APPARATUS AND SYSTEM FOR FLOW CONTROL AND TUNING IN SEMICONDUCTOR PROCESSING

INCORPORATION BY REFERENCE

[0000] A PCT Request Form is filed concurrently with this specification as part of the present application. Each application that the present application claims benefit of or priority to as identified in the concurrently filed PCT Request Form is incorporated by reference herein in their entireties and for all purposes.

BACKGROUND

[0001] Semiconductor manufacturing typically involves one or more processing operations to deposit and/or etch a structure on or in a semiconductor wafer (or substrate). For instance, a typical processing operation may involve a substrate being supported on a pedestal within a processing chamber and one or more process gases being flowed into the processing chamber via a gas distributor to bring about a desired effect, such as the deposition of a layer of material onto the substrate. As semiconductor manufacturing scales to meet consumer demand, the viability of the processing operations may depend not only upon within-wafer uniformity, but also wafer-to-wafer repeatability at least with respect to the processing conditions at and between processing chambers and/or stations of one or more semiconductor manufacturing tools. Variations, however, may lead to disparities in a desired effect, such as inhomogeneous deposition and/or dissimilar etching profiles relative to disparate processing chambers/stations.

[0002] The background provided herein is for the purposes of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent that it is described in this background, 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 disclosure.

SUMMARY

[0003] Details of one or more implementations of the subject matter described in this specification are set forth in the accompanying drawings and the description below. Other features, aspects, and advantages will become apparent from the description, the drawings, and the claims. The following, non-limiting implementations are considered part of the disclosure; other implementations will be evident from the entirety of this disclosure and the

accompanying drawings as well.

[0004] Additional aspects will be set forth in the detailed description which follows, and, in part, will be apparent from the disclosure, or may be learned by practice of the disclosed embodiments and/or the claimed subject matter.

[0005] In one embodiment, a bypass plate for use in a semiconductor processing tool may be provided. The bypass plate may include a body partially defined by a first side and a second side opposite the first side, an inlet extending through the body between the first side and the second side. an outlet extending through the body between the first side and the second side; and a bypass passage. The first side may be configured to interface with a valve, and the bypass passage may extend within the body and only between the inlet and the outlet, fluidically connect the inlet and the outlet within the body, and may be only fluidically connected to the inlet and the outlet.

[0006] In some embodiments, the bypass passage may include a first orifice at the inlet and having a first orifice diameter, and a secod orifice at the outlet and having a second orifice diameter larger than the first orifice diameter.

[0007] In some such embodiments, the second orifice diameter may be at least twice as large as the first orifice diameter.

[0008] In any one of the above embodiments, the bypass passage may further include a passage portion extending between the first orifice and the second orifice, and the passage portion may include a curved section.

[0009] In one of the above embodiments, the bypass passage may further include a passage portion that extends between the first orifice and the second orifice, includes a first section that extends along a first axis and has a variable circular cross-sectional area, and includes a second section that extends along a second axis and has a constant circular cross-sectional area.

[0010] In some embodiments, the bypass passage may include a first orifice at the inlet and having a first orifice diameter, and a secod orifice at the outlet and having a second orifice diameter less than or equal to the first orifice diameter.

[0011] In any one of the above embodiments, the inlet may extend through the body only along an inlet linear axis, and the outlet may extend through the body only along a outlet linear axis.

[0012] In any one of the above embodiments, the body may not have other internal fluid passages except the inlet, the outlet, and the bypass passage.

[0013] In any one of the above embodiments, the bypass passage may not extend through the first side, the second side, or any other side of the body.

[0014] In any one of the above embodiments, the inlet and the outlet may be substantially parallel to each other.

[0015] In any one of the above embodiments, the bypass passage may be substantially perpendicular to the inlet and the outlet.

[0016] In any one of the above embodiments, the bypass passage may be only internal to the body.

[0017] In any one of the above embodiments, the bypass plate may further have a leak-check through-hole extending through the body from the first side to the second side, and the first side further may include a groove spanning between the outlet and the leak-check through-hole.

[0018] In some embodiments, the bypass plate may further have a second leak-check through-hole extending through the body from the first side to the second side, and the first side may further include a second groove spanning between the outlet and the second leak-check through-hole.

[0019] In any one of the above embodiments, the bypass plate may further have a plurality of mounting through holes that each extend through the body from the first side to the second side and that each are positioned in a different corner area of the body.

[0020] In any one of the above embodiments, the first side may further include a first seal seat recessed below a surface of the first side, extending around the inlet, and configured to interface with a first seal, and a second seal seat recessed below the surface, extending around the outlet, and configured to interface with a second seal.

[0021] In any one of the above embodiments, the body may be comprised of stainless steel.

[0022] In any one of the above embodiments, when a valve is interfaced with the first side and in a closed configuration, the inlet and the outlet may be fluidically connected to each other through only the bypass passage and not through the valve.

[0023] In some such embodiments, when the valve is in an open position, the inlet and the

outlet may be fluidically connected to each other through both the bypass passage and the valve.

[0024] In any one of the above embodiments, the body may have a thickness that is less than or equal to 200% a bore diameter of the inlet.

[0025] In one embodiment, a valve assembly may be provided. The valve assembly may have a valve having at least an open position and a closed position, and a bypass plate having a body partially defined by a first side configured to interface with the valve and a second side opposite the first side, an inlet extending through the body between the first side and the second side, an outlet extending through the body between the first side and the second side, and a bypass passage. The bypass passage may extend within the body and only between the inlet and the outlet, may fluidically connect the inlet and the outlet within the body, and may only be fluidically connected to the inlet and the outlet, the first side may be interfaced with the valve, when the valve is in the closed position, fluid may be configured to flow between the inlet and the outlet through only the bypass passage and not the valve, and when the valve is in the open position, fluid may be configured to flow between the inlet and the outlet through both the bypass passage and the valve.

[0026] In some embodiments, the bypass plate may include the features of any one of the above embodiments.

[0027] The foregoing general description and the following detailed description are illustrative and explanatory and are intended to provide further explanation of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] Various embodiments disclosed herein are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings, in which like reference numerals refer to similar elements.

[0029] Figure 1 depicts an off-angle view of a bypass plate, according to various embodiments.

[0030] Figure 2 depicts a magnified cross-sectional off-angle view of the bypass plate of Figure 1 taken along line A-A.

[0031] Figure 3 depicts a cross-sectional side view taken along line A-A in Figure 1.

[0032] Figure 4 depicts a magnified portion of Figure 3.

[0033] Figures 5A and 5B depict cross-sectional side views of the plate of Figure 3 interfaced with a representative valve.

[0034] Figure 6 depicts the bypass plate 100 of Figure 1 according to various embodiments.

[0035] Figure 7 schematically illustrates a multi-station processing tool according to some embodiments.

[0036] Figure 8 depicts a magnified portion of a cross-sectional side view of another bypass plate.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

[0037] In the following description, numerous specific details are set forth in order to provide a thorough understanding of various embodiments. The disclosed embodiments may be practiced without some or all of these specific details. In other instances, well-known process operations have not been described in detail to not unnecessarily obscure the disclosed embodiments. While the disclosed embodiments will be described in conjunction with specific embodiments, it will be understood that it is not intended to limit the disclosed embodiments.

[0038] In this application, the terms "semiconductor wafer," "wafer," "substrate," "wafer substrate" and "partially fabricated integrated circuit" are used interchangeably. One of ordinary skill in the art would understand that the term "partially fabricated integrated circuit" can refer to a silicon wafer during any of many stages of integrated circuit fabrication thereon. A wafer or substrate used in the semiconductor device industry typically has a diameter of 200 mm, or 300 mm, or 450 mm. In addition to semiconductor wafers, other work pieces that may take advantage of the disclosed embodiments include various articles, such as printed circuit boards, magnetic recording media, magnetic recording sensors, mirrors, optical elements, micro-mechanical devices, and the like.

Introduction and Context

[0039] Semiconductor processing tools having multi-station configurations typically deliver one or more process gases (hereinafter "process gasses") to each station by flowing the process gases from a common source to a junction point, and from the junction point to each station via a respective path (or passageway) fluidically connected to, for instance, a gas distributor of the corresponding station. Although painstaking effort is usually devoted to forming the flow

paths as identical as possible, differences in flow conditions, such as flow conductance or flow velocity, between the flow paths may still exist due to inherent variabilities, such as variabilities relating to manufacturing tolerances and valve operations. As design constraints on wafer features (e.g., minimum dimensions, feature spacing, etc.) become increasingly complex and onerous, the permissible magnitude of flow condition deviations between flow paths is becoming correspondingly smaller. Further, some new and emerging semiconductor processing techniques are beginning to use flow conditions, such as flowrates, that exceed the maximum operating envelope of valves that are used in semiconductor processing. Many existing valves have limited adjustability and calibration capabilities which limits the ability to adequately balance flow between stations. Previously miniscule variances in flow conditions that were traditionally ignored as irrelevant are becoming sources of unacceptable differences in, for instance, material properties, deposition thicknesses, etch depths, etc.

[0040] Some embodiments provided herein stem from the recognition that a flow condition, such as flowrate, in or along a flow path controlled by a valve can be expanded and adjusted beyond the operating envelope of the valve by using a valve in combination with a bypass plate that includes a bypass passage between its inlet and outlet. The adjustability and calibration of valves, as well as adjustability and calibration between stations and flow paths, can also be expanded beyond their operating range by using the bypass plate. The bypass passage is configured to create an additional flow path that allows one portion of fluid to flow between the inlet and outlet directly through the plate, and allows another portion of fluid flow between the inlet and the outlet to be controlled by the valve. Such configuration can enable higher total fluid flow between the inlet and outlet, as well as more adjustability, control, and calibration with and by the valve. Accordingly, various systems, apparatuses, and techniques for adjusting and equalizing fluid flow along flow paths of a multi-station semiconductor processing tool with a bypass plate are provided herein. This, in turn, may serve to adjust deposited material properties, balance resulting etch depths, improve station-to-station matching of a desired effect, etc. In some cases, improving station-to-station matching of flow conditions along the different flow paths to corresponding stations of a multi-station semiconductor processing tool may be achieved via independent and/or collective adjustments affecting a single or multiple flow paths of the multi-station semiconductor processing tool. In some cases, using the described bypass plate with a valve enables processing flow rates higher than previously permitted with just the valve, thereby enabling additional processing techniques.

Systems for Semiconductor Processing

[0041] According to various embodiments, fluid flow along one or more flow paths of a multi-chamber semiconductor processing tool may be controlled, adjusted, and calibrated by using a flow control valve mounted onto a bypass plate having an inlet, outlet, and bypass passage between the inlet and outlet. In some instances, the flow control valve is a surface mount valve and the bypass plate is configured to interface with, and be mounted to, the surface mount valve. The flow control valve may further be configured to control flow between the bypass plate's single inlet and single outlet such that when the valve is in an open position, fluid can flow between the inlet and outlet through the valve, and when the valve is closed, fluid cannot flow between the inlet and outlet through the valve. In various embodiments, the bypass passage extends through the bypass plate's body and provides a fluidic connection between the inlet and outlet. The bypass passage may not extend through any other part of the body and may only have two fluidic orifices, one orifice in the inlet and another orifice in the outlet. The inlet orifice of the bypass passage may be sized smaller than the outlet orifice of the bypass passage, and the diameter of the inlet orifice may be sized to permit a particular fluid flowrate between the inlet and outlet through the bypass passage. The bypass plate provided herein is for use in semiconductor processing tools, including tools with more than one processing station, e.g., multi-station processing tools.

[0042] Figure 1 depicts an off-angle view of a bypass plate, according to various embodiments. The bypass plate 100 includes a body 102 partially defining a first side 104 and a second side, not visible here, opposite the first side 104. The first side 104 may be considered a top or top surface of the bypass plate 100 and the second side may be a bottom or bottom surface of the bypass plate 100. The bypass plate 100 also includes an inlet 106 and an outlet 108 that are both through-holes such that they extend through the body 102 between the first side 104 and the second side.

[0043] The bypass plate 100 also includes a bypass passage, not visible in Figure 1, that extends within the body 102 and fluidically connects the inlet 106 and the outlet 108 as shown in Figures 2 to 5B. Figure 2 depicts a magnified cross-sectional off-angle view of the bypass plate of Figure 1 taken along line A-A. Here, the inlet 106 and the outlet 108 can be seen extending through all of the body 102 of the bypass plate 100. The bypass passage 110 is also visible and is highlighted with a dashed line and shading therein. The bypass passage 110 extends within the body 102, extends only between the inlet 106 and the outlet 108, fluidically

connects the inlet 106 and the outlet 108 within the body 102, and is only fluidically connected to the inlet 106 and the outlet 108. The bypass passage 110 is not fluidically connected to other elements of the bypass plate 100, does not extend to other parts of the body 102, and does not extend through any other exterior surface of the body 102 such as a side or other hole. For example, the bypass passage 110 does not extend through the first side 104 or the second side 116, or any other side of the body 102, as illustrated in Figure 2.

[0044] The bypass passage 110 includes a first orifice 112 at the interface with the inlet 106 and a second orifice 114 at the interface with the outlet 108. The first orifice 112 and second orifice 114 may both be circular, e.g., circular holes, and a first orifice diameter of the first orifice 112 may be sized smaller than a second orifice diameter of the second orifice 114. In some instances, the second orifice diameter may be at least twice as large as the first orifice diameter.

[0045] Figure 3 depicts a cross-sectional side view taken along line A-A in Figure 1. Here, the first side 104, which may also be considered a first surface, top side, or top surface, is opposite a second side 116, which may also be considered a second surface, bottom side, or bottom surface. These two sides 104 and 116 partially define the body 102. The inlet 106 and outlet 108 are seen extending fully through the body 102. In some instances, such as shown in Figure 3, the inlet 106 may include a first end 118 in the first side 104 and a second end 120 in the second side 116. The inlet 106 may also extend through the body along an inlet axis 122, which may be linear, or substantially linear (e.g., within +/- 5% of linear), in some implementations. Similarly, the outlet 108 may include a first end 124 in the first side 104 and a second end 126 in the second side 116. The outlet 108 may also extend through the body along an outlet axis 128, which may be linear, or substantially linear (e.g., within +/- 5% of linear), in some implementations. In some embodiments, the inlet 106 and the outlet 108 only extend along their respective linear axes. In some implementations, the inlet 106 and outlet 108 are parallel, or substantially parallel (e.g., within 1%, 5%, or 10% of parallel), to each other; manufacturing tolerances may affect how parallel they are to each other.

[0046] The bypass passage 110 is also shown in Figure 3, along with the first orifice 112 that is fluidically connected with the inlet 106, and the second orifice 114 that is fluidically connected with the outlet 108. The bypass passage 110 extends through body 102 between the inlet 106 and the outlet 108 along an axis 130 for a total length 132. The bypass passage 110 may be perpendicular, or substantially perpendicular (e.g., within 1%, 5%, or 10% of perpendicular), to

the inlet 106 or inlet axis 122, the outlet 108 or outlet axis 128, both the inlet 106 and the outlet 108, or both the inlet axis 122 and the outlet axis 128; manufacturing tolerances may affect how perpendicular they are to each other. As shown in Figure 3, for instance, the bypass passage 110 is perpendicular to the inlet 106 and the outlet 108, and to the inlet axis 122 and the outlet axis 128. The bypass passage 110 is also only internal to the body 102. In some embodiments, the body 102 does not have any other internal fluid passages except the inlet 106; the outlet 108 and the bypass passage 110 may not be considered internal passages in some implementations because they extend through one or more exterior surfaces or sides of the body102, e.g., through the first side 104 and second side 116.

[0047] In some embodiments, like in Figure 3, the first orifice 112 is a circular hole that extends along the axis 130 for a first length L1 and that has a first orifice diameter D1. The first orifice 112 may, in some instances, also be considered to have a constant cross-sectional area along the axis 130 for the first length L1. In some implementations, like in Figure 3, the second orifice 114 is a circular hole that has a second orifice diameter D2. In between the second orifice 114 and the first orifice 112, the bypass passage 110 has a passage portion 134 that extends along the axis 130 for a second length L2. The passage portion 134 may have a cross-sectional area that varies along at least a portion of the second length L2 and that is bigger than the first orifice diameter D1.

[0048] Additional or alternative features of the bypass passage are further described and illustrated in Figure 4 which depicts a magnified portion of Figure 3. As illustrated in Figure 4, in some implementations, the passage portion 134 may have a first section 136, shown with dark shading and a dotted boundary line, that extends along the axis 130 for a third length L3 and has a variable and circular cross-sectional area along the third length L3. The passage portion 134 may have a second section 138, shown with light shading and a dotted boundary line, that extends along the axis 130 for a fourth length L4 and has a constant and circular cross-sectional area along the fourth length L4. In some instances, the passage portion 134 may have sidewalls that partially define a spherical, or partially spherical, curved shape, or curved section. In the view of Figures 3 and 4, the first section 136 of the passage portion 134 has sidewalls adjacent to the first orifice 112 that are curved, e.g., partially spherical, and the second section 138 has sidewalls adjacent to the second orifice 114 that are straight, e.g., cylindrical. In some implementations, the configuration of the bypass passage 110 advantageously reduces particle generation and contamination by limiting and reducing the number of sharp edges and surfaces

that the fluid flowing through the bypass passage 110 contacts. By configuring the bypass passage 110 as shown, manufacturing of the bypass passage 110 may also be made easier, simpler, quicker, more efficient, and cheaper than other alternatives.

[0049] The bypass passage 110 is configured to allow or enable a particular flowrate of fluid to flow from the inlet 106 to the outlet 108. This configuration may include configuring the size of the first orifice 112 to allow or enable the desired flowrate between the inlet and the outlet. In some implementations, like shown in Figures 2–4, the first orifice 112 acts as a flow restrictor since it is the smallest orifice as compared to the size of the inlet 106, the outlet 108, and the remaining sections of the bypass passage 110, e.g., the first section 136 and the second section 138. In some embodiments, the size of the first orifice 112, including its first orifice diameter D1, may be configured to permit a fluid flow of a particular flowrate through the bypass passage, such as 3, 10, and 30 standard liters per minute, for instance. Some implementations may have the first orifice 112 configured to enable a flowrate through the bypass passage 110 that is a percentage of the maximum operating flowrate of a valve interfaced with the plate 100. For example, the first orifice 112 may be configured to enable a flowrate that is at least 100%, 95%, 85%, 75%, or 50% of the maximum operating flowrate of the valve interfaced with the plate 100. This percentage-based configuration of the bypass passage 110 enables flowrates above the maximum operating flowrate of the valve interfaced with the plate 100. For instance, when the valve is in a partially open, or fully open, position the flowrate from the inlet 106 to the outlet 108 through both the valve and the bypass passage 110 is higher than when the valve is closed, and in some instances may be higher than through only the valve.

[0050] Examples of fluid flows between the inlet 106 and outlet 1)8 when a valve is interfaced with the plate are illustrated with Figures 5A and 5B which depict cross-sectional side views of the plate of Figure 3 interfaced with a representative valve. In Figure 5A, a representative portion of a valve 540 is interfaced with the first side 104 of the plate 100 and in a closed position such that the valve 540 prevents fluid from flowing between the inlet 106 and the outlet 108 through the valve 540. Although the specifics and internal flow mechanisms of the valve 540 may differ, Figure 5A represents that a valve interfaced with the plate 100 is configured to prevent or stop fluid from flowing between the inlet 106 and outlet 108 through the valve. As illustrated, in some instances the valve prevents fluid from flowing out the first end 118 of the inlet 106, into the valve 540, and through the first end 124 of the outlet 108. With the valve 540 in the closed position, fluid can flow between the inlet 106 and the outlet

108 through only the bypass passage 110, as illustrated with arrows 542. When the valve 540 is closed, fluid cannot flow through the valve between the inlet 106 and the outlet 108. The bypass passage 110 provides a fluidic connection between the inlet 106 and outlet 108 such that the fluid 542 flows from the inlet 106 through the first orifice 112, into the bypass passage 110 and through the first and second sections (not illustrated for clarity in Figure 5A) of the bypass passage 110, and out the bypass passage 110 through the second orifice 114 into the outlet 108.

[0051] In Figure 5B, the valve 540 is in an open position such that fluid can flow between the inlet 106 and the outlet 108 through both the valve 540 and the bypass passage 110. As noted above, although the specifics and internal flow mechanisms of the valve 540 may differ, Figure 5B represents that a valve interfaced with the plate 100 is configured to allow fluid to flow between the inlet 106 and outlet 108 through or within the valve. As can be seen, one representative fluid flow 542A flows through the second end 120 of the inlet 106, through the inlet 106 and out the first end 118 into the valve 540, out of the valve 540 through the first end 124 of the outlet 108, through the outlet 108 and out the second end 126. A second representative fluid flow 542B flows through the second end 120 of the inlet 106, into the first orifice 112 of the bypass passage 110, through the bypass passage 110 and the second orifice 114 into the outlet 108, through the outlet 108, and out the second end 126. As illustrated, when the valve 540 is in an open position, the inlet 106 and the outlet 108 are fluidically connected to each other through both the bypass passage 110 and the valve 540 such that fluid can flow between the inlet 106 and the outlet 108 through both the valve 540 and the bypass passage 110. The bypass plate therefore enables at least two different flowrates between the inlet 106 and the outlet 108. When the valve 540 is in a closed position, fluid can flow between the inlet 106 and the outlet 108 through only the bypass passage 110 which is at a first flowrate. When the valve is in an open position, fluid can flow between the inlet 106 and the outlet 108 through both the valve 540 and the bypass passage 110 such that the fluid flowrate between the inlet 106 and the outlet 108 is at a second flowrate higher than the first flowrate. In some implementations, the valve may be configured to have more than one open position, such as a fully open position and a partially open position.

[0052] The bypass plate 100 may include additional or alternative features which will now be discussed. Figure 6 depicts the bypass plate 100 of Figure 1 according to various embodiments. In some implementations, the bypass plate 100 may include one or more leak-check through-

holes for checking the seal of the valve interfaced with the first side 104. For example, the bypass plate 100 of Figure 6 includes a first leak-check through-hole 644 that extends through the body 102 from the first side 104 to the second side 116, and a second leak-check through-hole 646 that extends through the body 102 from the first side 104 to the second side 116. The first side 104 also includes a first groove 648 spanning between the outlet 108 and the first leak-check through-hole 644, and a second groove 650 spanning between the outlet 108 and the second leak-check through-hole 646. When a valve is interfaced with the first side 104, these grooves provide a fluidic connection between the valve and the first and second leak-check through-holes 644 and 646 which, in some instances, may enable such leak checking.

[0053] The bypass plate 100 may also include seal seats that are recessed below a surface of the first side 104 and each extend around the inlet 106 and the outlet 108, respectively. In Figure 6, the first side 104 has a surface 652 that is planar. A first seal seat 654, highlighted with shading, extends around the inlet 106 and is recessed below the surface 652. A second seal seat 656, also highlighted with shading, extends around the outlet 108 and is recessed below the surface 652. These seal seats 654 and 656 are configured to provide a location for a seal to be positioned in order to create a seal between a valve and the plate 100.

[0054] The bypass plate 100 may include a plurality of mounting through-holes that are configured to enable a valve to be mounted to or with the bypass plate 100. In Figure 6, four mounting through-holes 658A–658D are shown, with one mounting through-hole in each corner of the bypass plate 100. In some embodiments, the mounting through-holes 658A–658D may be threaded holes and a valve may be mounted to the bypass plate 100 by using screws or bolts that secure directly to the threads of the mounting through-holes 658A–658D. In some other implementations, the mounting through-holes 658A–658D may be un-threaded, smooth holes and a valve may be mounted to the bypass plate 100 by using screws or bolts that pass through the mounting through-holes 658A–658D and are secured to another element, such as a manifold block.

[0055] The bypass plate 100 may be made of various materials used in semiconductor processing. In some embodiments, the bypass plate 100 may be made of a material comprising stainless steel, an aluminum, a nickel, a nickel alloy, an alloy, or a combination thereof. The bypass plate 100 may also be a relatively thin plate. Referring back to Figure 3, in some embodiments, the body 102 of the plate may have a thickness 162 that is less than or equal to 200% of a bore diameter D3 of the inlet 106. The dimensions of the bypass plate features may

also have various ranges. For example, in some implementations the first orifice diameter D1 may range between about 1mm and 3mm, the second orifice diameter D2 may range between about 2mm and 5mm, the bore diameter D3 of the inlet 106 may range between about 3mm and 7mm, the bore diameter D4 of the outlet 108 may range between about 3mm and 7mm, and the thickness 162 of the plate 100 may range between about 4mm and 8mm.

[0056] In some implementations, during the manufacturing of the bypass plate, some material of the body may be removed to create the bypass plate and afterwards, additional material may be placed into the body to replace the removed material. For example, referring back to Figure 3, a mill may be used to drill into body 102 along an axis collinear with the axis 130 to remove various material in the body 102, including material to create the bypass passage 110. After creating the bypass passage 110, a portion of material 160 may be placed in the body 102 to replace some of the removed body 102 adjacent the outlet 108. This material 160 also enables the outlet 108 to have its three fluidic connections or ports which are the first end 124, the second end 126, and the second orifice 114.

[0057] Some implementations may include a valve assembly having the bypass plate provided herein and a valve interfaced with the bypass plate. The valve may be a surface mount valve and may have one or more open positions, such as a fully open position that allows a maximum flowrate and one or more partially open positions that allow for flow rates through the valve that are less than the maximum flowrate.

[0058] The bypass plate provided herein is used in semiconductor processing tools, including in the multi-station processing tool provided below. The bypass plate described herein is also for use in combination with a valve mounted to the first side of the bypass plate.

[0059] In some implementations, the plate provided herein may be made using additive manufacturing, e.g., three-dimensional printing.

[0060] In some implementations, the bypass passage of the bypass plate may have substantially uniform cross-sectional area for its entire length. For example, the bypass passage may have a circular, or substantially circular (e.g., within +/- 1%, 5%, or 10% of circular), cross-sectional area that extends along the length of the bypass passage. In some instances, the cross-sectional area is constant along the length of the bypass passage. In some implementations, such a bypass-passage may be considered a through-hole through the body between only the inlet and the outlet.

[0061] Figure 8 depicts a magnified portion of a cross-sectional side view of another bypass plate. Here, bypass plate 800 includes many of the same features as bypass plate 100 as indicated by the same numbered elements. For example, bypass plate 800 includes the same inlet 106 and outlet 108, as well as a body 102. The bypass passage 810 of bypass plate 800 is configured with a first orifice 812 at the inlet 106 and a second orifice 814 at the outlet that both have the same, or substantially same, diameter D1 as each other. The bypass passage 810 extends along the passage center axis 830 and has a substantially constant cross-sectional area along its entire length L2.

[0062] In some implementations, the first orifice of the bypass passage at the inlet and the second orifice of the bypass passage at the outlet may have the same, or substantially the same (e.g., within +/- 1%, 5%, or 10% of each other), diameter. In some embodiments, the diameter of the first orifice of the bypass passage at the inlet may be larger than the diameter of the second orifice of the bypass passage at the outlet.

[0063] With the use and configuration of the bypass passage, fluid flow through the bypass plate can be increased beyond the maximum valve flowrate and adjusted more and to a finer degree than the valve alone without the bypass plate. This adjustment also enables a higher degree of flow calibration along the flow path to which the bypass plate and valve are connected as well as station-to-station calibration and adjustability which can advantageously reduce non-uniformity at the subject station and reduce station-to-station variability and station-to-station non-uniformity.

Multi-station Processing Tool

[0064] Figure 7 schematically illustrates a multi-station processing tool according to some embodiments.

[0065] In some implementations, multi-station processing tool 700 can include an inbound load lock 703 and an outbound load lock 705, either or both of which may include a plasma source and/or an ultraviolet (UV) source. Robot 707, at atmospheric pressure, is configured to move wafers from a cassette loaded through pod 709 into inbound load lock 703 via an atmospheric port 711. Wafer 107 is placed by robot 707 on pedestal 713 in inbound load lock 703, atmospheric port 711 is closed, and inbound load lock 703 is pumped down. In instances in which inbound load lock 703 includes a remote plasma source, wafer 107 may be exposed to a remote plasma treatment in inbound load lock 703 prior to being introduced into processing chamber 715. Further, wafer 107 may be heated in inbound load lock 703 to, for example,

remove moisture and/or adsorbed gases. Next, chamber transport port 717 to processing chamber 715 is opened, and another robot 719 places wafer 107 into the reactor on a pedestal of a first station shown in the reactor for processing. While the implementation depicted in FIG. 7 includes load locks, it will be appreciated that, in some implementations, direct entry of wafer 107 into a processing station may be provided.

[0066] As seen in FIG. 7, processing chamber 715 includes four process stations, numbered 1 to 4. Each station has a temperature-controlled pedestal (such as temperature-controlled pedestal 721 of station 1), and gas line inlets, one or more of which may include a corresponding flow adjuster (such as flow adjuster 151) configured to match (or substantially match) flow conditions (e.g., flow conductance, flow velocity, etc.) to the gas line inlets. It will be appreciated that, in some cases, each process station may have different or multiple purposes. For example, in some embodiments, a process station may be switchable between a chemical vapor deposition (CVD) and PECVD process mode. In another example, deposition operations, e.g., PECVD operations, may be performed in one station, while exposure to UV radiation for UV curing may be performed in another station. In some cases, deposition and UV curing may be performed in the same station. Further, although processing chamber 715 shown as including four stations, embodiments are not limited thereto. For example, processing chamber 715 may have any suitable number of stations, such as five or more stations, or three or less stations.

[0067] As previously mentioned, multi-station processing tool 700 may include a wafer handling system (e.g., robot 719 including spider forks 701) for transferring and/or positioning wafers within processing chamber 715. In some embodiments, the wafer handling system may transfer wafers between various process stations and/or between a process station and a load lock. It is contemplated, however, that any suitable wafer handling system may be employed, such as, for example, wafer carousels, other wafer handling robots, etc. Further, multi-station processing tool 700 may include (or otherwise be coupled to) a system controller 723 employed to control process conditions and hardware states of multi-station processing tool 700. System controller 723 may include one or more memory devices 725, one or more mass storage devices 727, and one or more processors 729. Each processor 729 may include a central processing unit (CPU) or computer, analog, and/or digital input/output connections, stepper motor controller boards, etc.

[0068] In some embodiments, system controller 723 controls each of the activities of multi-

station processing tool 700. For instance, system controller 723 may execute system control software 731 stored in mass storage device 727, loaded into memory device 725, and executed by processor 729. Alternatively, control logic may be hard coded in system controller 723. Application specific integrated circuits (ASIC), programmable logic devices (e.g., field-programmable gate arrays (FPGAs)) and/or the like may be used for these purposes. In the following discussion, wherever "software" or "code" is used, functionally comparable hard coded logic may be used in its place. System control software 731 may include instructions for controlling the timing, mixture of gases, gas flow rates, flow conductance, chamber and/or station pressure, chamber and/or station temperature, wafer temperature, target power levels, RF power levels, substrate pedestal, chuck and/or susceptor position, and other parameters of a particular process performed by multi-station processing tool 700. Further, system control software 731 may be configured in any suitable way. For example, various process tool component subroutines or control objects may be written to control operation of the process tool components used to carry out various process tool processes. System control software 731 may be coded in any suitable computer readable programming language.

[0069] In some embodiments, system control software 731 may include input/output control (IOC) sequencing instructions for controlling the various parameters described above. Other computer software and/or programs stored on mass storage device 727 and/or memory device 725 associated with system controller 723 may be employed in some embodiments. Examples of programs or sections of programs for this purpose include a substrate positioning program, a process gas control program, a pressure control program, a heater control program, a cooler control program, and a plasma control program.

[0070] A substrate positioning program may include program code for process tool components that are used to load and orientate wafer 107 on pedestal 721 and to control the spacing between wafer 107 and other parts of multi-station processing tool 700.

[0071] A process gas control program may include code for controlling gas composition (e.g., silicon-containing gases, oxygen-containing gases, nitrogen-containing gases, dilution (or inert) gases, etc.) flow rates, flow conductances, and optionally for flowing gas into one or more process stations prior to deposition to stabilize the pressure in the process station. A pressure control program may include code for controlling the pressure in the process station by regulating, for example, a throttle valve in an exhaust system of the process station or the like.

[0072] A heater control program may include code for controlling current to one or more

heating units used to heat a pedestal (e.g., pedestal 721) and/or a showerhead of processing chamber 715. Additionally or alternatively, the heater control program may control delivery of a heat transfer gas (such as helium) to a gas distributor, and, thereby, to wafer 107.

[0073] A cooling control program may include code for controlling a flow rate of conductive cooling fluid through a cooling unit used to extract heat from a pedestal (e.g., pedestal 721) and/or a showerhead of processing chamber 715, and, thereby, transfer such thermal energy to, for instance, a waste heat capturing, storage, recycling, and/or disposing system. The flow of the cooling fluid through the cooling unit may also extract heat from wafer 107.

[0074] A plasma control program may include code for setting RF power levels applied to the process electrodes in one or more process stations in accordance with various embodiments.

[0075] A pressure control program may include code for maintaining pressure in a reaction chamber in accordance with various embodiments.

[0076] In some embodiments, a user interface may be provided in association with system controller 723. The user interface may include a display screen, graphical software displays of the apparatus and/or process conditions, and user input devices, such as pointing devices, keyboards, touch screens, microphones, etc.

[0077] In some embodiments, parameters adjusted by system controller 723 may relate to process conditions. Non-limiting examples include process gas composition and flow rates, temperature, pressure, plasma conditions (such as RF bias power levels), pressure, temperature, etc. These parameters may be provided to the user in the form of a recipe, which may be entered utilizing the user interface.

[0078] Signals for monitoring the process may be provided by analog and/or digital input connections of system controller 723 from various process tool sensors. The signals for controlling the process may be output on analog and/or digital output connections of multi-station process tool 700. Non-limiting examples of process tool sensors that may be monitored include mass flow controllers, pressure sensors (such as manometers), thermocouples, etc. Appropriately programmed feedback and control algorithms may be used with data from the sensors to maintain process conditions.

[0079] System controller 723 may provide program instructions for implementing one or more of the above-described processes. The program instructions may control a variety of process parameters, such as direct current (DC) power level, RF bias power level, pressure,

temperature, etc. The instructions may control the parameters to operate deposition of film stacks of a stress compensation layer according to various embodiments.

[0080] System controller 723 will typically include one or more memory devices and one or more processors configured to execute the instructions so that the apparatus will perform a method in accordance with some embodiments. In some instances, machine-readable media containing instructions for controlling process operations in accordance with various embodiments may be coupled to system controller 723.

[0081] In some embodiments, system controller 723 may be part of a system, which may be part of at least one of the above-described examples. Such systems may include semiconductor processing equipment, including a processing tool or tools, a chamber or chambers, a platform or platforms for processing, and/or specific processing components (e.g., a wafer pedestal, a gas flow system, a thermal management system, etc.). The systems discussed above may be integrated with electronics for controlling their operation before, during, and/or 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. For instance, system controller 723, 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), valve operation, flow adjuster operation, light source control for radiative heating, pressure settings, vacuum settings, power settings, RF generator settings, RF matching circuit settings, frequency settings, flow rate settings, fluid delivery settings, positional and operational settings, wafer transfers into and out of a tool or chamber and other transfer tools and/or load locks connected to or interfaced with a specific system. In this manner, system controller 723 may be configured to control, among other systems, the various actuators and motors of a wafer processing system and flow adjusters of a fluid delivery system.

[0082] Broadly speaking, system controller 723 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/or 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). Program instructions may be instructions communicated to

system controller 723 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 oxide, surfaces, circuits, dies of a wafer, etc.

[0083] System controller 723, in some implementations, may be a part of or coupled to a computer that is integrated with, coupled to the system, otherwise networked to the system, or a combination thereof. For example, system controller 723 may be in the "cloud" or all or a part of a fab host computer system, which can allow for remote access of 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. 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 is to 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. Thus, as described above, system controller 723 may be distributed, such as by including 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.

[0084] 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/or any other semiconductor processing system that may be associated or used in the fabrication and/or manufacturing of semiconductor wafers.

[0085] As noted above, depending on the process step or steps to be performed by the tool, system controller 723 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, and/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.

Additional and/or Alternative Embodiments

[0086] Unless otherwise specified, the illustrated embodiments are to be understood as providing example features of varying detail of some embodiments. Thus, unless otherwise specified, the features, components, modules, layers, films, regions, aspects, structures, etc. (hereinafter individually or collectively referred to as an "element" or "elements"), of the various illustrations may be otherwise combined, separated, interchanged, and/or rearranged without departing from the teachings of the disclosure.

[0087] The terminology used herein is for the purpose of describing some embodiments and is not intended to be limiting. As used herein, the singular forms, "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It is to be understood that the phrases "for each <item> of the one or more <items>," "each <item> of the one or more <items>," and/or the like, if used herein, are inclusive of both a single-item group and multiple-item groups, i.e., the phrase "for . . . each" is used in the sense that it is used in programming languages to refer to each item of whatever population of items is referenced. For example, if the population of items referenced is a single item, then "each" would refer to only that single item (despite dictionary definitions of "each" frequently defining the term to refer to "every one of two or more things") and would not imply that there must be at least two of those items. Similarly, the term "set" or "subset" should not be viewed, in itself, as necessarily encompassing a plurality of items—it is to be understood that a set or a subset can encompass only one member or multiple members (unless the context indicates otherwise). The terms "comprises," "comprising," "includes," and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements,

components, and/or groups thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. It is also noted that, as used herein, the terms "substantially," "about," and other similar terms, are used as terms of approximation and not as terms of degree, and, as such, are utilized to account for inherent deviations in measured, calculated, and/or provided values that would be recognized by one of ordinary skill in the art. Accordingly, the term "substantially" as used herein, unless otherwise specified, means within 5% of a referenced value. For example, substantially perpendicular means within ±5% of parallel.

[0088] The use of cross-hatching and/or shading in the accompanying drawings is generally provided to clarify boundaries between adjacent elements. As such, neither the presence nor the absence of cross-hatching or shading conveys or indicates any preference or requirement for particular materials, material properties, dimensions, proportions, commonalities between illustrated elements, and/or any other characteristic, attribute, property, etc., of the elements, unless specified. Further, in the accompanying drawings, the size and relative sizes of elements may be exaggerated for clarity and/or descriptive purposes. As such, the sizes and relative sizes of the respective elements are not necessarily limited to the sizes and relative sizes shown in the drawings. When an embodiment may be implemented differently, a specific process order may be performed differently from the described order. For example, two consecutively described processes may be performed substantially at the same time or performed in an order opposite to the described order.

[0089] When an element, such as a layer, is referred to as being "on," "connected to," or "coupled to" another element, it may be directly on, directly connected to, or directly coupled to the other element or at least one intervening element may be present. When, however, an element is referred to as being "directly on," "directly connected to," or "directly coupled to" another element, there are no intervening elements present. Other terms and/or phrases if used herein to describe a relationship between elements should be interpreted in a like fashion, such as "between" versus "directly between," "adjacent" versus "directly adjacent," "on" versus "directly on," etc. Further, the term "connected" may refer to physical, electrical, and/or fluid connection. To this end, for the purposes of this disclosure, the phrase "fluidically connected" is used with respect to volumes, plenums, holes, etc., that may be connected to one another, either directly or via one or more intervening components or volumes, to form a fluidic connection, similar to how the phrase "electrically connected" is used with respect to

components that are connected to form an electric connection. The phrase "fluidically interposed," if used, may be used to refer to a component, volume, plenum, hole, etc., that is fluidically connected with at least two other components, volumes, plenums, holes, etc., such that fluid flowing from one of those other components, volumes, plenums, holes etc., to the other or another of those components, volumes, plenums, holes, etc., would first flow through the "fluidically interposed" component before reaching that other or another of those components, volumes, plenums, holes, etc.. For example, if a pump is fluidically interposed between a reservoir and an outlet, fluid flowing from the reservoir to the outlet would first flow through the pump before reaching the outlet. The phrase "fluidically adjacent," if used, refers to placement of a fluidic element relative to another fluidic element such that no potential structures fluidically are interposed between the two elements that might potentially interrupt fluid flow between the two fluidic elements. For example, in a flow path having a first valve, a second valve, and a third valve arranged sequentially therealong, the first valve would be fluidically adjacent to the second valve, the second valve fluidically adjacent to both the first and third valves, and the third valve fluidically adjacent to the second valve.

[0090] For the purposes of this disclosure, "at least one of X, Y, . . ., and Z" and "at least one selected from the group consisting of X, Y, . . ., and Z" may be construed as X only, Y only, . . ., Z only, or any combination of two or more of X, Y, . . ., and Z, such as, for instance, XYZ, XYY, YZ, and ZZ. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0091] Although the terms "first," "second," "third," etc., may be used herein to describe various elements, these elements should not be limited by these terms. These terms are used to distinguish one element from another element. Thus, a first element discussed below could be termed a second element without departing from the teachings of the disclosure. To this end, use of such identifiers, e.g., "a first element," should not be read as suggesting, implicitly or inherently, that there is necessarily another instance, e.g., "a second element." Further, the use, if any, of ordinal indicators, such as (a), (b), (c), . . ., or (1), (2), (3), . . ., or the like, in this disclosure and accompanying claims, is to be understood as not conveying any particular order or sequence, except to the extent that such an order or sequence is explicitly indicated. For example, if there are three steps labeled (i), (ii), and (iii), it is to be understood that these steps may be performed in any order (or even concurrently, if not otherwise contraindicated), unless indicated otherwise. For example, if step (ii) involves the handling of an element that is created

in step (i), then step (ii) may be viewed as happening at some point after step (i). In a similar manner, if step (i) involves the handling of an element that is created in step (ii), the reverse is to be understood.

[0092] Spatially relative terms, such as "beneath," "below," "under," "lower," "above," "upper," "over," "higher," "side" (e.g., as in "sidewall"), and the like, may be used herein for descriptive purposes, and, thereby, to describe one element's spatial relationship to at least one other element as illustrated in the drawings. Spatially relative terms are intended to encompass different orientations of an apparatus in use, operation, and/or manufacture in addition to the orientation depicted in the drawings. For example, if the apparatus in the drawings is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" or "over" the other elements or features. Thus, the term "below" can encompass both an orientation of above and below. Furthermore, the apparatus may be otherwise oriented (e.g., rotated 90 degrees or at other orientations), and, as such, the spatially relative descriptors used herein interpreted accordingly.

[0093] The term "between," as used herein and when used with a range of values, is to be understood, unless otherwise indicated, as being inclusive of the start and end values of that range. For example, between 1 and 5 is to be understood as inclusive of the numbers 1, 2, 3, 4, and 5, not just the numbers 2, 3, and 4.

[0094] As used herein, the phrase "operatively connected" is to be understood as referring to a state in which two components and/or systems are connected, either directly or indirectly, such that, for example, at least one component or system can control the other. For instance, a controller may be described as being operatively connected with (or to) a resistive heating unit, which is inclusive of the controller being connected with a sub-controller of the resistive heating unit that is electrically connected with a relay that is configured to controllably connect or disconnect the resistive heating unit with a power source that is capable of providing an amount of power that is able to power the resistive heating unit so as to generate a desired degree of heating. The controller itself likely will not supply such power directly to the resistive heating unit due to the current(s) involved, but it is to be understood that the controller is nonetheless operatively connected with the resistive heating unit.

[0095] As used herein, the singular forms, "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It is also to be understood that the phrases "for each <item> of the one or more <items>," "each <item> of the one or

more <items>," and/or the like, if used herein, are inclusive of both a single-item group and multiple-item groups, i.e., the phrase "for . . . each" is used in the sense that it is used in programming languages to refer to each item of whatever population of items is referenced. For example, if the population of items referenced is a single item, then "each" would refer to only that single item (despite dictionary definitions of "each" frequently defining the term to refer to "every one of two or more things") and would not imply that there must be at least two of those items. Similarly, the term "set" or "subset" should not be viewed, in itself, as necessarily encompassing a plurality of items—it is to be understood that a set or a subset can encompass only one member or multiple members (unless the context indicates otherwise). In addition, the terms "comprises," "comprising," "includes," and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, components, and/or groups thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0096] Various embodiments are described herein with reference to sectional views, isometric views, perspective views, plan views, and/or exploded illustrations that are schematic depictions of idealized embodiments and/or intermediate structures. As such, variations from the shapes of the illustrations as a result of, for example, manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments disclosed herein should not be construed as limited to the particular illustrated shapes of regions, but are to include deviations in shapes that result from, for instance, manufacturing. To this end, regions illustrated in the drawings may be schematic in nature and shapes of these regions may not reflect the actual shapes of regions of a device, and, as such, are not intended to be limiting.

[0097] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure is a part. Terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and are not to be interpreted in an idealized or overly formal sense, unless expressly so defined herein.

[0098] As customary in the field, some embodiments are described and illustrated in the accompanying drawings in terms of functional blocks, units, and/or modules. Those skilled in the art will appreciate that these blocks, units, and/or modules are physically implemented by

electronic (or optical) circuits, such as logic circuits, discrete components, microprocessors, hard-wired circuits, memory elements, wiring connections, and the like, which may be formed using semiconductor-based fabrication techniques or other manufacturing technologies. In the case of the blocks, units, and/or modules being implemented by microprocessors or other similar hardware, they may be programmed and controlled using software (e.g., microcode) to perform various functions discussed herein and may optionally be driven by firmware and/or software. It is also contemplated that each block, unit, and/or module may be implemented by dedicated hardware, or as a combination of dedicated hardware to perform some functions and a processor (e.g., one or more programmed microprocessors and associated circuitry) to perform other functions. Also, each block, unit, and/or module of some embodiments may be physically separated into two or more interacting and discrete blocks, units, and/or modules without departing from the inventive concepts. Further, the blocks, units, and/or modules of some embodiments may be physically combined into more complex blocks, units, and/or modules without departing from the teachings of the disclosure.

[0099] Although the foregoing embodiments have been described in some detail for purposes of clarity of understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims. It should be noted that there are many alternative ways of implementing the processes, systems, and apparatuses of the disclosed embodiments. Accordingly, embodiments are to be considered as illustrative and not as restrictive, and embodiments are not to be limited to the details given herein.

CLAIMS

What is claimed is:

1. A bypass plate for use in a semiconductor processing tool, the bypass plate comprising:

a body partially defined by a first side and a second side opposite the first side;

an inlet extending through the body between the first side and the second side;

an outlet extending through the body between the first side and the second side; and

a bypass passage, wherein:

the first side is configured to interface with a valve, and

the bypass passage:

extends within the body and only between the inlet and the outlet,

fluidically connects the inlet and the outlet within the body, and

is only fluidically connected to the inlet and the outlet.

2. The bypass plate of claim 1, wherein the bypass passage includes:

a first orifice at the inlet and having a first orifice diameter, and

a secod orifice at the outlet and having a second orifice diameter larger than the first orifice diameter.

3. The bypass plate of claim 2, wherein the second orifice diameter is at least twice as large as the first orifice diameter.

4. The bypass plate of claim 2 or 3, wherein the bypass passage further includes:

a passage portion extending between the first orifice and the second orifice, and

the passage portion includes a curved section.

5. The bypass plate of claim 2 or 3, wherein the bypass passage further includes a passage portion that:

extends between the first orifice and the second orifice,

includes a first section that extends along a first axis and has a variable circular cross-sectional area, and

includes a second section that extends along a second axis and has a constant circular cross-sectional area.

6. The bypass plate of claim 1, wherein the bypass passage includes:

a first orifice at the inlet and having a first orifice diameter, and

a secod orifice at the outlet and having a second orifice diameter less than or equal to the first orifice diameter.

7. The bypass plate of any one of claims 1 to 6, wherein:

the inlet extends through the body only along an inlet linear axis, and

the outlet extends through the body only along a outlet linear axis.

8. The bypass plate of any one of claims 1 to 7, wherein the body does not have other internal fluid passages except the inlet, the outlet, and the bypass passage.

9. The bypass plate of any one of claims 1 to 8, wherein the bypass passage does not extend through the first side, the second side, or any other side of the body.

10. The bypass plate of any one of claims 1 to 9, wherein the inlet and the outlet are substantially parallel to each other.

11. The bypass plate of any one of claims 1 to 10, wherein the bypass passage is substantially perpendicular to the inlet and the outlet.

12. The bypass plate of any one of claims 1 to 11, wherein the bypass passage is only internal to the body.

13. The bypass plate of any one of claims 1 to 12, further comprising a leak-check through-hole extending through the body from the first side to the second side, wherein the first side further includes a groove spanning between the outlet and the leak-check through-hole.

14. The bypass plate of claim 13, further comprising a second leak-check through-hole extending through the body from the first side to the second side, wherein the first side further includes a second groove spanning between the outlet and the second leak-check through-hole.

15. The bypass plate of any one of claims 1 to 14, further comprising a plurality of mounting through holes that each extend through the body from the first side to the second side and that each are positioned in a different corner area of the body.

16. The bypass plate of any one of claims 1 to 15, wherein the first side further includes:

a first seal seat recessed below a surface of the first side, extending around the inlet, and configured to interface with a first seal, and

a second seal seat recessed below the surface, extending around the outlet, and configured to interface with a second seal.

17. The bypass plate of any one of claims 1 to 16, wherein the body is comprised of stainless steel.

18. The bypass plate of any one of claims 1 to 17, wherein when a valve is interfaced with the first side and in a closed configuration, the inlet and the outlet are fluidically connected to each other through only the bypass passage and not through the valve.

19. The bypass plate of any one of claims 18, wherein, when the valve is in an open position, the inlet and the outlet are fluidically connected to each other through both the bypass passage and the valve.

20. The bypass plate of any one of claims 1 to 19, wherein the body has a thickness that is less than or equal to 200% a bore diameter of the inlet.

21. A valve assembly, comprising:

a valve having at least an open position and a closed position; and

a bypass plate having:

a body partially defined by a first side configured to interface with the valve and a second side opposite the first side,

an inlet extending through the body between the first side and the second side,

an outlet extending through the body between the first side and the second side, and

a bypass passage, wherein:

the bypass passage:

extends within the body and only between the inlet and the outlet,

fluidically connects the inlet and the outlet within the body, and

is only fluidically connected to the inlet and the outlet,

the first side is interfaced with the valve,

when the valve is in the closed position, fluid is configured to flow between the inlet and the outlet through only the bypass passage and not the valve, and

when the valve is in the open position, fluid is configured to flow between the inlet and the outlet through both the bypass passage and the valve.

22. The valve assembly of claim 21, wherein the bypass plate includes the features of any one of claims 2 to 20.