclosure has the following beneficial effects:

according to the gas mixing device provided in the present disclosure, by setting the gas outgoing directions of the first and second gas intake passages to enable the gases, which respectively flow into the annular gas mixing passage from the gas outlet end of the first gas intake passage and the gas outlet end of the second gas intake passage, to rotationally flow in the same direction (clockwise or counterclockwise) along the circumferential direction of the annular gas mixing passage when being mixed, all gases can be mixed while being rotating, that is, forming a rotational flow, so that smoothness of flow of the gases can be improved, flow resistance can be reduced, and flow velocity can be increased, thereby shortening the gas mixing time, increasing the gas mixing efficiency, and facilitating improvement of production capacity. Meanwhile, component momentum exchange and mass mixing can be sufficiently carried out among all the gases while the gases are rotating, so that the mixing uniformity can be effectively improved, thereby improving the product performance. In addition, an external structure of the gas mixing device provided in the present disclosure only consists of the gas

mixing component, the first gas intake pipeline, and the second gas intake pipeline, which makes the gas mixing device simple in structure and high in integration level, so that occupied space can be saved and processing cost can be reduced.

[0025] According to the semiconductor process apparatus provided in the present disclosure, by adopting the gas mixing device provided in the present disclosure, the gas mixing time can be shortened, the gas mixing efficiency can be increased, and the production capacity can be improved; moreover, the mixing uniformity can be effectively improved, thereby improving the product performance.

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BRIEF DESCRIPTION OF DRAWINGS

[0026] FIG. 1 is a schematic diagram of an external structure of a gas mixing device according to a first embodiment of the present disclosure;

[0027] FIG. 2 is a sectional view of the gas mixing device according to the first embodiment of the present disclosure;

15 [0028] FIG. 3 is a sectional view taken along line A-A of FIG. 2;

[0029] FIG. 4 is a sectional view taken along line B-B of FIG. 2;

[0030] FIG. 5 is a schematic diagram illustrating three positional relationships between a second connecting sub-passage and a second annular sub-passage according to the first embodiment of the present disclosure;

20 [0031] FIG. 6 is a perspective sectional view taken along line C-C of FIG. 2;

[0032] FIG. 7 is a top sectional view taken along line C-C of FIG. 2;

[0033] FIG. 8 is a perspective sectional view taken along line D-D of FIG. 2;

[0034] FIG. 9 is a top sectional view taken along line D-D of FIG. 2;

25 [0035] FIG. 10 is a schematic diagram illustrating flow directions of gases in a gas mixing component according to the first embodiment of the present disclosure;

[0036] FIG. 11 is a sectional view of a gas mixing device according to a second embodiment of the present disclosure;

[0037] FIG. 12 is a schematic diagram of an external structure of a gas mixing component according to the second embodiment of the present disclosure;

30 [0038] FIG. 13 is a perspective sectional view taken along line E-E of FIG. 11;

[0039] FIG. 14 is a top view of a third gas intake passage according to the second embodiment of the present disclosure;

[0040] FIG. 15 is a schematic structural diagram of the third gas intake passage according to the second embodiment of the present disclosure;

[0041] FIG. 16 is another schematic structural diagram of the third gas intake passage according to the second embodiment of the present disclosure;

5 [0042] FIG. 17 is still another schematic structural diagram of the third gas intake passage according to the second embodiment of the present disclosure;

[0043] FIG. 18 is a sectional view of an on-off valve according to the second embodiment of the present disclosure;

10 [0044] FIG. 19 is a top view of a valve plate according to the second embodiment of the present disclosure;

[0045] FIG. 20 is a sectional view of a semiconductor process apparatus according to a third embodiment of the present disclosure;

[0046] FIG. 21 is a partial sectional view of a cover plate and a spray device according to the third embodiment of the present disclosure;

15 [0047] FIG. 22 is a radial sectional view of a flow guide plug according to the third embodiment of the present disclosure; and

[0048] FIG. 23 is another radial sectional view of the flow guide plug according to the third embodiment of the present disclosure.

20 DETAIL DESCRIPTION OF EMBODIMENTS

[0049] In order to enable those of ordinary skill in the art to better understand the technical solutions of the present disclosure, a gas mixing device and a semiconductor process apparatus provided in the present disclosure are described in detail below with reference to the drawings.

25 First Embodiment

[0050] A first embodiment of the present disclosure provides a gas mixing device applied to a semiconductor process apparatus such as an ALD apparatus, and the gas mixing device is communicated with a process chamber in the semiconductor process apparatus, for example, the gas mixing device is connected to a spray device disposed on
30 the process chamber. The gas mixing device is configured to mix gases and convey a mixed gas into the process chamber through the spray device.

[0051] Referring to FIG. 1 and FIG. 2, the gas mixing device includes a gas mixing component 1, a first gas intake pipeline 2, and a second gas intake pipeline 3; the first gas intake pipeline 2 and the second gas intake pipeline 3 introduce gases from a side of the gas mixing component 1; each of a gas inlet end of the first gas intake pipeline 2 and a gas inlet end of the second gas intake pipeline 3 is configured to be communicated with at least one gas source, taking the ALD apparatus as an example, the gas inlet end of the first gas intake pipeline 2 is connected to two first branches (21, 22), and is communicated with two different gas sources through the two first branches (21, 22), respectively; a gas inlet end of the second gas intake pipeline 3 is connected to two second branches (31, 32), and is communicated with two different gas sources through the two second branches (31, 32), respectively. Here, the gas sources may include one or more of a reactant gas source, a carrier gas source, and a diluent gas source and the like. During the process, the first gas intake pipeline 2 or the second gas intake pipeline 3 may be separately controlled to introduce a gas, or the first gas intake pipeline 2 and the second gas intake pipeline 3 may be alternately controlled to introduce a gas, or the first gas intake pipeline 2 and/or the second gas intake pipeline 3 may be controlled in a pulsed manner to introduce a gas.

[0052] It should be noted that, in the present embodiment, an extension direction of the first gas intake pipeline 2 and an extension direction of the second gas intake pipeline 3 are both perpendicular to an axial direction (i.e., a vertical direction) of the gas mixing component 1. Illustratively, the extension directions of the first gas intake pipeline 2 and the second gas intake pipeline 3 may be parallel to each other, but the embodiments of the present disclosure are not limited thereto. In practical applications, each of the extension directions of the first gas intake pipeline 2 and the second gas intake pipeline 3 may form any other included angle less than 90° with the axial direction of the gas mixing component 1, and the included angle between the extension direction of the first gas intake pipeline 2 and the axial direction of the gas mixing component 1 may be the same as or different from that between the extension direction of the second gas intake pipeline 3 and the axial direction of the gas mixing component 1, which is not particularly limited in the embodiments of the present disclosure.

[0053] As shown in FIG. 2, the gas mixing component 1 is provided therein with a first gas intake passage 11, a second gas intake passage 12, and an annular gas mixing passage 15, and a gas inlet end of the first gas intake passage 11 and a gas inlet end of

the second gas intake passage 12 are communicated with a gas outlet end of the first gas intake pipeline 2 and a gas outlet end of the second gas intake pipeline 3, respectively; a gas outlet end of the first gas intake passage 11 and a gas outlet end of the second gas intake passage 12 are both communicated with the annular gas mixing passage 15; and a gas outlet end of the annular gas mixing passage 15 is configured to be communicated with the process chamber (not shown) of the semiconductor process apparatus. During the introduction of gases, a gas conveyed with the first gas intake pipeline 2 flows into the annular gas mixing passage 15 through the first gas intake passage 11, and then flows into the process chamber through the annular gas mixing passage 15; and similarly, a gas conveyed with the second gas intake pipeline 3 flows into the annular gas mixing passage 15 through the second gas intake passage 12, and then flows into the process chamber through the annular gas mixing passage 15.

[0054] Moreover, a gas outgoing direction of the first gas intake passage 11 and a gas outgoing direction of the second gas intake passage 12 are set to enable the gases, which respectively flow into the annular gas mixing passage 15 from the gas outlet end of the first gas intake passage 11 and the gas outlet end of the second gas intake passage 12, to rotationally flow in a same direction along a circumferential direction of the annular gas mixing passage 15 when being mixed. A flow direction of the gases in the annular gas mixing passage 15 is a direction of clockwise rotation or counterclockwise rotation around an axis of the annular gas mixing passage 15. When the gases flowing into the annular gas mixing passage 15 from the gas outlet ends of the first and second gas intake passages 11 and 12 are mixed, the gases both rotationally flow in the direction of clockwise rotation around the axis of the annular gas mixing passage 15, or both rotationally flow in the direction of counterclockwise rotation around the axis of the annular gas mixing passage 15. Thus, all the gases flowing into the annular gas mixing passage 15 can be mixed while being rotating, that is, forming a rotational flow, so that smoothness of the flow of the gases can be improved, flow resistance can be reduced, and flow velocity can be increased, which can shorten gas mixing time, increase gas mixing efficiency, and facilitate improvement of production capacity. Meanwhile, component momentum exchange and mass mixing can be sufficiently carried out among all the gases while the gases are rotating, so that mixing uniformity can be effectively improved, thereby improving product performance.

[0055] In the ALD process, the gases are usually introduced under various conditions of large gas flow (e.g., greater than 5000sccm) and small pulse time (less than or equal to 50ms). By mixing all the gases flowing into the annular gas mixing passage 15 while the gases are rotating, the gas mixing device provided in the embodiment of the present disclosure can meet the requirements of the process on the gas mixing time and the gas mixing uniformity well under the above conditions.

[0056] In addition, an external structure of the gas mixing device provided in the embodiment of the present disclosure only consists of the gas mixing component 1, the first gas intake pipeline 2, and the second gas intake pipeline 3, which makes the gas mixing device simple in structure and high in integration level, so that occupied space can be saved and processing cost can be reduced.

[0057] In some alternative embodiments, as shown in FIG. 6, FIG. 7, and FIG.10, the first gas intake passage 11 includes a plurality of first dispersion holes 113 uniformly distributed along the circumferential direction of the annular gas mixing passage 15. As shown in FIG. 7, a connecting line between an orthographic projection of a gas outlet end B1 of each first dispersion hole 113 on a radial section of the annular gas mixing passage 15 and a center O of the radial section is a first connecting line L1, a connecting line between an orthographic projection of a gas inlet end B2 of each first dispersion hole 113 on the radial section and the center O of the radial section is a second connecting line L2, and an included angle is formed between the first connecting line L1 and the second connecting line L2, that is, the gas outlet end B1 and the gas inlet end B2 of each first dispersion hole 113 are not in the same radial direction. For example, an extension direction of each first dispersion hole 113 is tangential to the circumferential direction of the annular gas mixing passage 15, such that a gas outgoing direction of each first dispersion hole 113 deviates from a radial direction. Moreover, the plurality of first dispersion holes 113 deviate towards the same direction. The gas outgoing direction of each first dispersion hole 113 is as shown by the arrows in FIG. 7, such that the gas flowing into the annular gas mixing passage 15 through each first dispersion hole 113 can rotationally flow along the same direction (clockwise or counterclockwise), thereby forming the rotational flow.

[0058] It should be noted that the number and sizes of the first dispersion holes 113, an angle at which the gas outgoing direction of each first dispersion hole 113 deviates from the radial direction, and a size of the angle may be set according to specific needs in

practical applications, which is not particularly limited in the embodiments of the present disclosure.

[0059] Similarly, in some alternative embodiments, as shown in FIG. 8, FIG. 9, and FIG. 10, the second gas intake passage 12 includes a plurality of second dispersion holes 123 uniformly distributed along the circumferential direction of the annular gas mixing passage 15. As shown in FIG. 9, a connecting line between an orthographic projection of a gas outlet end B3 of each second dispersion hole 123 on the radial section of the annular gas mixing passage 15 and the center O of the radial section is a third connecting line L3, a connecting line between an orthographic projection of a gas inlet end B4 of each second dispersion hole 123 on the radial section and the center O of the radial section is a fourth connecting line L4, and an included angle is formed between the third connecting line L3 and the fourth connecting line L4, that is, the gas outlet end B3 and the gas inlet end B4 of each second dispersion hole 123 are not in the same radial direction. For example, an extension direction of each second dispersion hole 123 is tangential to a circumferential direction of a second annular sub-passage 122 (described in detail below), such that a gas outgoing direction of each second dispersion hole 123 deviates from a radial direction. Moreover, the plurality of second dispersion holes 123 deviate towards the same direction. The gas outgoing direction of each second dispersion hole 123 is as shown by the arrows in FIG. 9, such that the gas flowing into the annular gas mixing passage 15 through each second dispersion hole 123 can rotationally flow along the same direction (clockwise or counterclockwise), thereby forming a rotational flow. Moreover, a flow direction of the gas flowing into the annular gas mixing passage 15 from each second dispersion hole 123 is the same as a flow direction of the gas flowing into the annular gas mixing passage 15 from each first dispersion hole 113, that is, the flow directions are both clockwise or are both counterclockwise. It should be understood that the gas outgoing direction of each second dispersion hole 123 is from a center to an edge because the second gas intake passage 12 is located on an inner side of the annular gas mixing passage 15, and the gas outgoing direction of each first dispersion hole 113 is from the edge to the center because the first gas intake passage 11 is located on an outer side of the annular gas mixing passage 15.

[0060] It should be noted that the number and sizes of the second dispersion holes 123, an angle at which the gas outgoing direction of each second dispersion hole 123 deviates from the radial direction, and a size of the angle may be set according to specific needs

in practical applications, which is not particularly limited in the embodiments of the present disclosure. In addition, the above parameters of the second dispersion holes 123 may be the same as or different from the above parameters of the first dispersion holes 113.

5 [0061] In a specific implementation, directions of the first dispersion holes 113 may be perpendicular to the axial direction of the gas mixing component 1, or may incline towards the axial direction of the gas mixing component 1, which is not limited herein. Similarly, directions of the second dispersion holes 123 may be perpendicular to the axial direction of the gas mixing component 1, or may incline towards the axial direction
10 of the gas mixing component 1, which is not limited herein.

[0062] In some alternative embodiments, a height of the gas outlet end (i.e., a portion of the first dispersion hole 113 which is communicated with the annular gas mixing passage 15) of the first dispersion hole 113 is different from that of the gas outlet end (i.e., a portion of the second dispersion hole 123 which is communicated with the annular gas
15 mixing passage 15) of the second dispersion hole 123. Illustratively, taking a case where the directions of the first dispersion hole 113 and the directions of the second dispersion hole 123 are perpendicular to the axial direction of the gas mixing member 1 as an example, as shown in FIG. 10, a height of the first dispersion hole 113 is different from that of the second dispersion hole 123, that is, the first dispersion hole 113 and the
20 second dispersion hole 123 are staggered from each other in the vertical direction, which can avoid direct meeting of the gas flowing out from the first dispersion hole 113 and the gas flowing out from the second dispersion hole 123 in the annular gas mixing passage 15; and with the first dispersion hole 113 and the second dispersion hole 123 staggered from each other in the vertical direction, the gas flowing into the annular gas mixing
25 passage 15 from one of the first dispersion hole 113 and the second dispersion hole 123 may be allowed to meet, after rotationally flowing for a while, the gas flowing into the annular gas mixing passage 15 from the other of the first dispersion hole 113 and the second dispersion hole 123, which enables the gases to form stable rotational flow before being mixed, and avoids generation of a turbulent flow due to the direct meeting, thereby
30 avoiding an uncontrollable mixing effect. In practical applications, the height of the first dispersion hole 113 may be set to be greater than that of the second dispersion hole 123, or the height of the first dispersion hole 113 may be set to be less than that of the second dispersion hole 123.

[0063] In some alternative embodiments, referring to FIG. 2, FIG. 3, and FIG. 10, the first gas intake passage 11 further includes a first annular sub-passage 112 and a first connecting sub-passage 111, the first annular sub-passage 112 is disposed around the annular gas mixing passage 15 on an outer side of the annular gas mixing passage 15, the plurality of first dispersion holes 113 are located between the first annular sub-passage 112 and the annular gas mixing passage 15, the gas inlet end of each first dispersion hole 113 is communicated with the first annular sub-passage 112, and the gas outlet end of each first dispersion hole 113 is communicated with the annular gas mixing passage 15. Optionally, a top end of the first annular sub-passage 112 is higher than a top end of the annular gas mixing passage 15, and a bottom end of the first annular sub-passage 112 is lower than the top end of the annular gas mixing passage 15, so that the first annular sub-passage 112 and the annular gas mixing passage 15 partially overlap each other in the vertical direction, and the plurality of first dispersion holes 113 are communicated with the first annular sub-passage 112 and the annular gas mixing passage 15 at overlapping portions of the first annular sub-passage 112 and the annular gas mixing passage 15.

[0064] Moreover, two ends of the first connecting sub-passage 111 are communicated with the first annular sub-passage 112 and the gas outlet end of the first gas intake pipeline 2, respectively. In some alternative embodiments, a gas inlet end of the first connecting sub-passage 111 is located on a side surface of the gas mixing component 1, so that the gases can be introduced from the side, and a reserved space for a gas intake structure can be provided on the side of a top surface of the gas mixing component. Optionally, the first connecting sub-passage 111 is perpendicular to the axial direction (i.e., the vertical direction) of the annular gas mixing passage 15, but the embodiments of the present disclosure are not limited thereto. In practical applications, an included angle less than 90° may be formed between the first connecting sub-passage 111 and the axial direction of the annular gas mixing passage 15.

[0065] The gas conveyed with the first gas intake pipeline 2 may flow into the first annular sub-passage 112 through the first connecting sub-passage 111. Moreover, a gas outgoing direction of the first connecting sub-passage 111 is set to enable the gas flowing into the first annular sub-passage 112 to flow rotationally, and a flow direction of the gas in the first annular sub-passage 112 is the same as the flow direction of the gas in the annular gas mixing passage 15, that is, the gas in the first annular sub-passage 112

and the gas in the annular gas mixing passage 15 both rotationally flow clockwise or counterclockwise around the axis of the annular gas mixing passage 15. Thus, the gas flowing into the first annular sub-passagage 112 is also mixed while being rotating, thereby forming a rotational flow. A direction of the rotational flow in the first annular sub-passagage 112 is the same as that in the annular gas mixing passage 15, that is, if the direction of the rotational flow in the first annular sub-passagage 112 is counterclockwise, the direction of the rotational flow in the annular gas mixing passage 15 is also counterclockwise; and if the direction of the rotational flow in the first annular sub-passagage 112 is clockwise, the direction of the rotational flow in the annular gas mixing passage 15 is also clockwise. By making the direction of the rotational flow in the first annular sub-passagage 112 the same as that in the annular gas mixing passage 15, the gas in the first annular sub-passagage 112 can still flow rotationally in the same rotational-flow direction when flowing into the annular gas mixing passage 15 through the plurality of first dispersion holes 113, so that generation of a turbulent flow can be avoided, and smooth flow can be ensured. In addition, by enabling the gas flowing into the first annular sub-passagage 112 to be mixed while being rotating, flow smoothness and mixing uniformity of the gas can be further improved on the basis of enabling the gas flowing into the annular gas mixing passage 15 to form the rotational flow.

[0066] Similarly, referring to FIG. 2, FIG. 4, and FIG. 10, the second gas intake passage 12 further includes the second annular sub-passagage 122 and a second connecting sub-passagage 121, and the second annular sub-passagage 122 is disposed around the annular gas mixing passage 15 on the inner side of the annular gas mixing passage 15; and the plurality of second dispersion holes 123 are located between the second annular sub-passagage 122 and the annular gas mixing passage 15, the gas inlet end of each second dispersion hole 123 is communicated with the second annular sub-passagage 122, and the gas outlet end of each second dispersion hole 123 is communicated with the annular gas mixing passage 15. Optionally, a top end of the second annular sub-passagage 122 is higher than the top end of the annular gas mixing passage 15, and a bottom end of the second annular sub-passagage 122 is lower than the top end of the annular gas mixing passage 15, so that the second annular sub-passagage 122 and the annular gas mixing passage 15 partially overlap each other in the vertical direction, and the plurality of second dispersion holes 123 are communicated with the second annular sub-passagage 122 and the

annular gas mixing passage 15 at overlapping portions of the second annular sub-passage 122 and the annular gas mixing passage 15.

[0067] Moreover, a height of the second connecting sub-passage 121 is different from that of the first connecting sub-passage 111, that is, the second connecting sub-passage 121 and the first connecting sub-passage 111 are staggered from each other in the axial direction of the annular gas mixing passage 15. For example, as shown in FIG. 10, the second connecting sub-passage 121 is higher than the first connecting sub-passage 111, and adaptively, an upper end of the second annular sub-passage 122 is higher than an upper end of the first annular sub-passage 112, so that the first annular sub-passage 112 located on an outer side of the second annular sub-passage 122 can reserve an avoidance space thereabove for the second connecting sub-passage 121, so as to enable two ends of the second connecting sub-passage 121 to respectively extend to and be communicated with the second annular sub-passage 122 located on an inner side of the first annular sub-passage 112 and the gas outlet end of the second gas intake pipeline 3.

[0068] In some alternative embodiments, a gas inlet end of the second connecting sub-passage 121 is located on a side surface of the gas mixing component 1, so that the gases can be introduced from the side, and a reserved space for the gas intake structure can be provided on the side of the top surface of the gas mixing component. Optionally, the second connecting sub-passage 121 is perpendicular to the axial direction of the annular gas mixing passage 15, but the embodiments of the present disclosure are not limited thereto. In practical applications, an included angle less than 90° may be formed between the second connecting sub-passage 121 and the axial direction of the annular gas mixing passage 15.

[0069] The gas conveyed with the second gas intake pipeline 3 may flow into the second annular sub-passage 122 through the second connecting sub-passage 121. Moreover, a gas outgoing direction of the second connecting sub-passage 121 is set to enable the gas flowing into the second annular sub-passage 122 to flow rotationally, and a flow direction of the gas in the second annular sub-passage 122 is the same as that of the gas in the annular gas mixing passage 15, that is, the gas in the second annular sub-passage 122 and the gas in the annular gas mixing passage 15 both rotationally flow clockwise or counterclockwise around the axis of the annular gas mixing passage 15. Thus, the gas flowing into the second annular sub-passage 122 is also mixed while being rotating, thereby forming a rotational flow. A direction of the rotational flow in the second

annular sub-passage 122 is the same as that in the annular gas mixing passage 15, that is, if the direction of the rotational flow in the second annular sub-passage 122 is counterclockwise, the direction of the rotational flow in the annular gas mixing passage 15 is also counterclockwise; and if the direction of the rotational flow in the second annular sub-passage 122 is clockwise, the direction of the rotational flow in the annular gas mixing passage 15 is also clockwise. By making the direction of the rotational flow in the second annular sub-passage 122 the same as that in the annular gas mixing passage 15, the gas in the second annular sub-passage 122 can still flow rotationally in the same rotational-flow direction when flowing into the annular gas mixing passage 15 through the plurality of second dispersion holes 123, so that generation of a turbulent flow can be avoided, and smooth flow can be ensured. In addition, by enabling the gas flowing into the second annular sub-passage 122 to be mixed while being rotating, smoothness of gas flow and mixing uniformity of the gas can be further improved on the basis of enabling the gas flowing into the annular gas mixing passage 15 to form the rotational flow.

[0070] In some alternative embodiments, as shown in FIG. 5, taking the second annular sub-passage 122 and the second connecting sub-passage 121 as an example, an orthographic projection of an axis of the second connecting sub-passage 121 on the radial section of the gas mixing component 1 coincides with any one radial direction on the radial section, or is parallel with the any one radial direction, or forms an included angle with the any one radial direction. For example, a schematic diagram (a) of FIG. 5 shows a case where an axis A1 of the second connecting sub-passage 121 is parallel with a radial direction A2; a schematic diagram (b) of FIG. 5 shows a case where the axis A1 of the second connecting sub-passage 121 coincides with the radial direction A2; and a schematic diagram (c) of FIG. 5 shows a case where an included angle is formed between the axis A1 of the second connecting sub-passage 121 and the radial direction A2. The arrangement of the first annular sub-passage 112 and the first connecting sub-passage 111 is similar to that of the second annular sub-passage 122 and the second connecting sub-passage 121, that is, an orthographic projection of an axis of the first connecting sub-passage 111 on the radial section of the gas mixing component 1 coincides with any one radial direction on the radial section, or is parallel with the any one radial direction, or forms an included angle with the any one radial direction.

[0071] It should be noted that the first connecting sub-passage 111 and the second connecting sub-passage 121 may be parallel to each other, or may form an included

angle in a horizontal plane, as long as a size of the included angle can ensure that the direction of the rotational flow of the gas flowing into the second annular sub-passage 122 through the second connecting sub-passage 121 and the direction of the rotational flow of the gas flowing into the first annular sub-passage 112 through the first connecting sub-passage 111 are both the same as the direction of the rotational flow in the annular gas mixing passage 15.

Second Embodiment

[0072] The gas mixing device provided in a second embodiment of the present disclosure makes an improvement on the gas mixing device provided in the first embodiment. Specifically, referring to FIG. 11 and FIG. 12, on the basis of the first embodiment, the gas mixing device may further include a third gas intake pipeline 4 and an on-off valve 5 disposed on the third gas intake pipeline 4 and used for connection and disconnection of the third gas intake pipeline 4. A gas inlet end of the third gas intake pipeline 4 may be connected to, for example, a remote plasma source (for providing a cleaning gas carrying plasma radicals) for performing a plasma cleaning process on the pipelines and the process chamber to remove particles generated during the process. However, the embodiments of the present disclosure are not limited to the above example. In practical applications, the gas inlet end of the third gas intake pipeline 4 may be connected to at least one of a source for a purge gas, a source for a source gas, and a source for a diluent gas.

[0073] As shown in FIG. 11, the gas mixing component 1 is further provided therein with a third gas intake passage 17 located above the annular gas mixing passage 15; a gas inlet end of the third gas intake passage 17 is communicated with a gas outlet end of the third gas intake pipeline 4; and a gas outlet end of the third gas intake passage 17 is communicated with at least one of the first annular sub-passage 112 and the second annular sub-passage 122. A gas conveyed with the third gas intake pipeline 4 flows into at least one of the first annular sub-passage 112 and the second annular sub-passage 122 through the third gas intake passage 17. By use of the third gas intake pipeline 4 and the third gas intake passage 17, while performing a cleaning process or a purging process, a cleaning gas or a purge gas can be introduced into the pipelines, the passages, and the process chamber from a top of the gas mixing device, so that the cleaning process and the purging process can be performed sufficiently from the top of the gas mixing device,

thereby avoiding residue in a dead zone at the top and improving a cleaning and purging effect.

[0074] In some alternative embodiments, as shown in FIG. 13, FIG. 14, and FIG. 15, the third gas intake passage 17 includes a plurality of third dispersion holes 172 uniformly distributed along the circumferential direction of the annular gas mixing passage 15, and each third dispersion hole 172 has a gas inlet end communicated with the gas outlet end of the third gas intake pipeline 4, and a gas outlet end communicated with the first annular sub-passage 112, so as to uniformly convey the gas in the third gas intake pipeline 4 to the first annular sub-passage 112. However, the embodiments of the present disclosure are not limited thereto. For example, as shown in FIG. 16, the gas outlet end of each third dispersion hole 172 may be communicated with the second annular sub-passage 122, so as to uniformly convey the gas in the third gas intake pipeline 4 to the second annular sub-passage 122. Or, as shown in FIG. 17, the third gas intake passage 17 includes two gas hole groups each including a plurality of third dispersion holes uniformly distributed along the circumferential direction of the annular gas mixing passage 15, the plurality of third dispersion holes 172a in one of the two gas hole groups have gas inlet ends communicated with the gas outlet end of the third gas intake pipeline 4, and gas outlet ends communicated with the first annular sub-passage 112, so as to uniformly convey the gas in the third gas intake pipeline 4 to the first annular sub-passage 112; and the plurality of third dispersion holes 172b in the other of the two gas hole groups have gas inlet ends communicated with the gas outlet end of the third gas intake pipeline 4, and gas outlet ends communicated with the second annular sub-passage 122, so as to uniformly convey the gas in the third gas intake pipeline 4 to the second annular sub-passage 122.

[0075] In some alternative embodiments, as shown in FIG. 12, FIG. 14 to FIG. 18, the third gas intake passage 17 further includes a third connecting sub-passage 171, a gas inlet end of the third connecting sub-passage 171 is communicated with the gas outlet end of the third gas intake pipeline 4, and a gas outlet end of the third connecting sub-passage 171 is communicated with the gas inlet ends of the plurality of third dispersion holes 172. Optionally, an axis of the third connecting sub-passage 171 is parallel to the axial direction of the annular gas mixing passage 15, such that the gas inlet end of the third connecting sub-passage 171 is located at a top surface of the gas mixing component 1, thereby achieving introduction of the gases from the top.

[0076] In some alternative embodiments, as shown in FIG. 18 and FIG. 19, the on-off valve includes a valve body 51 and a valve plate 52, the valve body 51 is connected between the third gas intake pipeline 4 and the gas mixing component 1, a connecting passage 511 is provided in the valve body 51, and is respectively communicated with the gas outlet end of the third gas intake pipeline 4 and the gas inlet end of the third gas intake passage 17 (e.g., the third connecting sub-passage 171); the valve plate 52 is movably disposed in the connecting passage 511, and is configured to open or close the connecting passage 511 for opening a gas path or closing and sealing the gas path; and the valve plate 52 is provided with at least one through hole 521 for allowing a gas with a flow less than or equal to a preset flow to pass through the through hole 521. With the through hole 521, even the valve plate 52 is in a state of disconnecting the connecting passage 511, a small flow of gas can be still allowed to pass through the through hole 521, so as to suppress backflow of the gases from downstream and prevent particles from escaping back to the upstream pipelines, thereby ensuring cleanliness of the pipelines. When a cleaning process or a purging process needs to be performed, the valve plate 52 may be controlled to open, so as to allow a large flow of cleaning gas or purge gas to pass through the connecting passage 511 and enter the third gas intake passage 17. The number of the through holes 521 may be three or more, and a plurality of through holes 521 may be uniformly or non-uniformly distributed on the valve plate 52; and a radial section shape of the through hole 521 is, for example, circular, rectangular, square, or oval. In practical applications, a ventilation volume may be adjusted by setting the number and ventilation cross-sectional areas of the through holes 521.

[0077] In other alternative embodiments, instead of the on-off valve, a butterfly valve may be adopted, and a valve core of the butterfly valve may be adjusted to switch between a low-flow constant-on state and a large-flow ventilation state.

[0078] In some alternative embodiments, as shown in FIG. 12 and FIG. 18, a flow guide protrusion 19 is provide on a surface of the gas mixing component 1 which is opposite to the gas outlet end of the third gas intake pipeline 4, a surface of the flow guide protrusion 19 which is opposite to the gas outlet end of the third gas intake pipeline 4 is an arc-shaped convex surface 191, and the flow guide protrusion 19 is configured to guide the gas flowing into the third connecting sub-passage 171 to the gas inlet ends of the plurality of third dispersion holes 172. The flow guide protrusion 19 can reduce a flow dead zone while performing a guiding function, thereby avoiding residual gas.

[0079] In some alternative embodiments, as shown in FIG. 11, a converging passage 16 is further provided below the annular gas mixing passage 15 in the gas mixing component 1, and includes a third annular sub-passage 161 and a vertical sub-passage 162. A gas inlet end of the third annular sub-passage 161 is communicated with the gas outlet end of the annular gas mixing passage 15, a gas outlet end of the third annular sub-passage 161 is communicated with a gas inlet end of the vertical sub-passage 162, and both an inner diameter and an outer diameter of the third annular sub-passage 161 decrease from the annular gas mixing passage 15 to the vertical sub-passage 162; a diameter of the vertical sub-passage 162 is equal to the minimum value of the outer diameter of the third annular sub-passage 161; an outer diameter of the annular gas mixing passage 15 is equal to the maximum value of the outer diameter of the third annular sub-passage 161; and a gas outlet end of the vertical sub-passage 162 is configured to be communicated with the process chamber of the semiconductor process apparatus. The gas obtained through full mixing in the annular gas mixing passage 15 is gathered under the action of the third annular sub-passage 161, and flows downwards along the vertical direction under a guiding action of the vertical sub-passage 162.

[0080] In summary, according to the gas mixing device provided in the above embodiments of the present disclosure, by setting the gas outgoing directions of the first and second gas intake passages to enable the gases, which respectively flow into the annular gas mixing passage from the gas outlet end of the first gas intake passage and the gas outlet end of the second gas intake passage, to rotationally flow in the same direction (clockwise or counterclockwise) along a circumferential direction of the annular gas mixing passage when being mixed, all the gases can be mixed while being rotating, that is, forming the rotational flow, so that the smoothness of the flow of the gases can be improved, the flow resistance can be reduced, and the flow velocity can be increased, thereby shortening the gas mixing time, increasing the gas mixing efficiency, and facilitating the improvement of production capacity. Meanwhile, component momentum exchange and mass mixing can be sufficiently carried out among all the gases while the gases are rotating, so that the mixing uniformity can be effectively improved, thereby improving the product performance. In addition, the external structure of the gas mixing device provided in the embodiments of the present disclosure only consists of the gas mixing component, the first gas intake pipeline, and the second gas intake pipeline,

which makes the gas mixing device simple in structure and high in integration level, so that the occupied space can be saved and the processing cost can be reduced.

Third Embodiment

[0081] As another technical solution, referring to FIG. 20, a third embodiment of the present disclosure further provides a semiconductor process apparatus, including a process chamber 6, and the gas mixing device provided in any of above embodiments of the present disclosure, and the gas mixing device is configured to introduce a mixed gas into the process chamber 6. A base 64 for bearing a wafer is provided in the process chamber 6, and a heating device may be provided in the base 64 for heating the wafer. In addition, a gas discharge pipeline 65 is disposed at a bottom of the process chamber 6, and is configured to discharge a gas from the process chamber 6.

[0082] In some alternative embodiments, as shown in FIG. 20 and FIG. 21, the process chamber 6 includes a cavity 61, and a cover plate 62 and a spray device 63 which are disposed at a top of the cavity 61, and the spray device 63 is located below the cover plate 62. The gas mixing component 1 is disposed on the cover plate 62, the cover plate 62 is provided with a first gas inlet 621 corresponding to the gas outlet end of the vertical sub-passage 162, one end of the first gas inlet 621 close to the spray device 63 is provided with a curved rounded corner for improving gas flow smoothness. In practical applications, the converging passage 16 may be omitted, in which case the gas outlet end of the annular gas mixing passage 15 is communicated with the first gas inlet 621.

[0083] Moreover, as shown in FIG. 21 and FIG. 22, a flow guide plug 7 is provided in the first gas inlet 621, and is provided with a plurality of straight through holes 71 for changing a flow direction of the mixed gas flowing through the flow guide plug 7 to a vertical downward direction. The flow guide plug 7 may perform baffling guiding on the gas flowing downwards (that is, after the gas in a rotational flow state strikes hole walls in the flow guide plug 7, a component of the flow velocity of the gas in the radial direction is almost 0), so that the gas is changed from the rotational flow state to a state of flowing vertically downwards, which facilitates distribution of the gas by the spray device 63. Thus, it can be ensured that the gas entering the process chamber does not rotate any more, which ensures controllability of a film formation process.

[0084] In some alternative embodiments, as shown in FIG. 22, the plurality of straight through holes 71 include a plurality of first straight through holes 71a and a plurality of second straight through holes 71b, a radial section shape of the first straight through hole

71a is hexagonal, and the plurality of first straight through holes 71a are arranged in a honeycomb shape; among the plurality of first straight through holes 71a in the outermost circle, at least one second straight through hole 71b is arranged in a gap between every two adjacent first straight through holes 71a, and a radial section area of the second straight through hole 71b is less than that of the first straight through hole 71a. Specifically, as shown in FIG. 22, six first straight through holes 71a are arranged in a circle and surround one first straight through hole 71a, and one second straight through hole 71b is arranged between every two adjacent two first straight through holes 71a among the six first straight through holes 71a. With such arrangement, a ratio of an area of a wall surface (i.e., a non-through-hole region) of the flow guide plug 7 to a whole radial section area of the flow guide plug 7 can be reduced as much as possible, so that the flow resistance can be reduced to the greatest extent, and the gas flow smoothness can be ensured. In practical applications, the first straight through holes 71a may be arranged in multiple circles around an axis of the flow guide plug 7, and the radial section shape of the first straight through hole 71a may be in any other shape, such as a circle, a square, a triangle, a rhombus, or a trapezoid. A radial section shape of the second straight through hole 71b may also take any shape, such as a circle, a square, a triangle, a hexagon, a rhombus, or a trapezoid.

[0085] In some other alternative embodiments, as shown in FIG. 23, the plurality of straight through holes 71 include one first straight through hole 71a having a circular radial section, and one or more second straight through holes 71b having ring-shaped radial sections; the second straight through hole 71b surrounds the first straight through hole 71a, and a plurality of second straight through holes 71b are nested with each other; and each second straight through hole 71b is provided with at least one reinforcing rib 72 extending along a radial direction of the second straight through hole 71b and configured to increase wall surface strength. For example, a plurality of reinforcing ribs 72 are provided and uniformly distributed along a circumferential direction of the second straight through hole 71b. Specifically, as shown in FIG. 23, two second straight through holes 71b are provided and both surround the first straight through hole 71a, one of the two second straight through holes 71b surrounds the other second straight through hole 71b, and four reinforcing ribs 72 are uniformly distributed in the inner second straight through hole 71b; and eight reinforcing ribs are uniformly distributed in the outer second straight through hole 71b, and are staggered from the four reinforcing ribs 72 in the inner

second straight through hole 71b in the circumferential direction of the second straight through hole 71b, so as to uniformly increase the wall surface strength. Optionally, the number of the second straight through holes 71b is 2 to 4.

[0086] It should be noted that the plurality of straight through holes 71 are not limited to the above two layout manners in practical applications, and may adopt any other layout manner in practical applications as long as the ratio of the area of the wall surface (i.e., the non-through-hole region) to the whole radial section area of the flow guide plug 7 can be reduced as much as possible on the basis of ensuring the strength of the wall surface, so as to reduce the flow resistance to the greatest extent and ensure the gas flow smoothness. Optionally, a wall thickness of a single hole is greater than or equal to 0.5mm and less than or equal to 2mm.

[0087] In some alternative embodiments, as shown in FIG. 21, a conical passage 622 is disposed at a surface of the cover plate 62 which is opposite to the spray device 63, an upper end of the conical passage 622 is communicated with the first gas inlet 621, a lower end of the conical passage 622 is communicated with a second gas inlet 631 of the spray device 63, and an inner diameter of the conical passage 622 increases from the first gas inlet 621 to the second gas inlet 631. Thus, a side wall of the conical passage 622 may form a space in a shape like an inverted “funnel”, and the space may press the gas flowing out from the first gas inlet 621 to diffuse to edges quickly, thereby increasing a diffusion speed of the gas. Therefore, uniformity of distributing the gas by the spray device 63 can be improved; and meanwhile, a whole volume of the chamber can be reduced, which facilitates shortening of cleaning or purging time, thereby improving process efficiency.

[0088] According to the semiconductor process apparatus provided in the embodiment of the present disclosure, by adopting the gas mixing device provided in each embodiment of the present disclosure, the gas mixing time can be shortened, the gas mixing efficiency can be increased, and the production capacity can be improved; moreover, the mixing uniformity can be effectively improved, thereby improving the product performance. By taking adopting the semiconductor process apparatus shown in FIG. 20 to perform an ALD process as an example, it is found through experiments that uniformity of mass distribution of a source gas on a surface of a wafer is less than 2%, uniformity of film thickness is less than 1%, and process uniformity is effectively improved.

[0089] 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. A gas mixing device applied to a semiconductor process apparatus, comprising a gas mixing component, a first gas intake pipeline, and a second gas intake pipeline; the gas mixing component being provided therein with a first gas intake passage, a second gas intake passage, and an annular gas mixing passage, wherein

a gas inlet end of the first gas intake passage and a gas inlet end of the second gas intake passage are communicated with a gas outlet end of the first gas intake pipeline and a gas outlet end of the second gas intake pipeline, respectively; a gas outlet end of the first gas intake passage and a gas outlet end of the second gas intake passage are both communicated with the annular gas mixing passage; and a gas outlet end of the annular gas mixing passage is configured to be communicated with a process chamber of the semiconductor process apparatus; and

a gas outgoing direction of the first gas intake passage and a gas outgoing direction of the second gas intake passage are set to enable gases, which respectively flow into the annular gas mixing passage from the gas outlet end of the first gas intake passage and the gas outlet end of the second gas intake passage, to rotationally flow in a same direction along a circumferential direction of the annular gas mixing passage when being mixed.

2. The gas mixing device of claim 1, wherein the first gas intake passage comprises a plurality of first dispersion holes uniformly distributed along the circumferential direction of the annular gas mixing passage, a connecting line between an orthographic projection of a gas outlet end of each of the plurality of first dispersion holes on a radial section of the annular gas mixing passage and a center of the radial section is a first connecting line, a connecting line between an orthographic projection of a gas inlet end of each of the plurality of first dispersion holes on the radial section and the center of the radial section is a second connecting line, and an included angle is formed between the first connecting line and the second connecting line.

3. The gas mixing device of claim 2, wherein the second gas intake passage

comprises a plurality of second dispersion holes uniformly distributed along the circumferential direction of the annular gas mixing passage, a connecting line between an orthographic projection of a gas outlet end of each of the plurality of second dispersion holes on the radial section of the annular gas mixing passage and the center of the radial section is a third connecting line, a connecting line between an orthographic projection of a gas inlet end of each of the plurality of second dispersion holes on the radial section and the center of the radial section is a fourth connecting line, and an included angle is formed between the third connecting line and the fourth connecting line; and

the plurality of second dispersion holes and the plurality of first dispersion holes are staggered from each other in an axial direction of the annular gas mixing passage.

4. The gas mixing device of claim 3, wherein the first gas intake passage further comprises a first annular sub-passage and a first connecting sub-passage, and the first annular sub-passage is disposed around the annular gas mixing passage on an outer side of the annular gas mixing passage; and the plurality of first dispersion holes are located between the first annular sub-passage and the annular gas mixing passage, the gas inlet end of each of the plurality of first dispersion holes is communicated with the first annular sub-passage, and the gas outlet end of each of the plurality of first dispersion holes is communicated with the annular gas mixing passage; and

two ends of the first connecting sub-passage are communicated with the first annular sub-passage and the gas outlet end of the first gas intake pipeline, respectively; and a gas outgoing direction of the first connecting sub-passage is set to enable a gas flowing into the first annular sub-passage to flow rotationally, and a flow direction of the gas in the first annular sub-passage is the same as a flow direction of a gas in the annular gas mixing passage.

5. The gas mixing device of claim 4, wherein the second gas intake passage further comprises a second annular sub-passage and a second connecting sub-passage, and the second annular sub-passage is disposed around the annular gas mixing passage on an inner side of the annular gas mixing passage; and the plurality of

second dispersion holes are located between the second annular sub-passage and the annular gas mixing passage, the gas inlet end of each of the plurality of second dispersion holes is communicated with the second annular sub-passage, and the gas outlet end of each of the plurality of second dispersion holes is communicated with the annular gas mixing passage; and

the second connecting sub-passage and the first connecting sub-passage are staggered from each other in the axial direction of the annular gas mixing passage; two ends of the second connecting sub-passage are communicated with the second annular sub-passage and the gas outlet end of the second gas intake pipeline, respectively; and a gas outgoing direction of the second connecting sub-passage is set to enable a gas flowing into the second annular sub-passage to flow rotationally, and a flow direction of the gas in the second annular sub-passage is the same as the flow direction of the gas in the annular gas mixing passage.

6. The gas mixing device of claim 5, wherein an orthographic projection of an axis of the first connecting sub-passage on a radial section of the gas mixing component coincides with any one radial direction on the radial section, or is parallel with the any one radial direction, or forms an included angle with the any one radial direction; and

an orthographic projection of an axis of the second connecting sub-passage on the radial section of the gas mixing component coincides with any one radial direction on the radial section, or is parallel with the any one radial direction, or forms an included angle with the any one radial direction.

7. The gas mixing device of claim 5, further comprising a third gas intake pipeline and an on-off valve disposed on the third gas intake pipeline; and

the gas mixing component is further provided therein with a third gas intake passage, which is located above the annular gas mixing passage; and a gas inlet end of the third gas intake passage is communicated with a gas outlet end of the third gas intake pipeline, and a gas outlet end of the third gas intake passage is communicated with at least one of the first annular sub-passage and the second annular sub-passage.

8. The gas mixing device of claim 7, wherein the third gas intake passage

comprises a plurality of third dispersion holes uniformly distributed along the circumferential direction of the annular gas mixing passage, a gas inlet end of each of the plurality of third dispersion holes is communicated with the gas outlet end of the third gas intake pipeline, and a gas outlet end of each of the plurality of third dispersion holes is communicated with the first annular sub-passage or the second annular sub-passage; or

the third gas intake passage comprises two gas hole groups, each of the two gas hole groups comprises a plurality of third dispersion holes uniformly distributed along the circumferential direction of the annular gas mixing passage, the plurality of third dispersion holes in one of the two gas hole groups have gas inlet ends communicated with the gas outlet end of the third gas intake pipeline, and gas outlet ends communicated with the first annular sub-passage; and the plurality of third dispersion holes in the other of the two gas hole groups have gas inlet ends communicated with the gas outlet end of the third gas intake pipeline, and gas outlet ends communicated with the second annular sub-passage.

9. The gas mixing device of claim 8, wherein the on-off valve comprises a valve body and a valve plate, the valve body is connected between the third gas intake pipeline and the gas mixing component, and a connecting passage is provided in the valve body, and is respectively communicated with the gas outlet end of the third gas intake pipeline and the gas inlet end of the third gas intake passage; and

the valve plate is movably disposed in the connecting passage, and is configured to open or close the connecting passage, and the valve plate is provided with at least one through hole for allowing a gas with a flow less than or equal to a preset flow to pass through the through hole.

10. The gas mixing device of claim 8, wherein the third gas intake passage further comprises a third connecting sub-passage, a gas inlet end of the third connecting sub-passage is communicated with the gas outlet end of the third gas intake pipeline, and a gas outlet end of the third connecting sub-passage is communicated with gas inlet ends of the plurality of third dispersion holes; and

a flow guide protrusion is provide on a surface of the gas mixing component which is opposite to the gas outlet end of the third gas intake pipeline, a surface of the

flow guide protrusion which is opposite to the gas outlet end of the third gas intake pipeline is an arc-shaped convex surface, and the flow guide protrusion is configured to guide a gas flowing into the third connecting sub-passage to the gas inlet ends of the plurality of third dispersion holes.

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11. The gas mixing device of claim 1, wherein a converging passage is further provided below the annular gas mixing passage in the gas mixing component, and comprises a third annular sub-passage and a vertical sub-passage, a gas inlet end of the third annular sub-passage is communicated with the gas outlet end of the annular gas mixing passage, a gas outlet end of the third annular sub-passage is communicated with a gas inlet end of the vertical sub-passage, and both an inner diameter and an outer diameter of the third annular sub-passage decrease from the annular gas mixing passage to the vertical sub-passage; and

a gas outlet end of the vertical sub-passage is configured to be communicated with the process chamber of the semiconductor process apparatus.

12. A semiconductor process apparatus, comprising a process chamber, wherein the semiconductor process apparatus further comprises the gas mixing device of any one of claims 1 to 11, which is configured to introduce a mixed gas into the process chamber.

13. The semiconductor process apparatus of claim 12, wherein the process chamber comprises a cavity, and a cover plate and a spray device which are disposed at a top of the cavity, and the spray device is located below the cover plate; wherein the gas mixing component is disposed on the cover plate, the cover plate is provided with a first gas inlet corresponding to the gas outlet end of the annular gas mixing passage, and a flow guide plug is provided in the first gas inlet, and is provided with a plurality of straight through holes for changing a flow direction of the mixed gas flowing through the flow guide plug to a vertical downward direction.

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14. The semiconductor process apparatus of claim 13, wherein the plurality of straight through holes comprise a plurality of first straight through holes and a plurality of second straight through holes, and the plurality of first straight through

holes are arranged in at least one circle around an axis of the flow guide plug; and

among the plurality of first straight through holes in an outermost circle, at least one second straight through hole is arranged in a gap between every two adjacent first straight through holes, and a radial section area of the second straight through hole is less than a radial section area of each of the first straight through holes.

15. The semiconductor process apparatus of claim 13, wherein the plurality of straight through holes comprise one first straight through hole having a circular radial section, and one or more second straight through holes having ring-shaped radial sections; and

the one or more second straight through holes surround the first straight through hole, and a plurality of second straight through holes are nested with each other; and each of the one or more second straight through holes is provided with at least one reinforcing rib extending along a radial direction of each of the one or more second straight through holes, and the at least one reinforcing rib is respectively connected to an inner circumferential wall and an outer circumferential wall of each of the one or more second straight through holes along the radial direction of each of the one or more second straight through holes.

16. The semiconductor process apparatus of claim 13, wherein a conical passage is disposed at a surface of the cover plate which is opposite to the spray device, an upper end of the conical passage is communicated with the first gas inlet, a lower end of the conical passage is communicated with a second gas inlet of the spray device, and an inner diameter of the conical passage increases from the first gas inlet to the second gas inlet.