

FLOW EQUALIZATION ASSEMBLY, GAS INLET APPARATUS, AND SEMICONDUCTOR PROCESS EQUIPMENT

TECHNICAL FIELD

[0001] The present disclosure relates to the technical field of semiconductor manufacturing, and specifically, to a flow equalization assembly, a gas inlet apparatus, and semiconductor process equipment.

BACKGROUND

[0002] A gas inlet apparatus is a very important component in semiconductor process equipment, and is mainly configured to introduce reactive process gas into a process chamber to implement related processes such as film growth and etching. The uniformity of gas sprayed by the gas inlet apparatus directly affects the uniformity of process results.

[0003] In some related technologies, a flow equalization plate is used to improve gas uniformity. Specifically, as shown in FIG. 1, a base 11' is arranged in a process chamber 10' of semiconductor process equipment 100', and the base 11' is configured to carry a wafer 200. The gas inlet apparatus of the semiconductor process equipment 100' has a gas inlet flow channel 21' and a flow equalization plate 31' arranged in the process chamber 10'. Process gas is transported into the process chamber 10' through the gas inlet flow channel 21'. The flow equalization plate 31' is provided with a plurality of through holes 311', and apertures of the through holes 311' are consistent, such that the process gas is guided to the surface of the wafer 200 after being equalized by the flow equalization plate 31'.

[0004] However, adopting this manner cannot ensure uniform distribution of the process gas above the wafer 200, thereby causing the problems of poor uniformity of process results and low product yield.

SUMMARY

[0005] The present disclosure aims to at least solve one of the technical problems existing in the related art, and provides a flow equalization assembly, a gas inlet apparatus, and semiconductor process equipment.

[0006] In a first aspect, the present disclosure provides a flow equalization assembly, where the flow equalization assembly internally has a flow equalization cavity, a plurality of gas inlet ports penetrating through a top wall of the flow equalization cavity along a thickness direction of the top wall are provided at the top wall of the flow equalization cavity, and a plurality of gas outlet ports penetrating through a bottom wall of the flow equalization cavity along a thickness direction of the bottom wall are provided at the bottom wall of the flow equalization cavity. A plurality of gas inlet pipes arranged in one-to-one correspondence with the plurality of gas inlet ports, and a plurality of gas outlet pipes arranged in one-to-one correspondence with the plurality of gas outlet ports are arranged inside the flow equalization cavity. A first end of each gas inlet pipe is connected to the corresponding gas inlet port, and a second end of the gas inlet pipe is in communication with the flow equalization cavity. A first end of each gas outlet pipe is connected to the corresponding gas outlet port, and a second end of the gas outlet pipe is in communication with the flow equalization cavity. The second end of the gas inlet pipe is located below the second end of the gas outlet pipe.

[0007] In some embodiments, the second end of the gas inlet pipe is closed, and a plurality of first flow equalization through holes are circumferentially spaced apart at a pipe wall of the

second end of the gas inlet pipe; and/or, the second end of the gas outlet pipe is closed, and a plurality of second flow equalization through holes are circumferentially spaced apart at a pipe wall of the second end of the gas outlet pipe.

[0008] In some embodiments, a channel inside the gas inlet pipe penetrates through the second end of the corresponding gas inlet pipe, and the second end of the gas inlet pipe is close to the bottom wall and forms a first gap with the bottom wall; and/or, a channel inside the gas outlet pipe penetrates through the second end of the corresponding gas outlet pipe, and the second end of the gas outlet pipe is close to the top wall and forms a second gap with the top wall.

[0009] In some embodiments, when the first gap is formed between the second end of the gas inlet pipe and the bottom wall and the second gap is formed between the second end of the gas outlet pipe and the top wall, dimensions of the first gap and the second gap in an axial direction of the flow equalization cavity are both greater than or equal to 0.1 mm and less than or equal to one-half of a height of the flow equalization cavity.

[0010] In some embodiments, all the gas inlet pipes and all the gas outlet pipes extend along the axial direction of the flow equalization cavity.

[0011] A plurality of rows of the gas inlet ports sequentially spaced apart along a first radial direction of the flow equalization cavity are distributed at the top wall, and each row of the gas inlet ports includes a plurality of the gas inlet ports sequentially spaced apart along a second radial direction of the flow equalization cavity; or, a plurality of rings of the gas inlet ports are radially spaced apart at the top wall along the flow equalization cavity, diameters of the gas inlet ports in the rings gradually increase from a center to an edge of the top wall, and quantities of the gas inlet ports in the rings gradually increase.

[0012] A plurality of rows of the gas outlet ports sequentially spaced apart along the first radial direction are distributed at the bottom wall, and each row of the gas outlet ports includes a plurality of the gas outlet ports sequentially spaced apart along the second radial direction.

[0013] The gas inlet ports and the gas outlet ports are staggered from each other in both the first radial direction and the second radial direction; where the first radial direction, the second radial direction, and the axial direction of the flow equalization cavity are perpendicular to each other in pairs.

[0014] In some embodiments, orthographic projections of all the gas outlet ports at the flow equalization cavity onto a carrying surface of a base of the semiconductor process equipment exceed an edge of a wafer carried on the carrying surface.

[0015] In a second aspect, the present disclosure provides a gas inlet apparatus, including: one flow equalization assembly or a plurality of flow equalization assemblies stacked and spaced apart, and at least one first main gas inlet pipe. The flow equalization assembly is any one of the flow equalization assemblies provided in the first aspect of the present disclosure. When the gas inlet apparatus includes one flow equalization assembly, an outlet of the first main gas inlet pipe is located at a gas inlet port side of the flow equalization assembly. When the gas inlet apparatus includes a plurality of flow equalization assemblies, the outlet of the first main gas inlet pipe is located at a gas inlet port side of a first flow equalization assembly stacked from top to bottom along the axial direction of the flow equalization cavity.

[0016] In some embodiments, when the gas inlet apparatus includes a plurality of flow equalization assemblies, the gas inlet apparatus further includes: a connection ring arranged between any two adjacent flow equalization assemblies and connected to both adjacent flow

equalization assemblies, where the connection ring and the two adjacent flow equalization assemblies jointly define a gas inlet space.

[0017] In some embodiments, among the plurality of flow equalization assemblies stacked from top to bottom along the axial direction of the flow equalization cavity, a last flow equalization assembly is a second flow equalization assembly, and the remaining flow equalization assemblies are all first flow equalization assemblies. The gas inlet apparatus further includes: at least one second main gas inlet pipe and a plurality of communication pipes arranged for each first flow equalization assembly. A gas inlet end of each communication pipe is connected to the gas outlet port of the corresponding first flow equalization assembly, and a gas outlet end of the communication pipe passes through all flow equalization assemblies located below the corresponding first flow equalization assembly and is exposed at the gas outlet port side of the second flow equalization assembly.

[0018] Each gas inlet space correspondingly communicates with at least one second main gas inlet pipe. The second main gas inlet pipe corresponding to the gas inlet space passes through other flow equalization assemblies located above the gas inlet space and enters the corresponding gas inlet space.

[0019] In some embodiments, each gas inlet space corresponds to one second main gas inlet pipe.

[0020] In some embodiments, when the gas inlet apparatus includes two flow equalization assemblies, the number of the gas inlet spaces is one, and the number of the communication pipes is the same as the number of the gas outlet ports of the first flow equalization assembly.

[0021] The communication pipes pass through the gas inlet space and the second flow equalization assembly, a gas inlet end of each communication pipe is connected to the gas outlet

port of the first flow equalization assembly, and a gas outlet end of the communication pipe is exposed at the gas outlet port side of the second flow equalization assembly.

[0022] In some embodiments, a first cover plate is connected to the gas outlet end of the first main gas inlet pipe, the first cover plate covers a port of the gas outlet end of the first main gas inlet pipe, a plurality of outlets are distributed at the first cover plate, and a plurality of outlets are circumferentially spaced apart at a pipe wall of the gas outlet end of the first main gas inlet pipe.

[0023] In some embodiments, a second cover plate is connected to the gas outlet end of the second main gas inlet pipe, the second cover plate covers a port of the gas outlet end of the second main gas inlet pipe, a plurality of openings are distributed at the second cover plate, and a plurality of openings are circumferentially spaced apart at a pipe wall of the gas outlet end of the second main gas inlet pipe.

[0024] In a third aspect, the present disclosure provides semiconductor process equipment, including: a process chamber and any one of the gas inlet apparatuses provided in the second aspect of the present disclosure. A base is arranged inside the process chamber, and the base includes a carrying surface configured to carry a wafer. The flow equalization assembly is located inside the process chamber, and the flow equalization assembly is opposite the base. A gas inlet end of the first main gas inlet pipe is located outside the process chamber, and a gas outlet end of the first main gas inlet pipe is located inside the process chamber.

[0025] In some embodiments, the semiconductor process equipment further includes a support ring arranged inside the process chamber, and the support ring is fixedly connected to an inner wall of the process chamber. When the gas inlet apparatus includes one flow equalization assembly, a bottom of the flow equalization assembly is fixedly arranged at the support ring.

When the gas inlet apparatus includes a plurality of flow equalization assemblies, among the plurality of flow equalization assemblies stacked from top to bottom along the axial direction of the flow equalization cavity, a last flow equalization assembly is a second flow equalization assembly, and a bottom of the second flow equalization assembly is fixedly arranged at the support ring.

[0026] In some embodiments, at least one flow equalization assembly at the gas inlet apparatus is grounded.

[0027] The present disclosure has the following beneficial effects:

[0028] In the flow equalization assembly provided by the present disclosure, a flow equalization cavity is designed inside the flow equalization assembly, gas inlet pipes and gas outlet pipes are arranged inside the flow equalization cavity, a first end of each gas inlet pipe is connected to a gas inlet port at a top wall of the flow equalization cavity and a second end of the gas inlet pipe is in communication with the flow equalization cavity, a first end of each gas outlet pipe is connected to a gas outlet port at a bottom wall of the flow equalization cavity and a second end of the gas outlet pipe is in communication with the flow equalization cavity, and the second end of the gas inlet pipe is located below the second end of the gas outlet pipe.

[0029] In this way, when the process gas passes through the flow equalization assembly, the process gas flows out from the second end of the gas inlet pipe into the flow equalization cavity, and then flows into the gas outlet pipe. During this process, the process gas needs to change a flow direction, such that pressures of the process gas at various positions in the flow equalization cavity are consistent, that is, gas pressure balance can be achieved inside the flow equalization cavity. In view of this, under a condition that apertures of the gas outlet ports are equal, flow velocities of the process gas sprayed from the respective gas outlet ports are also consistent, and

therefore gas spray amounts of the respective gas outlet ports are the same. In this way, the flow equalization is enhanced, distribution uniformity of the process gas is improved, and product yield is thereby improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. 1 is a schematic cross-sectional view of semiconductor process equipment provided in some related technologies.

[0031] FIG. 2 and FIG. 3 are schematic views of flow equalization plates in semiconductor process equipment provided in some other related technologies.

[0032] FIG. 4 is a schematic cross-sectional view of semiconductor process equipment provided in some other related technologies.

[0033] FIG. 5 is a schematic structural view of semiconductor process equipment provided in Embodiment 1 of the present disclosure.

[0034] FIG. 6 is a schematic cross-sectional view of the semiconductor process equipment shown in FIG. 5 along the A-A direction.

[0035] FIG. 7 is a schematic three-dimensional structural view of the flow equalization assembly in the semiconductor process equipment shown in FIG. 5.

[0036] FIG. 8 is a side view of the flow equalization assembly shown in FIG. 7.

[0037] FIG. 9 is a bottom view of the flow equalization assembly shown in FIG. 7.

[0038] FIG. 10 is a schematic cross-sectional view of the flow equalization assembly shown in FIG. 9 along the B-B direction.

[0039] FIG. 11 is a schematic structural view of the first main gas inlet pipe in the semiconductor process equipment shown in FIG. 5.

[0040] FIG. 12 is a schematic structural view of semiconductor process equipment provided in Embodiment 3 of the present disclosure.

[0041] FIG. 13 is a structure of another semiconductor process equipment provided in Embodiment 4 of the present disclosure.

[0042] FIG. 14 is a top view of the semiconductor process equipment shown in FIG. 13.

[0043] FIG. 15 is a schematic cross-sectional view of the semiconductor process equipment shown in FIG. 14 along the C-C direction.

[0044] FIG. 16 is a front view of the gas inlet apparatus in the semiconductor process equipment shown in FIG. 13.

[0045] FIG. 17 is a schematic cross-sectional view of the gas inlet apparatus shown in FIG. 16 along the D-D direction.

[0046] FIG. 18 is a schematic cross-sectional view of the gas inlet apparatus shown in FIG. 16 along the E-E direction.

[0047] FIG. 19 is a schematic cross-sectional view of the gas inlet apparatus shown in FIG. 16 along the F-F direction.

[0048] FIG. 20 is a schematic cross-sectional view of the gas inlet apparatus shown in FIG. 16 along the G-G direction.

[0049] FIG. 21 is a schematic cross-sectional view of the gas inlet apparatus shown in FIG. 16 along the H-H direction.

[0050] FIG. 22 is a schematic cross-sectional view of the gas inlet apparatus shown in FIG. 16 along the I-I direction.

[0051] FIG. 23 is a schematic cross-sectional view of the gas inlet apparatus shown in FIG. 16 along the J-J direction.

[0052] FIG. 24 is a schematic cross-sectional view of the gas inlet apparatus shown in FIG. 22 along the K-K direction.

[0053] FIG. 25 is a schematic cross-sectional view of the gas inlet apparatus shown in FIG. 22 along the L-L direction.

[0054] Description of reference numerals:

[0055] 100-semiconductor process equipment;

[0056] 10-process chamber; 11-base; 12-support ring;

[0057] 20-first main gas inlet pipe; 21-first cover plate; 211-outlet;

[0058] 30-gas inlet apparatus; 31-flow equalization assembly; 31a-first flow equalization assembly; 31b-second flow equalization assembly; 311-flow equalization cavity; 312-upper substrate; 3121-gas inlet port; 313-lower substrate; 3131-gas outlet port; 314-first structural ring; 315-second structural ring; 316-gas inlet pipe; 3161-first flow equalization through hole; 317-gas outlet pipe; 3171-second flow equalization through hole; 318-avoidance annular groove; 32-connection ring; 33-gas inlet space; 34-communication pipe; 35-second main gas inlet pipe; 351-second cover plate; 352-opening;

[0059] 200-wafer.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0060] It can be understood that, although the flow equalization plate 31' in the related technology shown in FIG. 1 can equalize the process gas, since the gas outlet end of the gas inlet flow channel 21' corresponds to the center of the flow equalization plate 31', a diffusion speed of the process gas toward the through holes 311' located in the middle of the flow equalization plate 31' is greater than a diffusion speed of the process gas toward the through holes 311' located at the peripheral of the flow equalization plate 31'. This causes differences in flow

velocities of the process gas passing through the respective through holes 311', thereby forming a jet effect, further resulting in uneven gas flow distribution inside the process chamber 10', and finally causing problems such as poor uniformity of process results and low product yield.

[0061] For this reason, in the related technologies shown in FIG. 2 and FIG. 3, multiple annular rows of through holes 311' radially spaced apart are distributed at the flow equalization plate 31', and each annular row of through holes 311' is composed of a plurality of through holes 311' circumferentially spaced apart along the flow equalization plate 31'. Moreover, diameters of the through holes 311' in the respective annular rows gradually increase from a center to an edge of the flow equalization plate 31', and quantities of the through holes 311' included in the respective annular rows gradually increase.

[0062] According to a relational expression between gas flow velocity and flow rate, namely: $Q=V \times S$, it can be understood that a gas spray amount Q of a single through hole 311' is related to a flow velocity V of the process gas flowing through the through hole 311' and a flow cross-sectional area S of the through hole 311'. In view of this, in the related technologies shown in FIG. 2 and FIG. 3, by arranging the through holes 311' closer to the edge of the flow equalization plate 31' to have larger diameters and greater quantities, distribution densities of the gas spray amounts Q through the respective through holes 311' are promoted to be nearly equal, thereby improving process uniformity. However, differences in the flow velocities V of the process gas flowing through the respective through holes 311' will cause consistency of process results to deteriorate.

[0063] However, for different process conditions (that is, gas pressure, flow velocity and flow rate of the process gas,), in order to achieve uniform distribution of the process gas inside the process chamber 10', arrangement of the through holes 311' should also be different. Therefore,

a single flow equalization plate 31' is difficult to adapt to different process conditions, and does not have good process compatibility and scalability.

[0064] In other related technologies, as shown in FIG. 4, the gas inlet apparatus of the semiconductor process equipment 100' is further provided with a diffusion channel 41'. After the process gas sprayed from the flow outlet end of the gas inlet flow channel 21' is diffused through the diffusion channel 41', the process gas then flows into the process chamber 10' through the through holes 311' of the flow equalization plate 31'.

[0065] When the semiconductor process equipment 100' shown in FIG. 4 is an Atomic Layer Deposition (Atomic Layer Deposition, abbreviated as ALD) equipment, one exemplary process specifically includes: i) introducing two dilution gases into the gas inlet flow channel 21'; ii) introducing a first precursor and a dilution gas into the gas inlet flow channel 21'; iii) stopping introduction of the first precursor into the gas inlet flow channel 21', and continuing to introduce the dilution gas into the gas inlet flow channel 21'; iv) introducing a second precursor and a dilution gas into the gas inlet flow channel 21'; v) stopping introduction of the second precursor into the gas inlet flow channel 21', and continuing to introduce the dilution gas into the gas inlet flow channel 21'; and vi) cyclically executing operation ii) to operation v). In this way, the first precursor and the second precursor are alternately introduced into the process chamber 10'.

Although the diffusion channel 41' is added in the related technologies, uniformity of distribution of the process gas still cannot be ensured, and compatibility and scalability are lacked for different process conditions. Therefore, films fabricated by using the semiconductor process equipment 100' have poor uniformity and consistency, and product yield is low.

[0066] After careful research, the applicant found that causes of the technical problem are as follows:

[0067] First, the process gas introduced into the gas inlet flow channel 21' usually includes multiple gas components. For example, in operation ii) and operation iv) above, multiple gases are simultaneously introduced. Since densities and flow rate settings of different gases are different, diffusion efficiencies and gas distributions of the gases are different. Gases with higher density tend to concentrate in a central region of the diffusion channel 41' and are difficult to diffuse to peripheral regions of the diffusion channel 41', thereby causing a concentration of the process gas reaching a center position of the wafer to be relatively high and a concentration of the process gas reaching an edge of the wafer to be relatively low, thus resulting in uneven distribution of the process gas. Since uniformity of process results is strongly correlated with uniformity of process gas distribution, poor uniformity of film fabrication is thereby caused, thereby affecting product yield.

[0068] Similarly, when the semiconductor process equipment 100' shown in FIG. 4 is applied to implement a plasma etching process, plasma is introduced into the gas inlet flow channel 21', and the diffusion channel 41' has a poor diffusion of the plasma toward edges of the flow equalization plate 31'. As a result, more plasma reaches a center of the wafer and less plasma reaches an edge of the wafer, thereby affecting uniformity and consistency of etching effects. Similarly, for a radical isotropic etching process, a combination of the diffusion channel 41' and the flow equalization plate 31' cannot completely filter charged particles in the plasma, thereby causing poor consistency of radical isotropic etching effects and affecting product yield.

[0069] Second, since the two precursors share one gas inlet flow channel 21', residual gases of the two precursors are likely to undergo a Chemical Vapor Deposition (Chemical Vapor Deposition, abbreviated as CVD) reaction in the gas inlet flow channel 21', thereby causing reaction by-products to be easily generated on a flow channel wall of the gas inlet flow channel

21'. As process time becomes longer and the reaction by-products accumulate to a certain thickness, the reaction by-products are easily blown off by the process gas or naturally fall onto the surface of the wafer, thereby causing particles on the film surface to increase, and affecting film formation quality and product yield.

[0070] Moreover, since reaction by-products are easily generated on the flow channel wall of the gas inlet flow channel 21', this manner further has many defects.

[0071] First, when the reaction by-products accumulate to a certain thickness, the reaction by-products will affect a flow cross-sectional area of the gas inlet flow channel 21'. Under a condition that the flow velocity is constant, an amount of gas introduced into the process chamber 10' will decrease, process efficiency will decrease, and product process consistency and equipment productivity will be affected.

[0072] Second, a cleaning cycle of the gas inlet apparatus is shortened, thereby affecting the service life of the gas inlet apparatus and equipment utilization rate.

[0073] In view of this, embodiments of the present disclosure provide a flow equalization assembly, a gas inlet apparatus, and semiconductor process equipment. In order to enable persons skilled in the art to better understand the technical solutions of the present disclosure, the flow equalization assembly, gas inlet apparatus, and semiconductor process equipment provided by the present disclosure are described in detail below with reference to the accompanying drawings.

[0074] Embodiment 1

[0075] Please refer to FIG. 5, FIG. 6, and FIG. 7. The semiconductor process equipment 100 provided in embodiments of the present disclosure includes a process chamber 10 and a gas inlet apparatus 30. A base 11 is arranged inside the process chamber 10, and the base 11 has a

carrying surface configured to carry a wafer 200, such that the wafer 200 undergoes process treatment inside the process chamber 10.

[0076] The gas inlet apparatus 30 is configured to introduce process gas into the process chamber 10. One gas inlet apparatus 30 provided in this embodiment includes a first main gas inlet pipe 20 and one flow equalization assembly 31. A gas inlet end of the first main gas inlet pipe 20 is located outside the process chamber 10, and a gas outlet end of the first main gas inlet pipe 20 extends into the process chamber 10 from a top of the process chamber 10. The gas outlet end of the first main gas inlet pipe 20 is located at a gas inlet port side of the flow equalization assembly 31.

[0077] The flow equalization assembly 31 is opposite the base 11, and the flow equalization assembly 31 can equalize the process gas flowing out from the gas outlet end of the first main gas inlet pipe 20, such that the process gas is uniformly sprayed onto the surface of the wafer 200. The structure of the flow equalization assembly 31 is described in detail below first.

[0078] Please refer to FIG. 7 to FIG. 10. A flow equalization assembly 31 provided in this embodiment internally has a flow equalization cavity 311. A plurality of gas inlet ports 3121 penetrating through a top wall along a thickness direction of the top wall are provided at the top wall of the flow equalization cavity 311, and a plurality of gas outlet ports 3131 penetrating through a bottom wall along a thickness direction of the bottom wall are provided at the bottom wall of the flow equalization cavity 311. Exemplarily, apertures of the respective gas outlet ports 3131 are equal.

[0079] A plurality of gas inlet pipes 316 and a plurality of gas outlet pipes 317 are further arranged inside the flow equalization cavity 311. The gas inlet pipes 316 and the gas outlet pipes 317 each have two ends. As used herein, a “first end” of the gas inlet pipe 316 and a “gas inflow

end” of the gas inlet pipe 316 may be used interchangeably, a “second end” of the gas inlet pipe 316 and a “gas outflow end” of the gas inlet pipe 316 may be used interchangeably, a “first end” of the gas outlet pipe 317 and a “gas outflow end” of the gas outlet pipe 317 may be used interchangeably, and a “second end” of the gas outlet pipe 317 and a “gas inflow end” of the gas outlet pipe 317 may be used interchangeably. Exemplarily, a quantity of the gas inlet pipes 316 is equal to a quantity of the gas inlet ports 3121, and the plurality of gas inlet pipes 316 correspond one-to-one with the plurality of gas inlet ports 3121. A gas inflow end of each gas inlet pipe 316 communicates with the corresponding gas inlet port 3121, and a gas outflow end is penetrated by an internal channel thereof, such that the gas outflow end of each gas inlet pipe 316 communicates with the flow equalization cavity 311. The gas outflow end of the gas inlet pipe 316 is close to the bottom wall of the flow equalization cavity 311 and forms a first gap with the bottom wall. In other words, two ends of each gas inlet pipe 316 are respectively the gas inflow end and the gas outflow end, and the gas inlet pipe 316 internally has a channel communicating the gas inflow end and the gas outflow end, such that the process gas flows from the gas inflow end to the gas outflow end of the gas inlet pipe 316. All the gas inlet pipes 316 are located inside the flow equalization cavity 311, the gas inflow end of each gas inlet pipe 316 communicates with the corresponding gas inlet port 3121, and the gas outflow end of each gas inlet pipe 316 is close to the bottom wall of the flow equalization cavity 311 and forms a first gap with the bottom wall, such that the gas outflow end of the gas inlet pipe 316 communicates with the flow equalization cavity 311. Exemplarily, a quantity of the gas outlet pipes 317 is equal to a quantity of the gas outlet ports 3131, and the plurality of gas outlet pipes 317 correspond one-to-one with the plurality of gas outlet ports 3131. A gas outflow end of each gas outlet pipe 317 is connected to the corresponding gas outlet port 3131, and a gas inflow end is penetrated by an internal

channel thereof, such that the gas inflow end of each gas outlet pipe 317 communicates with the flow equalization cavity 311. The gas inflow end of the gas outlet pipe 317 is close to the top wall of the flow equalization cavity 311 and forms a second gap with the top wall. In other words, two ends of each gas outlet pipe 317 are respectively the gas inflow end and the gas outflow end, and the gas outlet pipe 317 internally has a channel communicating the gas inflow end and the gas outflow end, such that the process gas flows from the gas inflow end to the gas outflow end of the gas outlet pipe 317. All the gas outlet pipes 317 are located inside the flow equalization cavity 311, the gas outflow end of each gas outlet pipe 317 communicates with the corresponding gas outlet port 3131, and the gas inflow end of each gas outlet pipe 317 is close to the top wall of the flow equalization cavity 311 and forms a second gap with the top wall, such that the gas inflow end of the gas outlet pipe 317 communicates with the flow equalization cavity 311.

[0080] It should further be noted that, along the axial direction of the process chamber 10, the gas outflow end of the gas inlet pipe 316 is located below the gas inflow end of the gas outlet pipe 317. That is, the first gap is located below the second gap. It should be noted that, in the accompanying drawings of the various embodiments of the present disclosure, the Z-axis direction represents the axial direction of the process chamber 10, and the axial direction of the flow equalization cavity 311 also extends along the Z-axis.

[0081] Please refer to FIG. 6. During operation of the semiconductor process equipment 100 in this embodiment, a flow path of the process gas is as follows: the process gas flows out from the gas outlet end of the first main gas inlet pipe 20 into a gas guide space S1 jointly defined by an upper top cover of the process chamber 10 and the top wall of the flow equalization assembly 31, and initial gas equalization is performed. Afterwards, the process gas is divided into multiple

streams of process gas, and each stream of process gas flows into the corresponding gas inlet pipe 316 through one gas inlet port 3121, flows into the first gap through the gas outflow end of the gas inlet pipe 316, and is sprayed downward toward the bottom wall of the flow equalization cavity 311. Through reflection from the bottom wall of the flow equalization cavity 311, the process gas flows and is equalized along a radial direction of the process chamber 10 inside the flow equalization cavity 311. Meanwhile, the process gas further flows upward toward the top wall of the flow equalization cavity 311, and through reflection from the top wall of the flow equalization cavity 311, the process gas flows into adjacent gas outlet pipes 317 through the second gaps, and is sprayed through the gas outlet ports 3131 connected to the corresponding gas outlet pipes 317 into a process space S2 between the bottom wall of the flow equalization assembly 31 and the base 11, and then is sprayed onto the surface of the wafer 200 to perform a corresponding film deposition process or etching process.

[0082] It can be seen that, in the flow equalization assembly 31 of this embodiment, by arranging the gas inlet pipes 316 and the gas outlet pipes 317, and arranging the gas outflow ends of the gas inlet pipes 316 below the gas inflow ends of the gas outlet pipes 317, the process gas is subjected to two reflections and changes a flow direction under action of the reflections when passing through the flow equalization assembly 31. In this way, pressure buffering of the process gas at various positions in the flow equalization cavity 311 is consistent, that is, gas pressure buffering balance can be achieved inside the flow equalization cavity 311. In view of this, under a condition that apertures of the respective gas outlet ports 3131 are equal (that is, flow cross-sectional areas S of the respective gas outlet ports 3131 are equal), flow velocities V of the process gas sprayed from the respective gas outlet ports 3131 are also consistent, and therefore gas spray amounts Q of the respective gas outlet ports 3131 are also the same. In this way, by

buffering and equalizing the process gas inside the flow equalization cavity 311, the flow equalization is enhanced and distribution uniformity of the process gas is improved, thereby improving product yield and consistency of process results at various positions on the wafer surface. In other words, in the flow equalization assembly 31 of this embodiment, by enabling a flow direction of the process gas flowing from the gas inlet pipes 316 to the gas outlet pipes 317 to change direction at least once in a vertical direction, the gas is buffered and equalized inside the flow equalization cavity 311, thereby relieving pressure differences of the process gas flowing out from the gas inlet pipes 316 inside the flow equalization cavity 311. In this way, pressure buffering of the gas at various positions in the flow equalization cavity 311 is consistent. Thus, under a condition that cross-sectional areas of the respective gas outlet ports 3131 are equal, gas spray amounts of the respective gas outlet ports 3131 are the same, thereby achieving flow equalization.

[0083] Moreover, since the flow equalization assembly 31 of this embodiment achieves gas pressure buffering and gas equalization by enabling the process gas to flow and change direction inside the flow equalization cavity 311, gas equalization performance thereof is less affected by machining and manufacturing errors. Meanwhile, compared with the related technologies shown in FIG. 2 and FIG. 3, the flow equalization assembly 31 of this embodiment and the gas inlet apparatus 30 having the flow equalization assembly 31 have excellent process condition compatibility, a simple structure, and beneficial effects on reducing a volume of the process chamber 10 applying the flow equalization assembly 31.

[0084] As shown in FIG. 8, in the flow equalization assembly 31 disclosed in the present disclosure, a dimension of the first gap in the axial direction Z of the flow equalization cavity 311 is h_1 , and a dimension of the second gap in the axial direction Z of the flow equalization

cavity 311 is h_2 , where $0.1 \text{ mm} \leq h_1 \leq H \times 1/2$, and $0.1 \text{ mm} \leq h_2 \leq H \times 1/2$. H is a height of the flow equalization cavity 311. Preferably, h_1 and h_2 are 0.1 mm, and h_1 and h_2 at this time are both relatively small. In this way, on one hand, a transport path of the process gas flowing from the gas outflow end of the gas inlet pipe 316 to the gas inflow end of the gas outlet pipe 317 can be effectively extended, thereby helping improve the gas equalization. On the other hand, the first gap and the second gap are equivalent to slits, thereby further promoting the process gas to flow along a radial direction of the flow equalization cavity 311 when entering and exiting the slits, such that a diffusion effect of the process gas in the radial direction of the process chamber 10 is effectively improved, and uniformity of diffusion of the process gas toward an edge of the process chamber 10 is improved.

[0085] The gas inlet pipes 316 and the gas outlet pipes 317 are not limited to straight pipes, and may also have bends. When the gas inlet pipes 316 and the gas outlet pipes 317 are straight pipes, extension directions of the respective gas inlet pipes 316 and the respective gas outlet pipes 317 are not limited. For example, with continued reference to FIG. 6 and FIG. 8, the gas inlet pipes 316 and the gas outlet pipes 317 extend along the axial direction Z of the flow equalization cavity 311. For another example, extension directions of the gas inlet pipes 316 and the gas outlet pipes 317 may also be inclined relative to the top wall of the flow equalization cavity 311. When the gas inlet pipes 316 and the gas outlet pipes 317 have bends, for example, the gas inlet pipes 316 may be in an “N” shape, and the process gas completes two changes in flow direction inside the gas inlet pipes 316 during transport.

[0086] Please continue to refer to FIG. 7 and FIG. 9. A plurality of rows of gas inlet ports 3121 sequentially spaced apart along a first radial direction of the flow equalization cavity 311 are distributed at the top wall, and each row of gas inlet ports 3121 includes a plurality of gas inlet

ports 3121 sequentially spaced apart along a second radial direction of the flow equalization cavity 311. The first radial direction and the second radial direction are perpendicular to each other. It should be noted that, in the accompanying drawings of the various embodiments of the present disclosure, the X-axis direction and the Y-axis direction respectively represent the first radial direction and the second radial direction of the flow equalization cavity 311. That is, the gas inlet ports 3121 are arranged in a grid pattern at the top wall of the flow equalization cavity 311, that is, arranged in multiple rows and multiple columns.

[0087] Specifically, the multiple rows of gas inlet ports 3121 may be uniformly distributed along the first radial direction, and the multiple columns of gas inlet ports 3121 may be uniformly distributed along the second radial direction. In this way, the gas inlet ports 3121 are uniformly distributed at the top wall, such that the process gas introduced into the gas guide space S1 can uniformly diffuse into the respective gas inlet ports 3121 along the radial direction of the flow equalization cavity 311, thereby ensuring uniformity of gas flow distribution.

[0088] For the arrangement of the gas outlet ports 3131, reference may be made to the arrangement of the gas inlet ports 3121. Specifically, multiple rows of gas outlet ports 3131 sequentially spaced apart along the first radial direction X are distributed at the bottom wall, and each row of gas outlet ports 3131 includes a plurality of gas outlet ports 3131 sequentially spaced apart along the second radial direction Y. In other words, the gas outlet ports 3131 are also arranged in a grid pattern at the bottom wall of the flow equalization cavity 311. Specifically, the multiple rows of gas outlet ports 3131 may be uniformly distributed along the first radial direction X, and the multiple columns of gas outlet ports 3131 may be uniformly distributed along the second radial direction Y. In this way, the gas outlet ports 3131 are uniformly distributed at the bottom wall and have equal apertures, such that the process gas can be

uniformly sprayed onto the surface of the wafer 200 along the bottom wall of the flow equalization cavity 311, thereby ensuring uniformity of distribution of the process gas flow.

[0089] It can be understood that, when the gas inlet pipes 316 and the gas outlet pipes 317 extend along the axial direction Z of the flow equalization cavity 311, arrangement of the gas inlet pipes 316 are the same as arrangement of the gas inlet ports 3121, and arrangement of the gas outlet pipes 317 are the same as arrangement of the gas outlet ports 3131. Specifically, in the example shown in FIG. 9, the gas inlet pipes 316 are arranged in ten rows along the first radial direction X and simultaneously arranged in ten columns along the second radial direction Y, and the gas outlet pipes 317 are arranged in nine rows along the first radial direction X and simultaneously arranged in nine columns along the second radial direction Y.

[0090] On the basis of this implementation solution, as a further embodiment, the gas inlet ports 3121 and the gas outlet ports 3131 are staggered from each other in both the first radial direction X and the second radial direction Y. In this way, as shown in FIG. 9, the gas inlet pipes 316 and the gas outlet pipes 317 are also staggered from each other in both the first radial direction X and the second radial direction Y.

[0091] In this way, a flow path of the process gas sprayed from the gas outflow ends of the gas inlet pipes 316 needs to change both in the radial direction of the flow equalization cavity 311 and in the axial direction of the flow equalization cavity 311 before flowing to the gas inflow ends of the gas outlet pipes 317. In this way, a number of changes in flow direction during passage of the process gas through the flow equalization assembly 31 is increased, thereby further enhancing the gas equalization of the flow equalization assembly 31, and thus significantly improving gas distribution uniformity and uniformity of corresponding process performance.

[0092] Numbers of rows and columns of the gas inlet pipes 316 and the gas outlet pipes 317 are not limited to the above quantities, and may be specifically designed according to needs and operation conditions.

[0093] In some embodiments, arrangement of the gas inlet ports 3121 may also be a circular array. That is, multiple rings of gas inlet ports 3121 radially spaced apart along the process chamber 10 are provided at the top wall of the flow equalization cavity 311. Moreover, from a center of the top wall to an edge of the top wall of the flow equalization cavity 311, the gas inlet ports 3121 in the respective rings gradually increase in size, and quantities of the gas inlet ports 3121 in the respective rings also gradually increase, that is, the gas inlet ports 3121 in an edge region of the top wall of the flow equalization cavity 311 are denser. In this way, it is beneficial to cause a gas inlet amount of the gas inlet pipes 316 close to an edge of the process chamber 10 to be comparable to a gas inlet amount of the gas inlet pipes 316 close to a center of the process chamber 10, thereby further effectively improving uniformity of gas flow distribution.

[0094] In some embodiments, orthographic projections of all the gas outlet ports 3131 on the carrying surface exceed an edge of the wafer 200 carried on the carrying surface of the base 11. In other words, each gas outlet port 3131 forms one orthographic projection on the carrying surface. Among these orthographic projections, most are located inside a position of the wafer 200, but some orthographic projections have partial regions or entire regions located outside the position of the wafer 200. In this manner, a spray region of the process gas after flow equalization by the flow equalization cavity 311 can cover the entire wafer 200, thereby ensuring uniformity of distribution of the process gas sprayed toward various regions of the surface of the wafer 200, and thus improving consistency of process performance at various positions of the wafer.

[0095] Please continue to refer to FIG. 6 and FIG. 8. The flow equalization assembly 31 may specifically include an upper substrate 312, a lower substrate 313, and a first structural ring 314 and a second structural ring 315 arranged between the upper substrate 312 and the lower substrate 313. The upper substrate 312, the first structural ring 314, the second structural ring 315, and the lower substrate 313 jointly define the flow equalization cavity 311.

[0096] Exemplarily, one first main gas inlet pipe 20 may be provided.

[0097] When one first main gas inlet pipe 20 is provided, the semiconductor process equipment 100 may be a plasma etching equipment configured to implement semiconductor plasma etching process, and the process gas transported by the first main gas inlet pipe 20 into the process chamber 10 is plasma. It is worth noting that the plasma is not limited to being provided by a Remote Plasma Source (Remote Plasma Source, abbreviated as RPS), and may also be generated by an Inductively Coupled Plasma (Inductively Coupled Plasma, abbreviated as ICP) technology or a Capacitively Coupled Plasma (Capacitively Coupled Plasma, abbreviated as CCP) technology adopted by the plasma etching equipment. In this way, during an etching process of the plasma etching equipment, the flow equalization assembly 31 can enable the plasma to uniformly diffuse in the process chamber 10, so as to avoid a problem that more plasma reaches a center of the wafer 200 and less plasma reaches an edge of the wafer 200, thereby improving uniformity of etching effects and consistency of process results at various positions of the wafer.

[0098] When one first main gas inlet pipe 20 is provided, the semiconductor process equipment 100 may also be an atomic layer deposition equipment configured to implement an atomic layer deposition process, and the process gas input into the process chamber 10 by the first main gas inlet pipe 20 is a precursor. Specifically, during a deposition process, different precursors are alternately transported to the first main gas inlet pipe 20. In this way, during the deposition

process of the atomic layer deposition equipment, the flow equalization assembly 31 can enable the precursors to uniformly diffuse in the process chamber 10, so as to avoid a problem that a precursor concentration reaching a center of the wafer 200 is high and a precursor concentration reaching an edge of the wafer 200 is low, thereby improving uniformity and consistency of deposition process results at various positions of the wafer.

[0099] Exemplarily, multiple first main gas inlet pipes 20 may also be provided, and precursors transported by the respective first main gas inlet pipes 20 may be different. The semiconductor process equipment 100 of this embodiment may specifically be an atomic layer deposition equipment, and precursors may be alternately transported to the respective first main gas inlet pipes 20 during the deposition process.

[0100] In this way, on one hand, when the respective first main gas inlet pipes 20 alternately introduce precursors into the process chamber 10, each precursor can be uniformly distributed by the flow equalization assembly 31 and then guided to the wafer 200, such that precursor distribution is uniform. On the other hand, since each first main gas inlet pipe 20 is configured to independently transport one precursor, it is beneficial to avoid different precursors sharing the first main gas inlet pipe 20 and thereby causing the Chemical Vapor Deposition reaction to occur inside the first main gas inlet pipe 20. Correspondingly, generation of particles caused by generation of reaction by-products inside the first main gas inlet pipe 20 and influence on film uniformity can be avoided, thereby significantly improving deposition uniformity and process yield.

[0101] Moreover, such an arrangement can further effectively avoid reaction by-products generated inside the first main gas inlet pipe 20 from affecting a flow cross-sectional area of the first main gas inlet pipe 20, thereby ensuring that process efficiency and productivity of the

atomic layer deposition equipment are not reduced. In addition, shortening of a cleaning cycle of the first main gas inlet pipe 20 can also be effectively avoided, thereby ensuring a service life of the first main gas inlet pipe 20 and an equipment utilization rate.

[0102] Overall, the semiconductor process equipment 100 provided in this embodiment can be compatible with multiple types of semiconductor processes, has good process compatibility and scalability, and has high uniformity of process performance and high product yield. The semiconductor process equipment 100 is not limited to being a plasma etching equipment or an atomic layer deposition equipment, and may also be other semiconductor process equipment such as a CVD equipment or a PECVD equipment.

[0103] In order to further improve process uniformity, please refer to FIG. 11. A first cover plate 21 is connected to the gas outlet end of the first main gas inlet pipe 20, and the first cover plate 21 covers a port of the gas outlet end of the first main gas inlet pipe 20. A plurality of outlets 211 are arranged at the first cover plate 21, and a plurality of outlets 211 are circumferentially spaced apart at a pipe wall of the gas outlet end of the first main gas inlet pipe 20. Axial directions of the outlets 211 at the pipe wall are perpendicular to the axial direction Z of the process chamber 10. Exemplarily, the plurality of outlets 211 at the pipe wall of the first main gas inlet pipe 20 may be uniformly distributed along a circumferential direction of the first main gas inlet pipe 20.

[0104] In this way, when the process gas flows from the outlets 211 of the first main gas inlet pipe 20 to the gas guide space S1, the process gas can be divided into multiple small gas flows. Part of the multiple small gas flows is transported into the gas guide space S1 from the outlets 211 at the first cover plate 21 along the axial direction Z of the process chamber 10, and the remaining part is transported into the gas guide space S1 from the outlets 211 at the pipe wall of the first main gas inlet pipe 20 along the radial direction of the process chamber 10.

[0105] In this embodiment, during a process in which the process gas flow flows from the outlets 211 of the first main gas inlet pipe 20 to the gas guide space S1, diffusion and gas equalization of the process gas in the axial direction Z of the process chamber 10 and in the radial direction of the process chamber 10 can be achieved, thereby improving the diffusion of the process gas toward an edge of the process chamber 10, and thus improving uniformity of gas distribution at various positions inside the process chamber 10.

[0106] In the semiconductor process equipment 100 disclosed in this embodiment, please refer to FIG. 6, a support ring 12 may further be arranged inside the process chamber 10, and the support ring 12 is fixedly connected to an inner wall of the process chamber 10. A bottom of the flow equalization assembly 31 is fixedly arranged at the support ring 12. In this way, the support ring 12 can support the flow equalization assembly 31, such that the flow equalization assembly 31 can be stably installed inside the process chamber 10.

[0107] The lower substrate 313 of the flow equalization cavity 311 may be fixedly attached at the support ring 12. Please refer to FIG. 8 and FIG. 10 together. An avoidance annular groove 318 may further be provided at the bottom of the flow equalization assembly 31, and the support ring 12 is embedded in the avoidance annular groove 318, such that the support ring 12 does not protrude beyond a bottom surface of the flow equalization assembly 31. In this way, the support ring 12 does not additionally occupy axial space of the process chamber 10.

[0108] In some embodiments, the flow equalization assembly 31 may further be grounded. Specifically, any one or more of the upper substrate 312, the lower substrate 313, the first structural ring 314, and the second structural ring 315 may be grounded.

[0109] By grounding the flow equalization assembly 31, when the semiconductor process equipment 100 of this embodiment is a radical etching equipment, process gas (for example,

fluorine-based gases such as CF₄ and NF₃) forms plasma after dissociation by an energy source such as RPS, CCP, or ICP. The plasma is introduced into the flow equalization assembly 31 through the gas inlet ports 3121. Charged particles (electrons, charged ions, radicals, and other types of charged particles) in the plasma undergo recombination during transport and collide with, are adsorbed by, and are neutralized by pipe walls of the gas inlet pipes 316, pipe walls of the gas outlet pipes 317, and top walls, side walls, and bottom walls of the flow equalization cavity 311, thereby being filtered out. Uncharged radicals in the plasma are fully and uniformly diffused inside the flow equalization cavity 311 and can smoothly pass through the flow equalization assembly 31, and are then sprayed into the process space S2 through the gas outlet ports 3131, uniformly sprayed onto the surface of the wafer 200, and subjected to an isotropic etching process. In this way, problems such as etching in a vertical direction and damage to surface materials of the wafer 200 caused by bombardment of the surface of the wafer 200 by charged particles in the plasma can be effectively avoided. Therefore, the radical etching equipment can implement isotropic radical etching, can be used for a radical lateral etching process, and can ensure consistency and uniformity of process performance.

[0110] It is worth noting that the process gas sprayed from the gas inlet pipes 316 needs to change a flow direction before being transported to the gas outlet pipes 317. This process increases probabilities that charged particles undergo recombination during transport and collide with, are adsorbed by, and are neutralized by the pipe walls of the gas inlet pipes 316, the pipe walls of the gas outlet pipes 317, and the top walls, side walls, and bottom walls of the flow equalization cavity 311, thereby significantly improving a filtering effect of the flow equalization assembly 31 on charged particles, and thus further improving uniformity and consistency at various positions of isotropic etching process performance. It should be particularly noted that

dissociated plasma and chemical gas may be simultaneously introduced into the flow equalization assembly 31, thereby implementing effective filtering of charged particles and radicals in the plasma and a gas equalization for radicals and chemical gas, so as to satisfy requirements of simultaneously performing radical etching and chemical etching processes in special processes.

[0111] Based on the above description, it can be understood that, in embodiments in which the gas inlet pipes 316 and the gas outlet pipes 317 have bends, when the semiconductor process equipment 100 implements a radical etching process, plasma flowing inside the gas inlet pipes 316 easily collides with the pipe walls of the gas inlet pipes 316 when changing direction at bent positions of the gas inlet pipes 316. In this way, possibilities that charged particles in the plasma are neutralized and filtered are effectively increased, thereby improving the filtering effect. Similarly, during flow of the plasma inside the gas outlet pipes 317, the plasma easily collides with the pipe walls of the gas outlet pipes 317 when changing direction at bent positions of the gas outlet pipes 317.

[0112] Embodiment 2

[0113] This embodiment is similar to Embodiment 1, and a main difference lies in different communication manners between the gas inlet pipes 316 and the gas outlet pipes 317 and the flow equalization cavity 311. In the flow equalization assembly 31 in Embodiment 1, the gas outflow ends of the gas inlet pipes 316 and the gas inflow ends of the gas outlet pipes 317 are penetrated by internal channels thereof to implement communication with the flow equalization cavity 311. However, in this embodiment, the gas outflow ends of the gas inlet pipes 316 and the gas inflow ends of the gas outlet pipes 317 are both closed. First flow equalization through holes 3161 communicating with the flow equalization cavity 311 are provided at pipe walls of the gas

outflow ends of the gas inlet pipes 316, and second flow equalization through holes 3171 communicating with the flow equalization cavity 311 are provided at pipe walls of the gas inflow ends of the gas outlet pipes 317.

[0114] It can be understood that axial directions of the first flow equalization through holes 3161 and the second flow equalization through holes 3171 are both perpendicular to the axial direction Z of the process chamber 10. Multiple first flow equalization through holes 3161 and multiple second flow equalization through holes 3171 are provided. The plurality of first flow equalization through holes 3161 may specifically be uniformly distributed and spaced apart along a circumferential direction of the gas inlet pipes 316, and the plurality of second flow equalization through holes 3171 may specifically be uniformly distributed and spaced apart along a circumferential direction of the gas outlet pipes 317.

[0115] In this way, during a semiconductor fabrication process, process gas sprayed from the gas inlet pipes 316 enters the flow equalization cavity 311 through the first flow equalization through holes 3161 along the radial direction of the process chamber 10. After the process gas performs buffered diffusion along the radial direction of the process chamber 10 while simultaneously flowing upward along the axial direction of the process chamber 10, the process gas then enters the gas outlet pipes 317 through the second flow equalization through holes 3171 along the radial direction of the process chamber 10, and is subsequently sprayed into the process space S2 from the gas outlet ports 3131.

[0116] In the flow equalization assembly 31 of this embodiment, by providing the first flow equalization through holes 3161 at the pipe walls of the gas inlet pipes 316 and providing the second flow equalization through holes 3171 at the pipe walls of the gas outlet pipes 317, not only can the process gas change flow direction and achieve buffered diffusion inside the flow

equalization cavity 311 to achieve gas pressure balance, thereby enhancing the flow equalization, but also flow equalization of the process gas can be performed in the radial direction of the flow equalization cavity 311, thereby improving uniformity of diffusion of the process gas toward edges of the process chamber 10.

[0117] The gas outflow ends of the gas inlet pipes 316 are closed should be broadly understood. Specifically, this may be understood as the gas outflow ends of the gas inlet pipes 316 being blocked by being fixedly connected to the bottom wall of the flow equalization cavity 311, or may also be understood as internal channels of the gas inlet pipes 316 not penetrating through the gas outflow ends of the gas inlet pipes 316. Similarly, the gas inflow ends of the gas outlet pipes 317 are blocked by being fixedly connected to the top wall, or internal channels of the gas outlet pipes 317 do not penetrate through the gas inflow ends of the gas outlet pipes 317.

[0118] Any semiconductor process equipment 100 in this embodiment may be a plasma etching equipment, and may also be an atomic layer deposition equipment, a PECVD equipment, a CVD equipment, a radical etching equipment, or the like.

[0119] It should be noted that communication manners between the gas outflow ends of the gas inlet pipes 316 and the flow equalization cavity 311 and communication manners between the gas inflow ends of the gas outlet pipes 317 and the flow equalization cavity 311 may adopt any one of the manners in Embodiment 1 and Embodiment 2, as long as the gas outflow ends of the gas inlet pipes 316 are located below the gas inflow ends of the gas outlet pipes 317.

[0120] Embodiment 3

[0121] This embodiment is similar to Embodiment 1 and Embodiment 2 above. A difference is that, in Embodiment 1 and Embodiment 2, the gas inlet apparatus 30 is provided with only one flow equalization assembly 31, the gas inlet apparatus 30 in this embodiment is provided with a

plurality of flow equalization assemblies 31, and the flow equalization cavities 311 of the respective flow equalization assemblies 31 communicate with each other. It should be understood that, in the accompanying drawings of this embodiment, illustration is provided by taking an example in which two flow equalization assemblies 31 are provided and structures of the flow equalization assemblies 31 is illustrated by taking the structure in Embodiment 2 as an example, and this should not be construed as limiting the present disclosure.

[0122] Please refer to FIG. 12. The gas inlet apparatus 30 includes a plurality of flow equalization assemblies 31 stacked and spaced apart. Moreover, the gas inlet apparatus 30 further includes a connection ring 32 arranged between any two adjacent flow equalization assemblies 31 and connected to both adjacent flow equalization assemblies 31. The connection ring 32 and the two adjacent flow equalization assemblies 31 jointly define a gas inlet space 33.

[0123] The gas inlet apparatus 30 may be provided with N flow equalization assemblies 31, where $N \geq 2$ and N is a positive integer. Correspondingly, N-1 connection rings 32 are provided, and a quantity of the gas inlet spaces 33 is also N-1. For convenience and clarity of description below, among the N flow equalization assemblies 31 stacked from top to bottom along the axial direction Z of the flow equalization cavity 311, the flow equalization assembly 31 closest to the base 11 is referred to as a second flow equalization assembly 31b, and the remaining flow equalization assemblies 31 are all referred to as first flow equalization assemblies 31a. A first stacked flow equalization assembly 31 (which is also the first flow equalization assembly 31a) is closest to an upper top cover of the process chamber 10. A top wall of the first stacked flow equalization assembly 31 (which is also the first flow equalization assembly 31a) and the upper top cover of the process chamber 10 jointly define a gas guide space S1. An outlet 211 of any first main gas inlet pipe 20 is located at a gas inlet port 3121 side of the first flow equalization

assembly 31. The second flow equalization assembly 31b is closest to a lower bottom plate of the process chamber 10, and a process space S2 is formed between a bottom wall of the second flow equalization assembly 31b and the base 11. The second flow equalization assembly 31b is fixedly attached and mounted at the support ring 12, such that the flow equalization assemblies 31 are stably mounted inside the process chamber 10. In order to avoid the support ring 12 occupying space of the process chamber 10 along the axial direction Z thereof, among the N flow equalization assemblies 31, only the bottom of the second flow equalization assembly 31b needs to be provided with the avoidance annular groove 318.

[0124] When $N=2$, as shown in FIG. 12, the quantity of the first flow equalization assemblies 31a is one, the gas inlet apparatus 30 has one gas inlet space 33, and the gas outlet ports 3131 of the first flow equalization assembly 31a communicate with the gas inlet ports 3121 of the second flow equalization assembly 31b through the gas inlet space 33.

[0125] When $N=3$, two first flow equalization assemblies 31a are provided, respectively being a first first flow equalization assembly 31a and a second first flow equalization assembly 31a, and the first first flow equalization assembly 31a is arranged above the second first flow equalization assembly 31a. Gas inlet spaces 33 are formed between the first first flow equalization assembly 31a and the second first flow equalization assembly 31a and between the second first flow equalization assembly 31a and the second flow equalization assembly 31b. Gas outlet ports 3131 of the first first flow equalization assembly 31a communicate with gas inlet ports 3121 of the second first flow equalization assembly 31a through the gas inlet space 33 located between the two first flow equalization assemblies 31a. Gas outlet ports 3131 of the second first flow equalization assembly 31a communicate with gas inlet ports 3121 of the second flow

equalization assembly 31b through the gas inlet space 33 between the second first flow equalization assembly 31a and the second flow equalization assembly 31b.

[0126] When $N > 3$, and so on, details are not enumerated one by one in this embodiment.

Overall, the flow equalization cavities 311 of the respective flow equalization assemblies 31 communicate with each other.

[0127] In the gas inlet apparatus 30 of this embodiment, by configuring a plurality of flow equalization assemblies 31, during a process, process gas entering the gas guide space S1 from the outlets 211 of the first main gas inlet pipe 20, after sequentially undergoing uniform distribution by the respective flow equalization assemblies 31 stacked from a top to a bottom of the process chamber 10, and is then sprayed into the process space S2 from the gas outlet ports 3131 of the second flow equalization assembly 31b, and subsequently sprayed onto the surface of the wafer 200 to perform film deposition or etching processes. In this way, compared with Embodiment 1 and Embodiment 2, the gas inlet apparatus 30 designs multi-stage flow equalization assemblies 31 to increase a frequency of flow equalization of the process gas, thereby significantly improving a gas equalization of the process gas flow and improving process uniformity and process result yield rate.

[0128] It can further be understood that the gas inlet apparatus 30 may be applied to a highly integrated semiconductor process equipment 100. Specifically, a dimension of the process chamber 10 of the highly integrated semiconductor process equipment 100 in a radial direction thereof is usually relatively small. In the gas inlet apparatus 30 of this embodiment, by designing a plurality of flow equalization assemblies 31 stacked and spaced apart, the gas inlet apparatus 30 can achieve a large-volume design, and each flow equalization assembly 31 can effectively perform flow equalization on the process gas. Therefore, even if a dimension of the gas inlet

apparatus 30 of this embodiment in the radial direction of the process chamber 10 is relatively small, effective uniform distribution of the process gas can still be ensured.

[0129] In some embodiments, for any two adjacent flow equalization assemblies 31, the gas outlet ports 3131 at the bottom wall of one flow equalization assembly 31 and the gas inlet ports 3121 at the top wall of the other adjacent flow equalization assembly 31 are staggered from each other in both the first radial direction X and the second radial direction Y.

[0130] In this embodiment, by taking an example in which two flow equalization assemblies 31 are provided, during actual application, process gas flowing out from the gas outlet ports 3131 of the first flow equalization assembly 31a is sprayed into the gas inlet space 33, and a flow direction thereof needs to change along the radial direction of the process chamber 10 before flowing toward the gas inlet ports 3121 of the second flow equalization assembly 31b. In this way, diffusion uniformity of the process gas is improved, the flow equalization is significantly enhanced, and thus uniformity of process results and process yield rate can be improved.

[0131] It is worth noting that, in the gas inlet apparatus 30 provided in this embodiment, any one of the plurality of flow equalization assemblies 31 may also be replaced with the flow equalization assembly 31 introduced in Embodiment 1.

[0132] It should be noted that, in this embodiment, one or more first main gas inlet pipes 20 may be provided. When one first main gas inlet pipe 20 is provided, the semiconductor process equipment 100 using any gas inlet apparatus 30 in this embodiment may be a plasma etching equipment, an atomic layer deposition equipment, a CVD equipment, a PECVD equipment, a radical etching equipment, or the like. If the semiconductor process equipment 100 is an atomic layer deposition equipment, different precursors may be alternately transported to the first main gas inlet pipe 20 during the deposition process.

[0133] When multiple first main gas inlet pipes 20 are provided, process gases transported by the respective first main gas inlet pipes 20 may be different. The semiconductor process equipment 100 using any gas inlet apparatus 30 in this embodiment may be an atomic layer deposition equipment, and during the deposition process, precursors may be alternately transported to the respective first main gas inlet pipes 20.

[0134] In addition, one flow equalization assembly 31 among the plurality of flow equalization assemblies 31 is grounded. The semiconductor process equipment 100 of this embodiment is applicable to a radical etching equipment. When process gas passes through the grounded flow equalization assembly 31, charged particles in plasma are filtered out, and uncharged radicals are sprayed onto the surface of the wafer 200 after flow equalization, so as to ensure implementation of isotropic etching.

[0135] Or, in preferred embodiments, multiple flow equalization assemblies 31 are grounded, for example, each flow equalization assembly 31 is grounded. In this way, after dissociated plasma sequentially passes through the stacked flow equalization assemblies 31, not only can the plasma uniformly diffuse along the radial direction and the axial direction of the process chamber 10, but multiple filtering operations can also be performed, thereby improving the filtering effect.

[0136] Embodiment 4

[0137] This embodiment is similar to Embodiment 3. A difference is that, in Embodiment 3, the flow equalization cavities 311 of the respective flow equalization assemblies 31 at the gas inlet apparatus 30 communicate with each other, the flow equalization cavities 311 of the respective flow equalization assemblies 31 at the gas inlet apparatus 30 in this embodiment do not communicate with each other. It should be understood that, in the accompanying drawings of this embodiment, illustration is provided by taking an example in which two flow equalization

assemblies 31 are provided and structures of the flow equalization assemblies 31 is illustrated taking structures in Embodiment 2 as an example, and this should not be construed as limiting the present disclosure.

[0138] In this embodiment, please refer to FIG. 13 to FIG. 18. The gas inlet apparatus 30 further includes a plurality of communication pipes 34 arranged for each first flow equalization assembly 31a. A gas inlet end of each communication pipe 34 is connected to the gas outlet port 3131 of the corresponding first flow equalization assembly 31a, and a gas outlet end of the communication pipe 34 passes through all flow equalization assemblies 31 below the corresponding first flow equalization assembly 31a and is exposed at the gas outlet port 3131 side of the second flow equalization assembly 31b.

[0139] Moreover, the gas inlet apparatus 30 further includes at least one second main gas inlet pipe 35. A gas inlet end of the second main gas inlet pipe 35 is located outside the process chamber 10, and a gas outlet end of the second main gas inlet pipe 35 extends into the process chamber 10 from a top of the process chamber 10. The gas outlet end of the second main gas inlet pipe 35 communicates with one of the gas inlet spaces 33. Each gas inlet space 33 correspondingly communicates with at least one second main gas inlet pipe 35, and the second main gas inlet pipe 35 corresponding to the gas inlet space 33 passes through other flow equalization assemblies 31 located above the gas inlet space 33 and enters the corresponding gas inlet space 33.

[0140] When $N=2$, as shown in FIG. 13 to FIG. 18, the gas inlet apparatus 30 includes a plurality of communication pipes 34 connected in one-to-one correspondence with the plurality of gas outlet ports 3131 of the first flow equalization assembly 31a. A quantity of the communication pipes 34 is equal to a quantity of the gas outlet ports 3131 of the first flow equalization assembly

31a. All the communication pipes 34 penetrate through the gas inlet space 33 and the second flow equalization assembly 31b. Gas inlet ends of the communication pipes 34 are connected to the gas outlet ports 3131 of the first flow equalization assembly 31a, and gas outlet ends of the communication pipes 34 penetrate through the bottom wall of the second flow equalization assembly 31b and are exposed at the gas outlet port 3131 side of the second flow equalization assembly 31b. In this way, arrangement of the communication pipes 34 are the same as arrangement of the gas outlet ports 3131 and the gas outlet pipes 317 of the first flow equalization assembly 31a.

[0141] According to the description in Embodiment 1, the gas inlet pipes 316 and the gas outlet pipes 317 of the flow equalization assembly 31 are arranged in a grid pattern.

[0142] As shown in FIG. 16, FIG. 19, and FIG. 20, the gas inlet pipes 316 of the first flow equalization assembly 31a are specifically arranged in ten rows along the first radial direction X and simultaneously arranged in eleven columns along the second radial direction Y. The gas outlet pipes 317 of the first flow equalization assembly 31a are specifically arranged in eleven rows along the first radial direction X and simultaneously arranged in ten columns along the second radial direction Y. It should be noted that, in FIG. 19, holes depicted by dashed lines are schematic patterns of the gas outlet pipes 317 in the first flow equalization assembly 31a, and holes depicted by solid lines are schematic patterns of the gas inlet pipes 316 in the first flow equalization assembly 31a. In some embodiments, in FIG. 20, holes depicted by dashed lines are schematic patterns of the gas inlet pipes 316 in the first flow equalization assembly 31a, and holes depicted by solid lines are schematic patterns of the gas outlet pipes 317 in the first flow equalization assembly 31a.

[0143] Since arrangement of the communication pipes 34 are the same as arrangement of the gas outlet pipes 317 of the first flow equalization assembly 31a, with reference to FIG. 16 and FIG. 19 to FIG. 21 together, the communication pipes 34 are also arranged in eleven rows along the first radial direction X and simultaneously arranged in ten columns along the second radial direction Y.

[0144] The gas inlet pipes 316 and the gas outlet pipes 317 of the second flow equalization assembly 31b are also arranged in a grid pattern. According to the examples shown in FIG. 16, FIG. 22, and FIG. 23, the gas inlet pipes 316 of the second flow equalization assembly 31b are specifically arranged in eleven rows along the first radial direction X and simultaneously arranged in eleven columns along the second radial direction Y. The gas outlet pipes 317 of the second flow equalization assembly 31b are specifically arranged in ten rows along the first radial direction X and simultaneously arranged in ten columns along the second radial direction Y. It should be noted that, in FIG. 22, holes depicted by dashed lines are schematic patterns of the gas outlet pipes 317 in the second flow equalization assembly 31b, and schematic patterns of the gas inlet pipes 316 in the second flow equalization assembly 31b and the communication pipes 34 are holes depicted by solid lines. In FIG. 23, holes depicted by dashed lines are schematic patterns of the gas inlet pipes 316 of the second flow equalization assembly 31b, and schematic patterns of the gas outlet pipes 317 of the second flow equalization assembly 31b and the communication pipes 34 are holes depicted by solid lines.

[0145] Please continue to refer to FIG. 20 to FIG. 23. It can be readily understood that a number of rows of the communication pipes 34 along the first radial direction X is equal to a number of rows of the gas inlet pipes 316 of the second flow equalization assembly 31b, and the rows of communication pipes 34 are arranged side by side with the rows of gas inlet pipes 316 of the

second flow equalization assembly 31b. Meanwhile, a number of columns of the communication pipes 34 arranged along the second radial direction Y is equal to a number of columns of the gas outlet pipes 317 of the second flow equalization assembly 31b, and the columns of communication pipes 34 are arranged side by side with the columns of gas outlet pipes 317 of the second flow equalization assembly 31b. In this way, when respective communication pipes 34 pass through the second flow equalization assembly 31b, it is ensured that respective communication pipes 34 can pass through gaps defined by adjacent two rows of gas outlet pipes 317 and adjacent two columns of gas inlet pipes 316 on the second flow equalization assembly 31b, so as to avoid interference between the communication pipes 34 and the gas outlet pipes 317 or the gas inlet pipes 316 of the second flow equalization assembly 31b. Certainly, the respective communication pipes 34 may also pass through gaps defined by adjacent two rows of gas inlet pipes 316 and adjacent two columns of gas outlet pipes 317 of the second flow equalization assembly 31b.

[0146] In this embodiment, process gas flowing out from the outlets 211 of the first main gas inlet pipe 20 enters the first flow equalization assembly 31a. After gas equalization by the first flow equalization assembly 31a, the process gas enters the communication pipes 34, and is then directly transported to the process space S2 from gas outlet ends of the communication pipes 34. Process gas flowing out from the gas outlet ends of the second main gas inlet pipes 35 enters the gas inlet space 33, then flows into the second flow equalization assembly 31b, and after gas equalization by the second flow equalization assembly 31b, is sprayed into the process space S2 from the gas outlet ports 3131 of the second flow equalization assembly 31b.

[0147] When $N=3$, two first flow equalization assemblies 31a are provided, respectively being a first first flow equalization assembly 31a and a second first flow equalization assembly 31a, and

the first first flow equalization assembly 31a is arranged above the second first flow equalization assembly 31a. Gas inlet spaces 33 are formed between the first first flow equalization assembly 31a and the second first flow equalization assembly 31a and between the second first flow equalization assembly 31a and the second flow equalization assembly 31b. The gas inlet apparatus 30 includes a plurality of communication pipes 34 connected in one-to-one correspondence with the plurality of gas outlet ports 3131 of the first first flow equalization assembly 31a, and a plurality of communication pipes 34 connected in one-to-one correspondence with the plurality of gas outlet ports 3131 of the second first flow equalization assembly 31a. The plurality of communication pipes 34 connected to the first first flow equalization assembly 31a pass through the gas inlet space 33 between the two first flow equalization assemblies 31a, and gas outlet ends of the plurality of communication pipes 34 connected to the first first flow equalization assembly 31a pass through the second first flow equalization assembly 31a and the second flow equalization assembly 31b so as to be exposed at a bottom of the second flow equalization assembly 31b. The plurality of communication pipes 34 connected to the second first flow equalization assembly 31a pass through the gas inlet space 33 between the second first flow equalization assembly 31a and the second flow equalization assembly 31b and the second flow equalization assembly 31b, and gas outlet ends of the plurality of communication pipes 34 connected to the second first flow equalization assembly 31a are exposed at the bottom of the second flow equalization assembly 31b.

[0148] In this embodiment, process gas flowing out from the outlets 211 of the first main gas inlet pipe 20 is directly transported into the process space S2 through the communication pipes 34 after gas equalization by the first first flow equalization assembly 31a. Process gas flowing out from the gas outlet ends of the second main gas inlet pipes 35 corresponding to the gas inlet

space 33 between the two first flow equalization assemblies 31a is directly transported into the process space S2 through the communication pipes 34 after gas equalization by the second first flow equalization assembly 31a. Process gas flowing out from the gas outlet ends of the second main gas inlet pipes 35 corresponding to the gas inlet space 33 between the second first flow equalization assembly 31a and the second flow equalization assembly 31b is sprayed into the process space S2 through the gas outlet ports 3131 of the second flow equalization assembly 31b after gas equalization by the second flow equalization assembly 31b.

[0149] When $N > 3$, and so on, details are not enumerated one by one in this embodiment.

[0150] Overall, when the gas inlet apparatus 30 is provided with a plurality of flow equalization assemblies 31 and the gas inlet apparatus 30 is provided with communication pipes 34, the respective flow equalization assemblies 31 do not communicate with each other and are mutually independent. Through such an arrangement, each flow equalization assembly 31 can independently perform gas equalization on process gas transported into the corresponding flow equalization cavity 311 thereof.

[0151] Moreover, in the gas inlet apparatus 30 of this embodiment, the second main gas inlet pipes 35 may further be fixedly connected to the flow equalization assemblies 31 penetrated thereby, thereby improving structural reliability of the gas inlet apparatus 30.

[0152] The gas inlet spaces 33 described above may correspondingly communicate with a plurality of second main gas inlet pipes 35, or may correspondingly communicate with one second main gas inlet pipe 35.

[0153] In the example shown in FIG. 13 and FIG. 15, one first main gas inlet pipe 20 and one second main gas inlet pipe 35 are provided. When the semiconductor process equipment 100 using the gas inlet apparatus 30 of this embodiment is an atomic layer deposition equipment,

different precursors may be alternately introduced into the first main gas inlet pipe 20 and the second main gas inlet pipe 35.

[0154] Specifically, please refer to FIG. 24. A first precursor is introduced into the first main gas inlet pipe 20, and the first precursor flows out from the outlets 211 of the first main gas inlet pipe 20 into the gas guide space S1, and then enters corresponding gas inlet pipes 316 through the gas inlet ports 3121 of the first flow equalization assembly 31a. The first precursor flows from gas outflow ends of the gas inlet pipes 316 into the flow equalization cavity 311 of the first flow equalization assembly 31a, then flows into the gas outlet pipes 317 after diffusion and gas equalization along radial and axial directions of the process chamber 10, and subsequently flows into the communication pipes 34 corresponding to the gas outlet ports 3131 through the gas outlet ports 3131 corresponding to the gas outlet pipes 317. Afterwards, the first precursor flows along the communication pipes 34 to the gas outlet port 3131 side of the second flow equalization assembly 31b and is then sprayed into the process space S2 and purged onto the surface of the wafer 200. A flow path of the first precursor is shown in FIG. 24 by solid arrows.

[0155] Specifically, please refer to FIG. 25. A second precursor is introduced into the second main gas inlet pipe 35, and the second precursor flows out from the gas outlet end of the second main gas inlet pipe 35 into the gas inlet space 33, and then enters corresponding gas inlet pipes 316 through the gas inlet ports 3121 of the second flow equalization assembly 31b. The second precursor flows from gas outflow ends of the gas inlet pipes 316 into the flow equalization cavity 311 of the second flow equalization assembly 31b, then flows into the gas outlet pipes 317 after diffusion and gas equalization along radial and axial directions of the process chamber 10, and is subsequently sprayed into the process space S2 through the gas outlet ports 3131 corresponding

to the gas outlet pipes 317 and purged onto the surface of the wafer 200. A flow path of the second precursor is shown in FIG. 25 by dashed arrows.

[0156] By adopting this design, each flow equalization assembly 31 can perform gas equalization on one precursor. Compared with the related technologies, in this embodiment, not only can different precursors sharing the same first main gas inlet pipe 20 be avoided, but also different precursors sharing the same flow equalization assembly 31 for flow equalization can be avoided. Correspondingly, a problem that different precursors share the same flow equalization assembly 31 and thereby cause a Chemical Vapor Deposition reaction to occur inside the flow equalization assembly 31 can be effectively avoided, which is beneficial to avoiding reaction by-products generated inside the flow equalization assembly 31 from affecting flow equalization uniformity, thereby ensuring quality of film fabrication and consistency and uniformity of process performance.

[0157] In some embodiments, please continue to refer to FIG. 13 and FIG. 15. A second cover plate 351 is connected to the gas outlet end of the second main gas inlet pipe 35, and the second cover plate 351 covers a port of the gas outlet end of the second main gas inlet pipe 35. A plurality of openings 352 are distributed at the second cover plate 351, and a plurality of openings 352 are circumferentially spaced apart at a pipe wall of the gas outlet end of the second main gas inlet pipe 35. Axial directions of the openings 352 at the pipe wall are perpendicular to the axial direction Z of the process chamber 10. The plurality of openings 352 at the pipe wall of the second main gas inlet pipe 35 may specifically be uniformly distributed along a circumferential direction of the second main gas inlet pipe 35.

[0158] In this way, when the process gas flows from the gas outlet end of the second main gas inlet pipe 35 to the gas inlet space 33, the process gas can be divided into multiple small gas

flows. Part of the multiple small gas flows enters the gas inlet space 33 through the openings 352 at the second cover plate 351 along the axial direction Z of the process chamber 10, and the remaining part enters the gas inlet space 33 through the openings 352 at the pipe wall along the radial direction of the process chamber 10.

[0159] In this embodiment, during a process in which the process gas flows from the gas outlet end of the second main gas inlet pipe 35 to the gas inlet space 33, not only can gas equalization be achieved along the axial direction Z of the process chamber 10, but also diffusion and gas equalization can be achieved along the radial direction of the process chamber 10, thereby improving the diffusion of the process gas toward edges of the process chamber 10 and further improving gas distribution uniformity and consistency of process performance.

[0160] As one embodiment, each flow equalization assembly 31 among the plurality of flow equalization assemblies 31 may be grounded, such that each flow equalization assembly 31 can filter the process gas introduced therein.

[0161] It can be understood that the above implementation solutions are merely exemplary implementations adopted for explaining principles of the present disclosure, and the present disclosure is not limited thereto. Various modifications and improvements may be made by persons of ordinary skill in the art without departing from the spirit and essence of the present disclosure, and these modifications and improvements are also regarded as falling within the scope of the present disclosure.

CLAIMS

WHAT IS CLAIMED IS:

1. A flow equalization assembly, comprising a flow equalization cavity inside the flow equalization assembly, wherein a plurality of gas inlet ports penetrating through a top wall of the flow equalization cavity along a thickness direction of the top wall are provided at the top wall of the flow equalization cavity, and a plurality of gas outlet ports penetrating through a bottom wall of the flow equalization cavity along a thickness direction of the bottom wall are provided at the bottom wall of the flow equalization cavity;

wherein a plurality of gas inlet pipes arranged in one-to-one correspondence with the plurality of gas inlet ports and a plurality of gas outlet pipes arranged in one-to-one correspondence with the plurality of gas outlet ports are arranged inside the flow equalization cavity; a first end of the gas inlet pipe is connected to a corresponding gas inlet port, and a second end of the gas inlet pipe is in communication with the flow equalization cavity; a first end of the gas outlet pipe is connected to a corresponding gas outlet port, and a second end of the gas outlet pipe is in communication with the flow equalization cavity; and the second end of the gas inlet pipe is located below the second end of the gas outlet pipe.

2. The flow equalization assembly according to claim 1, wherein the second end of the gas inlet pipe is closed, and a plurality of first flow equalization through holes are circumferentially spaced apart at a pipe wall of the second end of the gas inlet pipe; and/or, the second end of the gas outlet pipe is closed, and a plurality of second flow equalization through holes are circumferentially spaced apart at a pipe wall of the second end of the gas outlet pipe.

3. The flow equalization assembly according to claim 1, wherein a channel inside the gas inlet pipe penetrates through the second end of the corresponding gas inlet pipe, and the second end of the gas inlet pipe is close to the bottom wall and forms a first gap with the bottom wall;

and/or, a channel inside the gas outlet pipe penetrates through the second end of the corresponding gas outlet pipe, and the second end of the gas outlet pipe is close to the top wall and forms a second gap with the top wall.

4. The flow equalization assembly according to claim 3, wherein when the first gap is formed between the second end of the gas inlet pipe and the bottom wall and the second gap is formed between the second end of the gas outlet pipe and the top wall, dimensions of the first gap and the second gap in an axial direction of the flow equalization cavity are both greater than or equal to 0.1 mm and less than or equal to one-half of a height of the flow equalization cavity.

5. The flow equalization assembly according to claim 1, wherein all the gas inlet pipes and all the gas outlet pipes extend along an axial direction of the flow equalization cavity;

wherein a plurality of rows of gas inlet ports sequentially spaced apart along a first radial direction of the flow equalization cavity are distributed at the top wall, each row of gas inlet ports including the plurality of gas inlet ports sequentially spaced apart along a second radial direction of the flow equalization cavity; or, a plurality of rings of gas inlet ports are radially spaced apart at the top wall along the flow equalization cavity, diameters of the gas inlet ports in the respective rings gradually increasing from a center to an edge of the top wall, and quantities of the gas inlet ports in the respective rings gradually increasing;

wherein a plurality of rows of gas outlet ports sequentially spaced apart along the first radial direction are distributed at the bottom wall, each row of gas outlet ports including the plurality of gas outlet ports sequentially spaced apart along the second radial direction;

wherein the gas inlet ports and the gas outlet ports are staggered from each other in both the first radial direction and the second radial direction, the first radial direction, the second radial direction, and the axial direction of the flow equalization cavity being perpendicular to each other in pairs.

6. The flow equalization assembly according to claim 1, wherein orthographic projections of all the gas outlet ports at the flow equalization cavity onto a carrying surface of a base of semiconductor process equipment exceed an edge of a wafer carried on the carrying surface.

7. A gas inlet apparatus, comprising:

one flow equalization assembly or a plurality of flow equalization assemblies stacked and spaced apart according to any one of claims 1 to 6, and at least one first main gas inlet pipe;

wherein when the gas inlet apparatus includes one flow equalization assembly, an outlet of the first main gas inlet pipe is located at a gas inlet port side of the flow equalization assembly;

wherein when the gas inlet apparatus includes a plurality of flow equalization assemblies, the outlet of the first main gas inlet pipe is located at a gas inlet port side of a first flow equalization assembly stacked from top to bottom along an axial direction of the flow equalization cavity.

8. The gas inlet apparatus according to claim 7, wherein when the gas inlet apparatus includes the plurality of flow equalization assemblies, the gas inlet apparatus further includes:

a connection ring arranged between any two adjacent flow equalization assemblies and connected to both the two adjacent flow equalization assemblies, the connection ring and the two adjacent flow equalization assemblies jointly defining a gas inlet space.

9. The gas inlet apparatus according to claim 8, wherein among the plurality of flow equalization assemblies stacked from top to bottom along the axial direction of the flow equalization cavity, a last flow equalization assembly is determined as a second flow equalization assembly, and remaining flow equalization assemblies are all determined as first flow equalization assemblies;

wherein the gas inlet apparatus further includes: at least one second main gas inlet pipe and a plurality of communication pipes arranged for each first flow equalization assembly;

wherein a gas inlet end of each communication pipe is connected to a gas outlet port of the corresponding first flow equalization assembly, and a gas outlet end of each communication pipe passes through all the flow equalization assemblies located below the corresponding first flow equalization assembly and is exposed at a gas outlet port side of the second flow equalization assembly;

wherein each gas inlet space correspondingly communicates with the at least one second main gas inlet pipe; and a second main gas inlet pipe corresponding to the gas inlet space passes through other flow equalization assemblies located above the gas inlet space and enters the corresponding gas inlet space.

10. The gas inlet apparatus according to claim 9, wherein each gas inlet space corresponds to one second main gas inlet pipe.

11. The gas inlet apparatus according to claim 9, wherein when the gas inlet apparatus includes two flow equalization assemblies, there is one gas inlet space, and a quantity of the communication pipes is same as a quantity of gas outlet ports of the first flow equalization assembly;

wherein the communication pipes pass through the gas inlet space and the second flow equalization assembly, the gas inlet end of each communication pipe is connected to a gas outlet port of the first flow equalization assembly, and the gas outlet end of each communication pipe is exposed at the gas outlet port side of the second flow equalization assembly.

12. The gas inlet apparatus according to any one of claims 9 to 11, wherein a first cover plate is connected to a gas outlet end of the first main gas inlet pipe, the first cover plate covering a port of the gas outlet end of the first main gas inlet pipe, a plurality of outlets being distributed at the first cover plate, and a plurality of outlets being circumferentially spaced apart at a pipe wall of the gas outlet end of the first main gas inlet pipe;

and/or, a second cover plate is connected to a gas outlet end of the second main gas inlet pipe, the second cover plate covering a port of the gas outlet end of the second main gas inlet pipe, a plurality of openings being distributed at the second cover plate, and a plurality of openings being circumferentially spaced apart at a pipe wall of the gas outlet end of the second main gas inlet pipe.

13. Semiconductor process equipment, comprising:

a process chamber, wherein a base is arranged inside the process chamber, and the base includes a carrying surface configured to carry a wafer; and

the gas inlet apparatus according to any one of claims 7 to 12, wherein the flow equalization assembly is located inside the process chamber, and the flow equalization assembly is opposite the base, a gas inlet end of the first main gas inlet pipe being located outside the process chamber, and the gas outlet end of the first main gas inlet pipe being located inside the process chamber.

14. The semiconductor process equipment according to claim 13, further comprising a support ring arranged inside the process chamber, the support ring being fixedly connected to an inner wall of the process chamber;

wherein when the gas inlet apparatus includes one flow equalization assembly, a bottom of the flow equalization assembly is fixedly arranged at the support ring;

wherein when the gas inlet apparatus includes a plurality of flow equalization assemblies, among the plurality of flow equalization assemblies stacked from top to bottom along the axial direction of the flow equalization cavity, a last flow equalization assembly is determined as a second flow equalization assembly, and a bottom of the second flow equalization assembly is fixedly arranged at the support ring.

15. The semiconductor process equipment according to claim 13 or 14, wherein at least one flow equalization assembly at the gas inlet apparatus is grounded.