BAFFLE FOR PROVIDING UNIFORM PROCESS GAS FLOW ON SUBSTRATE AND AROUND PEDESTAL

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 63/439,882, filed on January 19, 2023. The entire disclosure of the application referenced above is incorporated herein by reference.

FIELD

[0002] The present disclosure relates generally to substrate processing systems and more particularly to a baffle for providing uniform process gas flow on a substrate and around pedestal in a substrate processing system.

BACKGROUND

[0003] The background description provided here is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

[0004] Atomic Layer Deposition (ALD) is a thin-film deposition method that sequentially performs a gaseous chemical process to deposit a thin film on a surface of a material (e.g., a surface of a substrate such as a semiconductor wafer). Most ALD processes use at least two chemicals called precursors (reactants) that react with the surface of the material one precursor at a time in a sequential, self-limiting manner. For example, a typical ALD process includes a series of dose and purge steps that are performed sequentially and repeatedly. Through repeated exposure to separate precursors, a thin film is gradually deposited on the surface of the material.

[0005] A thermal ALD (T-ALD) process is typically performed in a heated processing chamber. The processing chamber is maintained at a sub-atmospheric pressure using a vacuum pump and a controlled flow of an inert gas. The substrate to be coated with a film is placed in the processing chamber and is allowed to equilibrate with the temperature of the processing chamber before starting the ALD process. A plasma enhanced ALD (PEALD) process uses plasma during dose steps. The plasma may be

generated in-situ in the processing chamber. Alternatively, the plasma may be generated remotely from the processing chamber and supplied to the processing chamber.

SUMMARY

[0006] A substrate processing chamber comprises a well, a pedestal arranged in the well, and a baffle arranged in the well around the pedestal. The well is defined by a bottom portion and a sidewall extending vertically upwards from the bottom portion. The well comprises a plurality of exhaust ports near a bottom of the well. The pedestal comprises a base portion and a stem portion. The baffle comprises a sidewall and a plurality of sets of apertures in the sidewall. The baffle is configured to direct flow of gases supplied to the substrate processing chamber to flow around the pedestal from a periphery of the base portion of the pedestal towards the stem portion of the pedestal and through the sets of apertures in the sidewall of the baffle towards the plurality of exhaust ports.

[0007] In additional features, apertures in at least one set of the sets of apertures are of different size and shape than apertures in at least one other set of the sets of apertures.

[0008] In additional features, at least one set of the sets of apertures is of different size and shape than at least one other set of the sets of apertures.

[0009] In additional features, a first aperture in a first set of the sets of apertures is of different size and shape than a second aperture in a second set of the sets of apertures.

[0010] In additional features, the baffle is of same height as the well.

[0011] In additional features, the well and the baffle are cylindrical, and the baffle is smaller in diameter than the well.

[0012] In additional features, the sidewalls of the well and the baffle are cylindrical. A bottom end of the sidewall of the baffle is arranged on the bottom portion of the well. An outer diameter of the sidewall of the baffle is less than an inner diameter of the sidewall of the well.

[0013] In additional features, the sidewalls of the well and the baffle are of same height.

[0014] In additional features, the baffle comprises an annular flange and a plurality of arc-shaped flanges. The annular flange extends radially outward from a top end of the sidewall of the baffle. The annular flange is sealingly arranged on a top end of the sidewall of the well. The plurality of arc-shaped flanges extends radially outward from the sidewall of the baffle. The arc-shaped flanges are located at a predetermined distance from the bottom end of the sidewall of the baffle.

[0015] In additional features, the predetermined distance is greater than or equal to a height of the exhaust ports.

[0016] In additional features, the arc-shaped flanges are of different arc-lengths.

[0017] In additional features, arc lengths of the arc-shaped flanges are based on locations of the exhaust ports.

[0018] In additional features, the arc-shaped flanges sealingly mate with the sidewall of the well forming a channel between the annular flange, the arc-shaped flanges, and the sidewalls of the baffle and the well.

[0019] In additional features, the gases flowing towards the stem portion of the pedestal flow through the sets of apertures in the sidewall of the baffle into the channel towards the plurality of exhaust ports.

[0020] In additional features, the baffle comprises a plurality of interconnecting flanges extending radially outward from the sidewall of the baffle. The interconnecting flanges are located at the predetermined distance from the bottom of the sidewall of the baffle. The interconnecting flanges interconnect the arc-shaped flanges.

[0021] In additional features, the interconnecting flanges are arc shaped. The interconnecting flanges are of a smaller radial width than the arc-shaped flanges.

[0022] In additional features, the interconnecting flanges are arc shaped. The interconnecting flanges are of a smaller arc length than the arc-shaped flanges.

[0023] In additional features, the interconnecting flanges are arc shaped. The interconnecting flanges are of a smaller arc length than a width of the exhaust ports.

[0024] In additional features, the arc-shaped flanges and the interconnecting flanges are coplanar.

[0025] In additional features, the arc-shaped flanges and the interconnecting flanges form a continuous annular structure.

[0026] In additional features, the baffle is monolithic.

[0027] In additional features, the interconnecting flanges are proximate to the exhaust ports. At least one set of the sets of apertures is located proximate to the interconnecting flanges and the exhaust ports. At least one of other set of the sets of apertures is located away from the exhaust ports.

[0028] In additional features, apertures in the at least one set are smaller than apertures in the at least one other set.

[0029] In additional features, apertures in the at least one set are of different size and shape than apertures in the at least one other set.

[0030] In additional features, the at least one set is of a different size than the at least one other set.

[0031] In additional features, the at least one set is of a different shape than the at least one other set.

[0032] In additional features, the at least one set is vertically offset relative to the at least one other set on the sidewall of the baffle.

[0033] In additional features, the flow of the gases around the pedestal is uniform irrespective of locations of the exhaust ports in the well.

[0034] In additional features, the substrate processing chamber further comprises a substrate arranged on the pedestal. The flow of the gases is uniform over the substrate irrespective of locations of the exhaust ports in the well.

[0035] In additional features, the substrate processing chamber further comprises a showerhead and a vacuum pump. The showerhead is arranged above the pedestal to supply the gases into the substrate processing chamber during processing a substrate arranged on the pedestal. The vacuum pump is coupled to the exhaust ports to pump the gases from the substrate processing chamber during the processing.

[0036] In additional features, the substrate processing chamber further comprises a showerhead and a vacuum pump. The showerhead is arranged above the pedestal to supply the gases into the substrate processing chamber during cleaning of the substrate processing chamber. The vacuum pump is coupled to the exhaust ports to pump the gases from the substrate processing chamber during the cleaning.

[0037] Further areas of applicability of the present disclosure will become apparent from the detailed description, the claims, and the drawings. The detailed description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0039] FIG. 1 shows an example of a substrate processing system with a processing chamber comprising a baffle according to the present disclosure;

[0040] FIGS. 2A and 2B show a well of a station in the processing chamber comprising the baffle and uniform gas flow provided by the baffle in the processing chamber;

[0041] FIG. 3 shows a perspective view of the baffle showing the design, shape, and geometry of the baffle;

[0042] FIGS. 4 and 5 show front and back views of the baffle showing the design, shape, and geometry of the baffle, respectively;

[0043] FIGS. 6 and 7 show right and left side views of the baffle showing the design, shape, and geometry of the baffle, respectively;

[0044] FIG. 8 shows a top plan view of the baffle showing the design, shape, and geometry of the baffle;

[0045] FIG. 9 shows a bottom plan view of the baffle showing the design, shape, and geometry of the baffle; and

[0046] FIGS. 10-12 show the bottom view and transverse sections of the baffle showing the design, shape, and geometry of the baffle.

[0047] In the drawings, reference numbers may be reused to identify similar and/or identical elements.

DETAILED DESCRIPTION

[0048] In most substrate processing systems (also called tools), a processing chamber comprises one or more stations. Each station comprises a cylindrical well in which a pedestal and a showerhead are arranged to process substrates. Each well comprises

one or more exhaust ports through which process gases supplied to the station are pumped out using a pump. Generally, the exhaust ports are not arranged uniformly (symmetrically) in the well. Due to the asymmetric arrangement (e.g., locations) of the exhaust ports in the well, the flow of process gases around the pedestal in the well can be non-uniform. The non-uniform flow of the process gases around the pedestal affects the distribution of the process gases on the surface of the substrate arranged on the pedestal during processing and the distribution of the process gases beyond the edges of the pedestal.

[0049] The present disclosure provides a baffle that is arranged around the pedestal to achieve uniform process gas flow on the substrate surface and around the pedestal. The baffle redirects the flow of the process gases from the edges of the pedestal towards the stem of the pedestal in the well and then collectively towards the exhaust ports via various apertures provided in the baffle. The baffle is designed (shaped) such that the flow of process gases around the pedestal in the well can be uniform even if the exhaust ports are arranged non-uniformly (asymmetrically) in the well. Without the baffle, the flow uniformity around the pedestal and therefore around the substrate cannot be sufficiently uniform, particularly when the exhaust ports are arranged non-uniformly (asymmetrically) in the well. The flow non-uniformity causes non-uniform deposition on the substrate.

[0050] The baffle according to the present disclosure is generally cylindrical. Specifically, as described below in detail, the baffle comprises a cylindrical sidewall, an annular flange at a top end of the baffle, and a pair of semi-annular or arc-shaped flanges near a bottom end of the cylindrical sidewall of the baffle. The baffle is arranged in the well around the pedestal such that the annular flange rests on top end of the well. The annular flange seals the well and forces or directs the process gases flowing downstream from the pedestal towards an interior volume of the baffle surrounding the pedestal. The pair of arc-shaped flanges sealingly mate with an inner sidewall of the well near the bottom of the well. The arc-shaped flanges prevent the baffle from tilting relative to a vertical axis of the well and ensure that the baffle is centered in the well.

[0051] The cylindrical sidewall of the baffle comprises multiple sets of apertures. A set of apertures is a group of apertures localized in a particular region of the cylindrical sidewall of the baffle. For example, the apertures may comprise through holes, slits (e.g., elongated apertures), or a combination of holes and slits. For example, first and

second sets of apertures may comprise through holes drilled through portions of the cylindrical sidewall and may be positioned along the cylindrical sidewall at opposite locations (e.g., diametrically opposite locations) on the cylindrical sidewall of the baffle. Additionally, third and fourth sets of apertures may comprise slits (e.g., oval slits) drilled through the cylindrical sidewall and may be positioned along the cylindrical sidewall at opposite locations (e.g., diametrically opposite locations) on the cylindrical sidewall of the baffle. The locations of the first and second sets of apertures may be 90 degrees apart from the locations of the third and fourth sets of apertures.

[0052] The baffle is arranged in the well such that the spaces separating the two arc-shaped flanges coincide with the respective exhaust ports in the well. Accordingly, the space between the annular flange, the two arc-shaped flanges, and the inner sidewall of the well form a channel through which the process gases that exit the baffle through the apertures flow towards the exhaust ports.

[0053] The first and second sets of apertures comprising the through holes are located closer to the exhaust ports than the third and fourth sets of apertures comprising the slits. The process gases flowing downstream from the pedestal, which are routed into the baffle, flow into the channel more through the third and fourth sets of apertures comprising the slits, which are located farther from the exhaust ports, than through the first and second sets of apertures comprising the through holes, which are located closer to the exhaust ports. By providing more flow via the slits that are farther from the exhaust ports and less flow via the through holes that are closer to the exhaust ports, the baffle achieves a balanced and uniform gas flow around the pedestal and therefore around the substrate. Further, uniform pumping of the process gases is achieved with non-uniform arrangement of exhaust ports. The flow uniformity of the process gases achieved by the baffle improves the uniformity of deposition on the substrate. These and other features of the baffle are described below in detail.

[0054] The present disclosure is organized as follows. An example of a substrate processing system comprising a processing chamber and a baffle according to the present disclosure is schematically shown and described with reference to FIG. 1. A cross-sectional view of a well of a station in the processing chamber comprising the baffle is shown and described in further detail with reference to FIGS. 2A and 2B. The design of the baffle and uniform gas flow around the pedestal are shown and described

with reference to FIGS. 2A and 2B. The geometry of the baffle and various features of the baffle is shown and described in detail with reference to FIGS. 2A-12.

[0055] FIG. 1 shows an example of a substrate processing system 100. The substrate processing system 100 comprises a processing chamber 102. The processing chamber 102 typically comprises a plurality of stations in which substrates can be processed. For simplicity of illustration, only one station with the baffle is shown. Each station comprises a pedestal 104 arranged in a well (e.g., a well 105 is shown in FIG. 2) and a showerhead 106. A substrate 108 is arranged on the pedestal 104 during processing. The showerhead 106 supplies one or more process gases into the processing chamber 102 during substrate processing.

[0056] The pedestal 104 comprises a base portion 110 and a stem portion 112. The base portion 110 is generally cylindrical and has a larger diameter than the substrate 108. The stem portion 112 can be cylindrical or of the shape of the letter "Y" with the flared or forked end of the "Y" being attached to the base portion 110. The other end of the stem portion 112 is attached to the bottom of the processing chamber 102. The stem portion 112 is smaller in diameter than the base portion 110. A pedestal lift assembly 113 is coupled to the stem portion 112 to move the pedestal 104 relative to the showerhead 106.

[0057] The base portion 110 comprises a heater 114 to heat the substrate 108. The base portion 110 also comprises cooling channels (not shown) to circulate a coolant supplied by a coolant supply 116 to regulate the temperature of the pedestal 104. The base portion 110 comprises a temperature sensor 118 to sense the temperature of the pedestal 104. The temperature sensor 118 is connected to a temperature controller 119. Based on the temperature sensed by the temperature sensor 118, the temperature controller 119 controls the heater 114 and flow of the coolant from the coolant supply 116 into the cooling channels in the base portion 110 to regulate the temperature of the pedestal 104.

[0058] The showerhead 106 comprises a base portion 120 and a stem portion 122. The base portion 120 is cylindrical and extends radially across the substrate 108. The base portion 120 has a larger diameter than the substrate 108. On a substrate-facing surface, the base portion 120 comprises a faceplate comprising a plurality of holes (not shown) through which one or more process gases into the processing chamber 102 during substrate processing. The stem portion 122 is also generally cylindrical and is of

a smaller diameter than the base portion 120. A first end of the stem portion 122 is connected to a center portion of the base portion 120. A second end of the stem portion 122 is connected to a top plate of the processing chamber 102.

[0059] While not shown, the base portion 120 may comprise a heater to heat the process gases. The base portion 120 may also comprise cooling channels to circulate the coolant supplied by the coolant supply 116 to regulate the temperature of the showerhead 106. The base portion 120 comprises a temperature sensor 124 to sense the temperature of the showerhead 106. The temperature sensor 124 is connected to the temperature controller 119. Based on the temperature sensed by the temperature sensor 124, the temperature controller 119 controls the heater and flow of the coolant from the coolant supply 116 into the cooling channels in the base portion 120 to regulate the temperature of the showerhead 106.

[0060] A gas delivery system 130 supplies one or more gases to the processing chamber 102. The gas delivery system 130 comprises a plurality of gas sources 132-1, 132-2, ..., 132-N (collectively called the gas sources 132), where N is a positive integer. The gas sources 132 supply various gases comprising process gases, purge gases, precursors, cleaning gases, and so on. The gas delivery system 130 comprises a plurality of valves 134-1, 134-2, ..., 134-N (collectively called the valves 134). The valves 134 are connected to the gas sources 132 and control the flow of the gases supplied by the gas sources 132.

[0061] The gas delivery system 130 comprises a plurality of mass flow controllers (MFCs) 136-1, 136-2, ..., 136-N (collectively called the MFCs 136). The MFCs 136 are connected to the valves 134 and control mass flow of the gases supplied by the gas sources 132 through the valves 134. The gas delivery system 130 comprises a manifold 138. The manifold 138 is connected to the MFCs 136 and to the showerhead 106. The manifold 138 supplies the gases to the showerhead 106.

[0062] Some processes may use one or more vaporized precursors during substrate processing. Accordingly, while not shown, the substrate processing system 100 may further comprise a vaporized precursor supply to supply one or more vaporized precursors. The vaporized precursor supply may also be connected to the manifold 138. When used, the manifold 138 may supply one or more vaporized precursors supplied by the vaporized precursor supply to the showerhead 106.

[0063] In some processes, plasma may be used during substrate processing. While not shown, the substrate processing system 100 may further comprise a radio frequency (RF) power supply to supply RF power to generate plasma. For example, the RF power supply may supply the RF power to the showerhead 106 with the pedestal 104 grounded or floating. Alternatively, the RF power supply may supply the RF power to the pedestal 104 with the showerhead grounded or floating. In either case, when one or more process gases are supplied into the processing chamber 102 through the showerhead 106, the RF power supplied by the RF power supply activates the process gases in the processing chamber 102 to generate plasma between the showerhead and the substrate 108. In some processes, instead of generating plasma in the processing chamber 102, the plasma can be generated remotely from (outside) the processing chamber 102 and can be supplied to the processing chamber 102.

[0064] A plurality of exhaust ports (e.g., exhaust ports 103 shown in FIG. 2) is arranged around a lower periphery of the sidewall of the well 105 in the processing chamber 102. The exhaust ports 103 are coupled to a foreline 144 that is connected to the processing chamber 102. The substrate processing system 100 further comprises a vacuum pump 140 coupled to the processing chamber 102 via the foreline 144 through a valve 142. The vacuum pump 140 maintains pressure (e.g., vacuum) in the processing chamber 102 during substrate processing. The vacuum pump 140 also evacuates process gases and reaction byproducts from the processing chamber 102 during substrate processing and cleaning of the processing chamber 102.

[0065] When vacuum clamping is used to clamp the substrate 108 to the pedestal 104, the vacuum pump 140 also provides vacuum clamping. While not shown, the substrate can be clamped to the pedestal 104 using other clamping methods (e.g., electrostatic clamping provided by electrodes disposed in the base portion 110 of the pedestal 104, mechanical clamping, etc.). The processing chamber 102 further comprises a controller 150. The controller 150 controls all of the elements of the substrate processing system 100 described above.

[0066] The processing chamber 102 further comprises a baffle 160. The baffle 160 is shown only schematically in FIG. 1. The baffle 160 is also cylindrical and is disposed in a cylindrical well 105 (shown in FIGS. 2A and 2B) in the processing chamber 102. The baffle 160 is shown and described below in further detail with reference to FIGS. 2A-12.

[0067] FIGS. 2A and 2B show a cross-sectional view of the well 105 and the baffle 160 that is disposed in the well 105 and the uniform gas flow provided by the baffle 160 around the pedestal 104. FIG. 2A shows the cross-sectional view of the well 105 comprising the baffle 160 and the pedestal 104. FIG. 2B shows the uniform gas flow provided by the baffle 160 around the pedestal 104. The elements identified in FIGS. 2A and 2B by reference numerals that are already described with reference to FIG. 1 are not described again for brevity. The additional elements shown in FIGS. 2A and 2B are described below.

[0068] The well 105 is generally cylindrical. Specifically, the well 105 is of the shape of a right circular cylinder and is hollow. The well 105 is defined by and comprises a sidewall 105-1 and a bottom portion 105-2. The sidewall 105-1 of the well 105 is cylindrical (i.e., of the shape of a right circular cylinder). The bottom portion 105-2 of the well 105 is generally disc-shaped. More specifically, the bottom portion 105-2 of the well 105 is annular and comprises a hole in the center through which the stem portion 112 of the pedestal 104 passes. The bottom portion 105-2 of the well 105 is parallel to the base portion 110 of the pedestal 104 and to the substrate 108. The sidewall 105-1 of the well 105 extends vertically upwards (along a vertical axis of the pedestal 104) from the bottom portion 105-2 of the well 105. An inner diameter (ID) of the well 105 is greater than an outer diameter (OD) of the base portion 110 of the pedestal 104.

[0069] Before describing the baffle 160 in detail, an example of the geometry of the base portion 110 of the pedestal 104 is described in detail with reference to FIGS. 2A and 2B. For example, in FIGS. 2A and 2B, the base portion 110 of the pedestal 104 comprises an upper portion 111 and a lower portion 115. The upper portion 111 of the base portion 110 is cylindrical. The substrate 108 rests on the upper portion 111 of the base portion 110 during processing. The lower portion 115 of the base portion 110 extends from the bottom of the upper portion 111 downwardly towards the bottom of the processing chamber 102 as follows.

[0070] For example, the lower portion 115 of the base portion 110 has a trapezoidal cross-section. Specifically, in the example shown, the lower portion 115 of the base portion 110 tapers radially inwards from the bottom of the upper portion 111 towards the stem portion 112 of the pedestal 104 for a first distance. The lower portion 115 of the base portion 110 tapers downwards towards the bottom of the processing chamber 102 for the first distance. After the first distance, the lower portion 115 of the base

portion 110 extends radially inwards parallel to the upper portion 111. After the first distance, the lower portion 115 of the base portion 110 extends towards and up to the stem portion 112 of the pedestal 104. Accordingly, an upper end of the lower portion 115 has the same OD as the upper portion 111, but a lower end of the lower portion 115 has a smaller diameter than the upper end of the lower portion 115.

[0071] The geometry of the baffle 160 is now described in detail with reference to FIGS. 2A-12. FIGS. 2A and 2B show a cross-sectional view of the baffle 160. FIG. 3 shows a perspective view of the baffle 160. FIGS. 4 and 5 respectively show front and back views of the baffle 160. FIGS. 6 and 7 respectively show right and left views of the baffle 160. FIGS. 8 and 9 respectively show top and bottom plan views of the baffle 160. Different elements of the baffle 160 are visible and shown in different ones of FIGS. 2A-12. FIGS. 2A-12 collectively show all of the elements or features of the baffle 160 described below. Not all of the elements or features of the baffle 160 are visible in each of the FIGS. 2A-12. Only the elements or features of the baffle 160 that are visible in the views shown in FIGS. 2A-12 are labeled in FIGS. 2A-12. Therefore, in the following description of the baffle 160, FIGS. 2A-12 are referenced as needed to describe the design and the features of the baffle 160.

[0072] Note that the geometry of the baffle 160 described below can be the same if the base portion of the pedestal 104 is fully cylindrical (i.e., if both the upper portion 111 and the lower portion 115 of the base portion 110 are cylindrical). The baffle 160 can direct the flow of gases as described below even if the base portion 110 of the pedestal 104 is fully cylindrical.

[0073] In FIGS. 2A and 2B, generally, in each station of the processing chamber 102 (shown in FIG. 1), the exhaust ports 103 are not arranged uniformly (symmetrically) in the well 105. Due to the arrangement (e.g., locations) of the exhaust ports 103 in the well 105, the flow of process gases around the pedestal 104 arranged in the well 105 can be non-uniform. The non-uniform flow of the process gases around the pedestal 104 in the well 105 affects the distribution of the process gases on the surface of the substrate 108 and beyond the edges of the pedestal 104 during substrate processing. Therefore, the baffle 160 is arranged around the pedestal 104 to achieve uniform gas flow on the substrate 108 and around the pedestal 104.

[0074] As shown and described in further detail with reference to FIGS. 2A-12, the baffle 160 is designed (shaped) with features (e.g., apertures) to achieve uniform gas

flow on the substrate 108 and around the pedestal 104. The baffle 160 and the features of the baffle 160 are designed (shaped) such that the gas flow around the pedestal 104 can be uniform irrespective of the arrangement (locations) of the exhaust ports 103. Without the baffle 160, the flow uniformity around the pedestal 104 and therefore around the substrate 108 cannot be sufficiently uniform. The flow non-uniformity causes non-uniform deposition on the substrate 108.

[0075] The baffle 160 is generally cylindrical (i.e., of the shape of a right circular cylinder) and is hollow. Specifically, as described in further detail with reference to FIGS. 2A-12, the baffle 160 comprises a cylindrical sidewall 162. That is, the cylindrical wall 162 is of the shape of a right circular cylinder. A top end of the cylindrical sidewall 162 extends radially outwards to form an annular flange 164 at the top end of the baffle 160. A pair of semi-annular or arc-shaped flanges (see elements 166-1 and 166-2 shown in FIG. 3, collectively called the arc-shaped flanges 166) is disposed near a bottom end of the cylindrical sidewall 162 of the baffle 160. An OD of the cylindrical sidewall 162 of the baffle 160 is less than an ID of the sidewall 105-1 of the well 105. The arc-shaped flanges 166 extend radially outwards from near the cylindrical sidewall 162 of the baffle 160. The arc-shaped flanges 166 extend parallel to the annular flange 164. The arc-shaped flanges 166 sealingly mate with the sidewall 105-1 of the well 105 as described below in further detail.

[0076] The baffle 160 is arranged in the well 105 around the pedestal 104 such that the annular flange 164 of the baffle 160 rests on a top end of the sidewall 105-1 of the well 105. An OD of the annular flange 164 is greater than an OD of the sidewall 105-1 of the well 105. The annular flange 164 seals the well 105 and forces or directs the process gases flowing downstream from the pedestal 104 towards an interior volume 168 of the baffle 160 surrounding the pedestal 104.

[0077] The arc-shaped flanges 166 of the baffle 160 sealingly mate with an inner sidewall of the well 105 near the bottom of the well 105. An OD of the arc-shaped flanges 166 is equal to an ID of the sidewall 105-1 of the well 105. The OD of the arc-shaped flanges 166 is less than the OD of the annular flange 164. The arc-shaped flanges 166 of the baffle 160 prevent the baffle 160 from tilting relative to a vertical axis of the well 105 and ensure that the baffle 160 is centered in the well 105.

[0078] The exhaust ports 103 are generally oval or rectangular in shape (or have a generally elongated shape). For example, the baffle 160 is designed to operate with two

exhaust ports 103 in the well 105. However, the design of the baffle 160 described below can be extended to operate with any number of exhaust ports 103. For example, the number of the arc-shaped flanges 166 (and the number of arc-shaped flanges 167 described below), the arc lengths of the arc-shaped flanges 166 and 167, and the number and types of sets of apertures (described below) in the cylindrical sidewall 162 of the baffle 160 can be designed depending on the number and locations of the exhaust ports 103 in the well 105.

[0079] The exhaust ports 103 extend laterally and arcuately along the sidewall of the well 105 near the bottom of the well 105. Depending on the locations of the exhaust ports 103 in the well 105, the arc-shaped flanges 166 can have different arc lengths. For example, in the example shown, the first arc-shaped flange 166-1 can have a longer arc length than the second arc-shaped flange 166-2. The ends of the first and second arc-shaped flanges 166-1 and 166-2 extend up to a pair of the exhaust ports 103. For example, a first end of the first arc-shaped flange 166-1 extends up to a first end of a first exhaust port 103, and a first end of the second arc-shaped flange 166-2 extends up to a second end of the first exhaust port 103. The second ends of the first and second arc-shaped flanges 166-1, 166-2 extend up to first and second ends of a second exhaust port 103, respectively.

[0080] The first and second arc-shaped flanges 166-1, 166-2 may be connected to each other by a second pair of arc-shaped flanges 167-1, 167-2 (visible in views shown in FIGS. 9 and 10). Therefore, the arc-shaped flanges 167-1, 167-2 are also called interconnecting flanges 167-1, 167-2. The arc-shaped flanges 167-1, 167-2 (collectively called the arc-shaped flanges 167) have the same ID as the first and second arc-shaped flanges 166-1, 166-2. The arc-shaped flanges 167-1, 167-2 have a smaller OD than the first and second arc-shaped flanges 166-1, 166-2. The arc-shaped flanges 167-1, 167-2 have a smaller radial width than the first and second arc-shaped flanges 166-1, 166-2. The arc lengths of the arc-shaped flanges 167-1, 167-2 can be greater than or equal to a width or arc length of the exhaust ports 103.

[0081] The first and second arc-shaped flanges 166-1, 166-2 and the arc-shaped flanges 167-1, 167-2 form a continuous annular structure with radially inwards recessed portions provided by the arc-shaped flanges 167-1, 167-2. The arc-shaped flanges 166, 167 are coplanar (i.e., lie on of the cylindrical sidewall 162 of the baffle 160 in the same plane). When the baffle 160 is installed in the well 105, the arc-shaped flanges 167-1,

167-2 are proximate to the exhaust ports 103. The baffle 160 comprising the cylindrical sidewall 162, the annular flange 164, the first and second arc-shaped flanges 166-1, 166-2 and the arc-shaped flanges 167-1, 167-2 is a monolithic structure (i.e., the baffle 160 is manufactured as a single piece).

[0082] The cylindrical sidewall 162 of the baffle 160 comprises multiple sets of apertures (e.g., shown in FIG. 3). The apertures are drilled into and located on the cylindrical sidewall 162 of the baffle 160 between the annular flange 164 and arc-shaped flanges 166. For example, the apertures may comprise through holes, slits (e.g., elongated apertures), or a combination of holes and slits. For example, first and second sets of apertures 170-1, 170-2 (collectively called the first and second sets of apertures 170) may comprise through holes drilled through portions of the cylindrical sidewall 162 of the baffle 160. The first and second sets of apertures 170-1, 170-2 may be positioned along the cylindrical sidewall 162 of the baffle 160 at diametrically opposite locations. Depending on the locations of the exhaust ports 103, the first and second sets of apertures 170-1, 170-2 may be positioned along the cylindrical sidewall 162 of the baffle 160 at opposite locations along a chord smaller than a diameter of the cylindrical sidewall 162 of the baffle 160.

[0083] Additionally, third and fourth sets of apertures 172-1, 172-2 (collectively called the third and fourth sets of apertures 172) may comprise slits (e.g., oval slits) drilled through the cylindrical sidewall 162 of the baffle 160. The third and fourth sets of apertures 172-1, 172-2 may be positioned along the cylindrical sidewall 162 of the baffle 160 at diametrically opposite locations. Depending on the locations of the exhaust ports 103, the locations of the first and second sets of apertures 170-1, 170-2 may be 90 degrees apart from the locations of the third and fourth sets of apertures 172-1, 172-2. The locations of the first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 (collectively called the sets of apertures 170, 172) depend on the locations of the exhaust ports 103 as described below in further detail.

[0084] The size of the through holes in the first and second sets of apertures 170-1, 170-2 is less than the size of the slits in the third and fourth sets of apertures 172-1, 172-2. The density of the through holes in the first and second sets of apertures 170-1, 170-2 (i.e., the number of through holes per unit area of the first and second sets of apertures 170-1, 170-2) is less than the density of the slits in the third and fourth sets of

apertures 172-1, 172-2 (i.e., the number of slits per unit area of the third and fourth sets of apertures 172-1, 172-2).

[0085] The baffle 160 is arranged in the well 105 such that the spaces separating the two arc-shaped flanges (i.e., the arc-shaped flanges 167-1, 167-2 near the exhaust ports 103) coincide with the locations of the respective exhaust ports 103 in the well 105. The space between the annular flange 164, the two arc-shaped flanges 166 and the arc-shaped flanges 167-1, 167-2 near the exhaust ports 103, and the inner sidewall of the well 105 form a channel 107 (shown in FIGS. 2A and 2B). A radial width of the channel 107 is equal to a difference between the OD of the cylindrical sidewall 162 of the baffle 160 and the ID of the sidewall 105-1 of the well 105. The radial width of the channel 107 is also equal to the radial width of the arc-shaped flanges 166-1, 166-2 (i.e., a difference between the OD and the ID of the arc-shaped flanges 166-1, 166-2).

[0086] The process gases flowing downstream from the base portion 110 of the pedestal 104 flow through the interior volume 168 of the baffle 160. The process gases flow then through the first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 into the channel 107 towards and out through the exhaust ports 103. The gas flows are shown by arrows 180-1 through 180-12 in FIG. 2B and are described below in further detail. All other reference numerals shown in FIG. 2A are omitted in FIG. 2B to not clutter FIG. 2B and to clearly illustrate the gas flow. The reference numerals shown in FIG. 2A are presumed present in FIG. 2B.

[0087] The first and second sets of apertures 170-1, 170-2 comprising the through holes are located closer to the exhaust ports 103 than the third and fourth sets of apertures 172-1, 172-2 comprising the slits. The process gases flowing downstream from the base portion 110 of the pedestal 104, which are routed into the interior volume 168 the baffle 160, flow into the channel 107 more through the third and fourth sets of apertures 172-1, 172-2 comprising the slits, which are located farther from the exhaust ports 103, than through the first and second sets of apertures 170-1, 170-2 comprising the through holes, which are located closer to the exhaust ports. By providing more flow via the slits in the third and fourth sets of apertures 172-1, 172-2 that are farther from the exhaust ports 103 and less flow via the through holes in the first and second sets of apertures 170-1, 170-2 that are closer to the exhaust ports 103, the baffle 160 achieves a balanced and uniform gas flow around the pedestal 104 and therefore around the substrate 108. Further, uniform pumping of the process gases is achieved with non-

uniform arrangement of exhaust ports 103. The flow uniformity of the process gases achieved by the baffle 160 improves the uniformity of deposition on the substrate 108.

[0088] The first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 can comprise different types of openings drilled through the cylindrical sidewall 162 of the baffle 160. For example, similar to the first and second sets of apertures 170-1, 170-2, the third and fourth sets of apertures 172-1, 172-2 may also comprise through holes instead of slits except that the through holes in the third and fourth sets of apertures 172-1, 172-2 may be greater in size (diameter) than the through holes in the first and second sets of apertures 170-1, 170-2. For example, similar to the third and fourth sets of apertures 172-1, 172-2, the first and second sets of apertures 170-1, 170-2 may also comprise slits except that the slits in the first and second sets of apertures 170-1, 170-2 may be smaller than the slits in the third and fourth sets of apertures 172-1, 172-2.

[0089] Further, in some examples, each of the first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 can comprise a combination of through holes and slits, with the through holes and slits in the first and second sets of apertures 170-1, 170-2 being smaller than the through holes and slits in the third and fourth sets of apertures 172-1, 172-2. Furthermore, any number of the sets of apertures with through holes and any number of the sets of apertures with slits may be provided in the cylindrical sidewall 162 of the baffle 160. The size and shapes of the through holes and the slits can also be varied. For example, the through holes can be polygonal (e.g., circular, hexagonal, oval, rectangular, triangular, etc.), and the slits can be horizontal, vertical, slanted, zig-zag, stepped, or of any other shape. The size and shapes of the apertures (e.g., the through holes and the slits) in a single set of apertures can also be varied. Any combinations of the variations may be used.

[0090] Additionally, the first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 can have different shapes and sizes and therefore different surface areas. For example, the shapes can be circular or polygonal (e.g., rectangular, triangular, hexagonal, etc.). Each of the first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 can have the same shape, different shapes, or any combination of shapes. Each of the first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 can have the same size, different sizes, or any combination of sizes. The first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 also need not lie in the same plane on the cylindrical sidewall 162 of the baffle 160. For example, one or more of the first through

fourth sets of apertures 170-1, 170-2, 172-1, 172-2 may be slightly above or below a plane that lies at a center of the cylindrical sidewall 162 of the baffle 160. In other words, the first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 may be arranged along different planes on the cylindrical sidewall 162 of the baffle 160 and therefore may be vertically offset relative to one another on the cylindrical sidewall 162 of the baffle 160.

[0091] When installed in the well 105, a bottom end of the cylindrical sidewall 162 of the baffle 160 rests on the bottom portion 105-2 of the well 105. The annular flange 164 rests on the top end of the well 105. The arc-shaped flanges 166, 167 are located on the cylindrical sidewall 162 of the baffle 160 at a predetermined distance above the bottom end of the cylindrical sidewall 162 of the baffle 160. The predetermined distance is greater than or equal to a height of the exhaust ports 103. The first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 are disposed in the cylindrical sidewall 162 of the baffle 160 between the annular flange 164 and the arc-shaped flanges 166, 167. The height of the baffle 160 is the height of the cylindrical sidewall 162 of the baffle 160. The height of the baffle 160 is also a distance between the annular flange 164 and the bottom end of the cylindrical sidewall 162 of the baffle 160. The height of the baffle 160 is equal to the height (depth) of the well 105.

[0092] The baffle 160 does not contact any portion of the pedestal 104. The top end or the annular flange 164 of the baffle 160 lies at a level below the base of the upper portion 111 of the base portion 110 of the pedestal 104. The ID of the annular flange 164 of the baffle 160 surrounds the lower portion 115 of the base portion 110 of the pedestal 104. The ID of the annular flange 164 does not contact the lower portion 115 of the base portion 110 of the pedestal 104. Instead, a gap exists between the ID of the annular flange 164 (or the cylindrical sidewall 162 of the baffle 160) and a periphery of the lower portion 115 of the base portion 110 of the pedestal 104. The gap separates the ID of the annular flange 164 (or the cylindrical sidewall 162 of the baffle 160) and the lower portion 115 of the base portion 110 of the pedestal 104.

[0093] The baffle 160 facilitates the flow of gases in the well 105 as shown in FIG. 2B. Specifically, in FIG. 2A, the showerhead 106 delivers the process gases onto the substrate 108 arranged on the pedestal 104. The vacuum pump 140 (shown in FIG. 1) evacuates the process gases and reaction byproducts produced by the reaction between the process gases and the substrate 108 from the well 105. The process

gases and the reaction byproducts flow over the substrate 108, around the pedestal 104 and the baffle 160, and out of the exhaust ports of the well 105 as follows.

[0094] As shown in FIG. 2B, the process gases delivered by the showerhead 106 flow uniformly over the substrate 108 in the direction shown by arrows 180-1 and 180-2. The process gases and the reaction byproducts flow uniformly between the showerhead 106 and the substrate 108 towards the sidewall 105-1 of the well 105 in the direction shown by arrows 180-3 and 180-4.

[0095] The process gases and the reaction byproducts then flow around the upper portion 111 of the base portion 110 of the pedestal 104 downwardly into the interior volume 168 of the baffle 160 in the direction shown by arrows 180-5 and 180-6. The process gases and the reaction byproducts flow through the gap between the cylindrical sidewall 162 of the baffle 160 and the OD of the upper portion 111 of the base portion 110 of the pedestal 104 in the direction shown by arrows 180-5 and 180-6.

[0096] Subsequently, the process gases and the reaction byproducts flow through the first through fourth sets of apertures 170-1, 170-2 in the cylindrical sidewall 162 of the baffle 160 into the channel 107 (defined above) in the direction shown by arrows 180-7 and 180-8. The process gases and the reaction byproducts flow through the channel 107 downwardly towards the bottom of the well 105 in the direction shown by arrows 180-9 and 180-10.

[0097] Thereafter, the process gases and the reaction byproducts flow towards and out through the exhaust ports 103 and any other exhaust ports at the bottom of the well 105 into the foreline 144 (shown in FIG. 1) in the direction shown by arrows 180-11 and 180-12. Thus, regardless of the number and locations of the exhaust ports 103 in the well 105, the process gases flow uniformly over the substrate 108, and the process gases and the reaction byproducts flow uniformly around the pedestal 104 and exit the processing chamber 102 through the exhaust ports 103 more effectively than when the baffle 160 is not used.

[0098] Accordingly, due to the structure of the baffle 160 and the first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 in the baffle 160 and due to the positions of the first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 relative to the exhaust ports 103 described above, uniform pumping of the process gases and the reaction byproducts is achieved irrespective of whether the exhaust ports 103 are arranged non-uniformly (asymmetrically) in the well 105.

[0099] Furthermore, due to the design of the annular flange 164, the first and second arc-shaped flanges 166-1, 166-2, and the arc-shaped flanges 167-1, 167-2, the baffle 160 remains firmly centered in the well 105 during substrate processing. Firmly centering the baffle 160 in the well 105 also reduces the risk of metal-to-metal scraping between the baffle 160 and the well 105, which can otherwise cause particle contamination and migration of metallic content to the surface of the substrate 108.

[0100] FIGS. 3-12 show various views of the baffle 160 and show various elements or features of the baffle 160 described above. Each view shows some but not all of the elements (features) of the baffle 160. Together, the views shown in FIGS. 3-12 show all of the elements (features) of the baffle 160. In FIGS. 4-12, the elements 166, 167, 170, and 172 are sometimes shown only generally (i.e., without further identifying the elements as "-1" or as "-2"). In the following description, the elements that are already identified and described in FIGS. 1, 2A, and 2B are not described again for brevity.

[0101] FIG. 3 shows a perspective view of the baffle 160. In the perspective view, the first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 in the cylindrical sidewall 162 of the baffle 160 are visible. The annular flange 164, portions of the first and second arc-shaped flanges 166-1, 166-2 extending up to one of the exhaust ports 103, and one of the arc-shaped flanges 167-1, 167-2 of the baffle 160 are visible. The end of the first and second arc-shaped flanges 166-1, 166-2 can extend further (closer) towards the first and second sets of apertures 170-1, 170-2 than shown.

[0102] FIGS. 4 and 5 show front and back views of the baffle 160, respectively. As shown in further detail in FIGS. 10-12, when the exhaust ports 103 are not arranged at diametrically opposite locations at the bottom of the well 105, the first and second sets of apertures 170-1, 170-2, which are proximate to the exhaust ports 103 are also not arranged at diametrically opposite locations on the cylindrical sidewall 162 of the baffle 160. Instead, the first and second sets of apertures 170-1, 170-2 are positioned along the cylindrical sidewall 162 of the baffle 160 at opposite locations along a chord smaller than the diameter of the cylindrical sidewall 162 of the baffle 160. Accordingly, the first and second sets of apertures 170-1, 170-2 are partially visible in the front view shown in FIG. 4 but are not visible in the back view shown in FIG. 5. The third and fourth sets of apertures 172-1, 172-2 are arranged at diametrically opposite locations on the cylindrical sidewall 162 of the baffle 160. Accordingly, only one of the third and fourth sets of apertures 172-1, 172-2 is visible in the front and back views of the baffle 160

shown in FIGS. 4 and 5. The lines shown in FIGS. 8 and 9 provide the references F-B (F denoting front and B denoting back) along which the front and back views shown in FIGS. 4 and 5 are taken.

[0103] FIGS. 6 and 7 show right and left side views of the baffle 160, respectively. Again, as shown in further detail in FIGS. 10-12, when the exhaust ports 103 are not arranged at diametrically opposite locations at the bottom of the well 105, the first and second sets of apertures 170-1, 170-2, which are proximate to the exhaust ports 103 are also not arranged at diametrically opposite locations on the cylindrical sidewall 162 of the baffle 160. Instead, the first and second sets of apertures 170-1, 170-2 are positioned along the cylindrical sidewall 162 of the baffle 160 at opposite locations along a chord smaller than the diameter of the cylindrical sidewall 162 of the baffle 160. Accordingly, the first and second sets of apertures 170-1, 170-2 can be seen off-center, specifically to the left of the center of the baffle 160 in the right-side view of the baffle 160 shown in FIG. 6, and to the right of the center of the baffle 160 in the left-side view of the baffle 160 shown in FIG. 7. The third and fourth sets of apertures 172-1, 172-2 are arranged at diametrically opposite locations on the cylindrical sidewall 162 of the baffle 160. Accordingly, the third and fourth sets of apertures 172-1, 172-2 are only partially visible in the right and left side views of the baffle 160 shown in FIGS. 6 and 7. The lines shown in FIGS. 8 and 9 provide the references L-R (L denoting left side and R denoting right side) along which the right and left side views shown in FIGS. 6 and 7 are taken.

[0104] FIGS. 8 and 9 show top and bottom views of the baffle 160, respectively. In the top view of the baffle 160 shown in FIG. 8, only the annular flange 164 and the cylindrical sidewall 162 of the baffle 160 are visible. The first and second arc-shaped flanges 166-1, 166-2 and the arc-shaped flanges 167-1, 167-2 of the baffle 160 are not visible due to their smaller ODs than the OD of the annular flange 164. In the bottom view of the baffle 160 shown in FIG. 9, the annular flange 164, the cylindrical sidewall 162, the first and second arc-shaped flanges 166-1, 166-2, and the arc-shaped flanges 167-1, 167-2 of the baffle 160 are visible. The first through fourth sets of apertures 170-1, 170-2, 172-1, 172-2 in the cylindrical sidewall 162 of the baffle 160 are not visible in both the top and bottom views of the baffle 160.

[0105] FIG. 10 shows the bottom view of the baffle 160 shown in FIG. 9 and additionally shows axes X-X and Y-Y and planes A-A and B-B along which two

transverse sections of the baffle 160 are taken. The two transvers sections of the baffle 160 are shown in FIGS. 11 and 12 as first and second transverse sections, respectively.

[0106] FIG. 11 shows the first transvers section of the baffle 160 taken along the lines A-A shown in FIG. 10 with line X-X being the center of the first transvers section of the baffle 160. The line X-X bisects one of the arc-shaped flanges 167-1, 167-2. Having taken from the left side of the baffle 160 but at a different angle along the line X-X than the line L-R shown in FIG. 10, in the first transvers section of the baffle 160 shown in FIG. 11, one of the first and second sets of apertures 170-1, 170-2 is fully visible and the other of the first and second sets of apertures 170-1, 170-2 is not visible. One of the third and fourth sets of apertures 172-1, 172-2 is less visible than the other of the third and fourth sets of apertures 172-1, 172-2.

[0107] FIG. 12 shows the second transvers section of the baffle 160 taken along the lines B-B shown in FIG. 10 with line Y-Y being the center of the second transvers section of the baffle 160. The line Y-Y bisects one of the arc-shaped flanges 167-1, 167-2. Having taken from the right side of the baffle 160 but at a different angle along the line Y-Y than the line L-R shown in FIG. 10, in the second transvers section of the baffle 160 shown in FIG. 12, one of the first and second sets of apertures 170-1, 170-2 is fully visible and the other of the first and second sets of apertures 170-1, 170-2 is not visible. One of the third and fourth sets of apertures 172-1, 172-2 is less visible than the other of the third and fourth sets of apertures 172-1, 172-2.

[0108] The baffle 160 is useful in directing flow of gases and reaction byproducts not only during substrate processing but also during cleaning of the processing chamber 102. For example, during the cleaning of the processing chamber 102, the substrate 108 is not used. In some cleaning processes, a dummy substrate may be used. One or more cleaning gases are supplied through the showerhead 106 into the processing chamber 102. The cleaning gases react with residual material deposited throughout the processing chamber 102 during substrate processing. The vacuum pump 140 removes the cleaning gases, the residual material ejected from the components of the processing chamber 102, and any reaction byproducts formed by the reaction between the cleaning gases and the residual material. The vacuum pump 140 removes these substances from the processing chamber 102 via the exhaust ports of the processing

chamber 102. The baffle 160 directs the flow these substances during the cleaning process as described above with reference to FIGS. 2A and 2B.

[0109] Throughout the present disclosure, while the well 105 is shown and described as being cylindrical, the well can have other shapes, and the baffle 160 can be shaped to correspond to the shape of the well. For example, the well 105 can have an oblong or oval shape that is symmetrical about a major axis of the oval, with the exhaust ports 103 being located at the bottom of the well 105 near the ends of the major axis of the oval. The shape of the baffle 160 can be shaped (i.e., modified) to correspond the perimeter of the well 105 so that the flange at the top end of the baffle 160 (i.e., the counterpart of the cylindrical flange 164) seals the top end of the well 105. Further, in the differently shaped baffle 160, the arc-shaped flanges 166, 167 that form the continuous annular structure near the bottom of the baffle 160 (also called a lower ring of the baffle 160) can be shaped (i.e., modified) to seal against the inner wall of the well 105. All other features of the differently shaped baffle 160 (e.g., the sets of apertures 170, 172, the channel 107, the gas flow through the baffle, etc.) remain the same as described above.

[0110] The foregoing description is merely illustrative in nature and is not intended to limit the disclosure, its application, or uses. The broad teachings of the disclosure can be implemented in a variety of forms. Therefore, while this disclosure includes particular examples, the true scope of the disclosure should not be so limited since other modifications will become apparent upon a study of the drawings, the specification, and the following claims.

[0111] It should be understood that one or more steps within a method may be executed in different order (or concurrently) without altering the principles of the present disclosure. Further, although each of the embodiments is described above as having certain features, any one or more of those features described with respect to any embodiment of the disclosure can be implemented in and/or combined with features of any of the other embodiments, even if that combination is not explicitly described. In other words, the described embodiments are not mutually exclusive, and permutations of one or more embodiments with one another remain within the scope of this disclosure.

[0112] Spatial and functional relationships between elements (for example, between modules, circuit elements, semiconductor layers, etc.) are described using various

terms, including "connected," "engaged," "coupled," "adjacent," "next to," "on top of," "above," "below," and "disposed." Unless explicitly described as being "direct," when a relationship between first and second elements is described in the above disclosure, that relationship can be a direct relationship where no other intervening elements are present between the first and second elements but can also be an indirect relationship where one or more intervening elements are present (either spatially or functionally) between the first and second elements. As used herein, the phrase at least one of A, B, and C should be construed to mean a logical (A OR B OR C), using a non-exclusive logical OR, and should not be construed to mean "at least one of A, at least one of B, and at least one of C."

[0113] In some implementations, a controller is part of a system, which may be part of the above-described examples. Such systems can comprise semiconductor processing equipment, including a processing tool or tools, chamber or chambers, a platform or platforms for processing, and/or specific processing components (a wafer pedestal, a gas flow system, etc.). These systems may be integrated with electronics for controlling their operation before, during, and after processing of a semiconductor wafer or substrate. The electronics may be referred to as the "controller," which may control various components or subparts of the system or systems.

[0114] The controller, depending on the processing requirements and/or the type of system, may be programmed to control any of the processes disclosed herein, including the delivery of processing gases, temperature settings (e.g., heating and/or cooling), pressure settings, vacuum settings, power settings, radio frequency (RF) generator settings, RF matching circuit settings, frequency settings, flow rate settings, fluid delivery settings, positional and operation settings, wafer transfers into and out of a tool and other transfer tools and/or load locks connected to or interfaced with a specific system.

[0115] Broadly speaking, the controller may be defined as electronics having various integrated circuits, logic, memory, and/or software that receive instructions, issue instructions, control operation, enable cleaning operations, enable endpoint measurements, and the like. The integrated circuits may include chips in the form of firmware that store program instructions, digital signal processors (DSPs), chips defined as application specific integrated circuits (ASICs), and/or one or more microprocessors, or microcontrollers that execute program instructions (e.g., software).

[0116] Program instructions may be instructions communicated to the controller in the form of various individual settings (or program files), defining operational parameters for carrying out a particular process on or for a semiconductor wafer or to a system. The operational parameters may, in some embodiments, be part of a recipe defined by process engineers to accomplish one or more processing steps during the fabrication of one or more layers, materials, metals, oxides, silicon, silicon dioxide, surfaces, circuits, and/or dies of a wafer.

[0117] The controller, in some implementations, may be a part of or coupled to a computer that is integrated with the system, coupled to the system, otherwise networked to the system, or a combination thereof. For example, the controller may be in the "cloud" or all or a part of a fab host computer system, which can allow for remote access of the wafer processing. The computer may enable remote access to the system to monitor current progress of fabrication operations, examine a history of past fabrication operations, examine trends or performance metrics from a plurality of fabrication operations, to change parameters of current processing, to set processing steps to follow a current processing, or to start a new process.

[0118] In some examples, a remote computer (e.g., a server) can provide process recipes to a system over a network, which may include a local network or the Internet. The remote computer may include a user interface that enables entry or programming of parameters and/or settings, which are then communicated to the system from the remote computer. In some examples, the controller receives instructions in the form of data, which specify parameters for each of the processing steps to be performed during one or more operations. It should be understood that the parameters may be specific to the type of process to be performed and the type of tool that the controller is configured to interface with or control.

[0119] Thus, as described above, the controller may be distributed, such as by comprising one or more discrete controllers that are networked together and working towards a common purpose, such as the processes and controls described herein. An example of a distributed controller for such purposes would be one or more integrated circuits on a chamber in communication with one or more integrated circuits located remotely (such as at the platform level or as part of a remote computer) that combine to control a process on the chamber.

[0120] Without limitation, example systems may include a plasma etch chamber or module, a deposition chamber or module, a spin-rinse chamber or module, a metal plating chamber or module, a clean chamber or module, a bevel edge etch chamber or module, a physical vapor deposition (PVD) chamber or module, a chemical vapor deposition (CVD) chamber or module, an atomic layer deposition (ALD) chamber or module, an atomic layer etch (ALE) chamber or module, an ion implantation chamber or module, a track chamber or module, and any other semiconductor processing systems that may be associated or used in the fabrication and/or manufacturing of semiconductor wafers.

[0121] As noted above, depending on the process step or steps to be performed by the tool, the controller might communicate with one or more of other tool circuits or modules, other tool components, cluster tools, other tool interfaces, adjacent tools, neighboring tools, tools located throughout a factory, a main computer, another controller, or tools used in material transport that bring containers of wafers to and from tool locations and/or load ports in a semiconductor manufacturing factory.

CLAIMS

What is claimed is:

1. A substrate processing chamber comprising:

a well defined by a bottom portion and a sidewall extending vertically upwards from the bottom portion, the well comprising a plurality of exhaust ports near a bottom of the well;

a pedestal arranged in the well, the pedestal comprising a base portion and a stem portion; and

a baffle arranged in the well around the pedestal, the baffle comprising a sidewall and a plurality of sets of apertures in the sidewall of the baffle, and the baffle configured to direct flow of gases supplied to the substrate processing chamber to flow around the pedestal from a periphery of the base portion of the pedestal towards the stem portion of the pedestal and through the sets of apertures in the sidewall of the baffle towards the plurality of exhaust ports.

2. The substrate processing chamber of claim 1 wherein apertures in at least one set of the sets of apertures are of different size and shape than apertures in at least one other set of the sets of apertures.

3. The substrate processing chamber of claim 1 wherein at least one set of the sets of apertures is of different size and shape than at least one other set of the sets of apertures.

4. The substrate processing chamber of claim 1 wherein the baffle is of same height as the well.

5. The substrate processing chamber of claim 1 wherein the well and the baffle are cylindrical and wherein the baffle is smaller in diameter than the well.

6. The substrate processing chamber of claim 1 wherein:

the sidewalls of the well and the baffle are cylindrical;

a bottom end of the sidewall of the baffle is arranged on the bottom portion of the well; and

an outer diameter of the sidewall of the baffle is less than an inner diameter of the sidewall of the well.

7. The substrate processing chamber of claim 6 wherein the sidewalls of the well and the baffle are of same height.

8. The substrate processing chamber of claim 6 wherein the baffle comprises:

an annular flange extending radially outward from a top end of the sidewall of the baffle and sealingly arranged on a top end of the sidewall of the well; and

a plurality of arc-shaped flanges extending radially outward from the sidewall of the baffle, the arc-shaped flanges being located at a predetermined distance from the bottom end of the sidewall of the baffle.

9. The substrate processing chamber of claim 8 wherein the predetermined distance is greater than or equal to a height of the exhaust ports.

10. The substrate processing chamber of claim 8 wherein the arc-shaped flanges are of different arc-lengths.

11. The substrate processing chamber of claim 8 wherein arc lengths of the arc-shaped flanges are based on locations of the exhaust ports.

12. The substrate processing chamber of claim 8 wherein the arc-shaped flanges sealingly mate with the sidewall of the well forming a channel between the annular flange, the arc-shaped flanges, and the sidewalls of the baffle and the well.

13. The substrate processing chamber of claim 12 wherein the gases flowing towards the stem portion of the pedestal flow through the sets of apertures in the sidewall of the baffle into the channel towards the plurality of exhaust ports.

14. The substrate processing chamber of claim 8 wherein the baffle comprises a plurality of interconnecting flanges extending radially outward from the sidewall of the baffle, the interconnecting flanges being located at the predetermined distance from the bottom of the sidewall of the baffle, the interconnecting flanges interconnecting the arc-shaped flanges.

15. The substrate processing chamber of claim 14 wherein the interconnecting flanges are arc shaped and are of a smaller radial width than the arc-shaped flanges.

16. The substrate processing chamber of claim 14 wherein the interconnecting flanges are arc shaped and are of a smaller arc length than the arc-shaped flanges.

17. The substrate processing chamber of claim 14 wherein the interconnecting flanges are arc shaped and are of a smaller arc length than a width of the exhaust ports.

18. The substrate processing chamber of claim 14 wherein the arc-shaped flanges and the interconnecting flanges are coplanar.

19. The substrate processing chamber of claim 14 wherein the arc-shaped flanges and the interconnecting flanges form a continuous annular structure.

20. The substrate processing chamber of claim 14 wherein the baffle is monolithic.

21. The substrate processing chamber of claim 14 wherein:

the interconnecting flanges are proximate to the exhaust ports;

at least one set of the sets of apertures is located proximate to the interconnecting flanges and the exhaust ports; and

at least one of other set of the sets of apertures is located away from the exhaust ports.

22. The substrate processing chamber of claim 21 wherein apertures in the at least one set are smaller than apertures in the at least one other set.

23. The substrate processing chamber of claim 21 wherein apertures in the at least one set are of different size and shape than apertures in the at least one other set.

24. The substrate processing chamber of claim 21 wherein the at least one set is of a different size than the at least one other set.

25. The substrate processing chamber of claim 21 wherein the at least one set is of a different shape than the at least one other set.

26. The substrate processing chamber of claim 21 wherein the at least one set is vertically offset relative to the at least one other set on the sidewall of the baffle.

27. The substrate processing chamber of claim 1 wherein the flow of the gases around the pedestal is uniform irrespective of locations of the exhaust ports in the well.

28. The substrate processing chamber of claim 1 further comprising a substrate arranged on the pedestal wherein the flow of the gases is uniform over the substrate irrespective of locations of the exhaust ports in the well.

29. The substrate processing chamber of claim 1 further comprising:

a showerhead arranged above the pedestal to supply the gases into the substrate processing chamber during processing a substrate arranged on the pedestal; and

a vacuum pump coupled to the exhaust ports to pump the gases from the substrate processing chamber during the processing.

30. The substrate processing chamber of claim 1 further comprising:

a showerhead arranged above the pedestal to supply the gases into the substrate processing chamber during cleaning of the substrate processing chamber; and

a vacuum pump coupled to the exhaust ports to pump the gases from the substrate processing chamber during the cleaning.

31. The substrate processing chamber of claim 1 wherein a first aperture in a first set of the sets of apertures is of different size and shape than a second aperture in a second set of the sets of apertures.