United States Patent Application Publication	20250259829
Kind Code	A1
Publication Date	August 14, 2025
Inventor(s)	RAJ; Daemian Raj Benjamin et al.

COMPONENT, SYSTEM, AND METHOD FOR IMPROVED FORELINE CLEANING

Abstract

A component, system, and method for improved foreline cleaning of semiconductor chambers and components are disclosed herein. In one example, a processing chamber component includes a foreline constructed from stainless steel having a circular cross sectional shape and an inner surface. The foreline further includes a first end configured to couple to a processing chamber, a second end configured to couple to a valve, and a coating disposed within the inner surface of the foreline, the coating having a thickness between about 150 nanometers and about 525 nanometer. Further, the first end includes a first flange, the second end comprises a second flange, wherein the first end and the second end are coupled by a bend. Further, the coating has properties configured to reduce depositions within the foreline.

Inventors: **RAJ; Daemian Raj Benjamin (Santa Clara, CA), WANG; Nuo (Santa Clara, CA), GE; Zaoyuan (Santa Clara, CA), HA; Sungwon (Palo Alto, CA), NEELAMRAJU; Bharati (Sunnyvale, CA), KULSHRESHTHA; Prashant Kumar (San Jose, CA), SUN; Jennifer Y. (Mountain View, CA), POOMANI; Prasath (Dharmapuri, IN), HUDEDA; Prakash (Bengaluru, IN)**

Applicant: **Applied Materials, Inc.** (Santa Clara, CA)

Family ID: **1000008473668**

Appl. No.: **19/054159**

Filed: **February 14, 2025**

Related U.S. Application Data

us-provisional-application US 63553485 20240214

Publication Classification

Int. Cl.: **H01J37/32** (20060101)

U.S. Cl.:

CPC **H01J37/32862** (20130101); **H01J37/32834** (20130101); H01J2237/335 (20130101)

Background/Summary

RELATED APPLICATIONS [0001] This application claims benefit of and priority to U.S. Provisional Application No. 63/553,485 filed Feb. 14, 2024, which is herein incorporated in its entirety by reference for all purposes.

BACKGROUND
Field
[0002] Embodiments of the present disclosure generally relate to improved foreline cleaning of semiconductor chamber components, and more specifically, coatings on a foreline conduit of a semiconductor processing chamber to improve foreline cleaning.
Description of the Related Art
[0003] In semiconductor manufacturing, integrated circuit (IC) are formed on semiconductor substrates through various manufacturing steps, including etching, deposition, ion implantation, and annealing, performed in processing chambers. During some of these manufacturing steps, process gases and processing by-products are pumped out of the processing chambers into an exhaust system through a chamber foreline. Deposits may undesirably form in the chamber foreline and other downstream equipment. These undesired deposits may result in diminished performance of the exhaust system and/or exhaust component damage.
[0004] To reduce the buildup of undesired depositions within the foreline, a cleaning cycle is performed to dissolve, or otherwise break apart, the depositions within the foreline and downstream equipment. Conventionally, a cleaning cycle includes the use of excited cleaning gases within the foreline. However, it is difficult to maintain the excited state of the cleaning gases within the foreline. As the excitation state of the cleaning gases diminishes, so does the effectiveness of the cleaning cycle, resulting in inefficient deposition removal within the foreline and downstream equipment.
[0005] Thus, there is a need to improve cleaning of the foreline.
SUMMARY
[0006] A component, system, and method for improved foreline and component cleaning are disclosed herein. In one example, a processing chamber component includes a foreline having a circular cross sectional shape and an inner surface. The foreline is constructed from stainless steel. The foreline further includes a first portion having a first end configured to couple to a processing chamber, a second portion having a second end configured to couple to a valve, and a coating disposed on the inner surface of the foreline. The first end includes a first flange. The second end includes a second flange. The first portion and the second portion are coupled together. The coating has a thickness of about 150 nanometer to about 525 nanometer.
[0007] In another example, a processing system includes a processing chamber, a foreline having a circular cross sectional shape and an inner surface, and a valve. The foreline is constructed from stainless steel. The foreline further includes a first portion having a first end configured to couple to a processing chamber, a second portion having a second end configured to couple to a valve, and a coating disposed on the inner surface of the foreline. The first end includes a first flange. The second end includes a second flange. The first portion and the second portion are coupled together. The coating has a thickness of about 150 nanometer to about 525 nanometer. The valve directly

coupled to the second flange.
[0008] In another example, a method of cleaning a processing system comprises pumping a carbon containing gas out from a processing chamber and into a foreline, generate radicals from a cleaning gas and flow the radicals into the foreline, and etching deposits as the radicals flow through the foreline. The foreline has a coating comprising aluminum oxide and has a coating thickness of about 150 nanometer to about 525 nanometer.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0009] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only exemplary embodiments and are therefore not to be considered limiting of its scope and may admit to other equally effective embodiments.
[0010] FIG. **1** is a cross-sectional schematic view of an exemplary plasma processing chamber, according to certain aspects of the present disclosure.
[0011] FIG. **2** is a cross-sectional schematic view of the foreline coupled to the throttle valve, according to certain aspects of the present disclosure.
[0012] FIG. **3** is a schematic side view of the foreline, according to certain aspects of the present disclosure.
[0013] FIG. **4** is a method of a cleaning a processing system, according to certain aspects of the present disclosure.
[0014] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.
[0015] Many of the details, dimensions, angles, and other features shown in the figures are merely illustrative of particular implementations. Accordingly, other implementations can have other details, components, dimensions, angles, and features without departing from the spirit or scope of the present disclosure. In addition, further implementations of the disclosure can be practiced without several of the details described below.
DETAILED DESCRIPTION
[0016] The present disclosure is directed towards a system for improved foreline cleaning for a processing system. It has been found that foreline cleaning using the disclosed technology improves the removal of undesired depositions within or on chamber foreline components, such as a valve. For example, the techniques described herein increase the duration of the energization state of cleaning gases, thus enabling more effective cleaning within the chamber foreline.
[0017] The present disclosure will elaborate on a coating used within the foreline that lengthens the lifespan of the cleaning gases for improved foreline cleaning of undesired depositions and reduce the sticking coefficient of the foreline inner surface. In some embodiments, the coating advantageously results in more uniform removal of the undesired depositions within the foreline and from downstream components during a cleaning process. In some embodiments, the coating may also advantageously result in a decreased tendency for undesired depositions from processing by-products to adhere to the interior surfaces of the foreline and downstream components during processing, thereby reducing the amount of undesired depositions needing to subsequently be removed in the cleaning. The more effective cleaning of the foreline results in a reduction in the duration of cleaning operation, the frequency of cleaning cycles, process control drift,

equipment/component damage, and product waste, while improving operator safety, increasing product yield, increasing efficiency of processing, and lowering the cost of overall ownership.

[0018] FIG. **1** is a cross-sectional schematic view of an exemplary processing system **150**. The processing system **150** includes a plasma processing chamber **100**, a controller **122** and an exhaust system **160**. The processing system **150** is configured to effectively improve cleanliness of a foreline **106** and other components that couple the processing chamber **100** to the exhaust system **160**, enabling the advantages described above. In some embodiments, the processing chamber **100** is a vacuum processing chamber, such as a deposition chamber, an ion implant chamber, an etch reactor chamber, a plasma treatment chamber, and an atomic layer deposition chamber, among others. Representative deposition chambers include plasma enhanced chemical vapor deposition (PECVD) chambers, chemical vapor deposition (CVD) chambers, and physical vapor deposition (PVD) chambers, among others. In the example depicted in FIG. **1**, the processing chamber **100** is a PECVD chamber.

[0019] The processing chamber **100** includes a chamber body **102** having chamber sidewalls **144**, a chamber bottom **126**, and a removably coupled lid **128** that enclose an inner volume **104**. In some embodiments, the chamber lid **128** is coupled to a gas panel **136**. The gas panel **136** provides gases, such as processing and/or cleaning gases, to the inner volume **104** through a showerhead **146** that is coupled to a bottom of the chamber lid **128**. The showerhead **146** is also coupled to a radio frequency (RF) RF power supply **134**. The RF power supply **134** provides RF power through an RF matching circuit **132** and to the showerhead **146**. RF power provided to the showerhead **146** from the RF power supply **134** energizes the gases within the inner volume **104** for processing substrates within the processing chamber **100** and/or to clean the interior of the processing chamber **100**. In some embodiments, cleaning gases may optionally be provided to the inner volume **104** of the processing chamber **100** and/or directly to the foreline **106** via a remote plasma source (RPS) **152**. In some embodiments, the energized showerhead **146** excites the gases within the inner volume **104** to create a plasma **116**. Process gases, along with any processing by-products, are removed from the inner volume **104** through an exhaust port **148** formed in the chamber sidewalls **144**, or chamber bottom **126**, of the chamber body **102**. The exhaust port **148** is coupled to the exhaust system **160** via the foreline **106**, which may include further valves utilized to control the vacuum levels within the inner volume **104**. The exhaust system **160** may be coupled to a vacuum pump **124**.

[0020] A substrate support assembly **118** is disposed within the inner volume **104** of the chamber body **102**. The substrate support assembly **118** is configured to receive, support, and process a substrate **120** thereon.

[0021] The gas panel **136** may provide various types of gases to the inner volume **104** of the chamber body **102**. The gas panel **136** is coupled to a processing gas supply used to process the substrate **120** in the inner volume **104** of the plasma processing chamber **100**. The gas panel **136** may also be coupled to a cleaning gas supply (not shown) used to perform a cleaning cycle within the processing chamber **100**. In one example, the gas panel **136** is configured to supply a carbon containing deposition precursor utilized to deposit a carbon containing film on the substrate **120** within the processing chamber **100**. In another example, the gas panel **136** provides a cleaning gas for forming oxygen radicals for reacting with deposited carbon by-products to clean the processing chamber **100**, the foreline **106**, and any downstream components.

[0022] A controller **122** is configured to receive data or input from sensor readings from a plurality of sensors (not shown) and send or output instructions to various process chamber components or equipment. The controller **122** can monitor, estimate an optimized parameter, adjust an initiated operation, generate an alert on a display, halt an operation, initiate a chamber downtime period, delay a subsequent iteration of an operation, initiate a cleaning operation, halt a cleaning operation, adjust a heating power, and/or otherwise adjust the process recipe. The controller **122** includes a central processing unit (“CPU”) **142** (e.g., a processor), a memory **138** containing instructions, and support circuits **140** for the CPU **142**. The controller **190** controls various items directly, or via other computers and/or controllers. In one or more embodiments, the controller **122** is communicatively coupled to at least a throttle valve **114**. The memory **138** can contain instructions, that when executed by the CPU **142**, causes the processing system **150** to perform deposition and/or cleaning operations, such as later described below.

[0023] FIG. **2** is a cross-sectional schematic view of the foreline **106** extending from a portion of the processing chamber **100** and coupled to the throttle valve **114**.

[0024] The foreline **106** is coupled to the processing chamber **100** at a foreline connection **208**. The foreline **106** is coupled to the throttle valve **114** at a foreline connection **210**. The foreline connections **208**, **210** may be fastened to their adjacent components by, for example, flange couplers including bolts, compression clamps, or the like, or welds including butt, lap, corner, tee, or edge joints and the like. In some embodiments, as illustrated in FIG. **2**, the foreline **106** has a first portion **212** and a second portion **214** coupled by a bend **206**. The first portion **212** is at least twice as long as the second portion **214**. The bend **206** generally ranges between 60 and 120 degrees, such as 90 degrees, although other angles may be utilized. The first portion **212** terminates at the foreline connection **208**, while the second portion **214** terminates at the foreline connection **210**. In other embodiments, the foreline **106** may be oriented out of the chamber body **102** and be substantially horizontal or substantially vertical. The foreline **106** may be oriented in multiple manners and is not illustrated to be limiting in positioning.

[0025] In the example shown, the foreline **106** illustrated in FIG. **2** includes undesired deposits **250**. In one example, the undesired deposits **250** are carbon deposits resulting from depositing carbon containing films on the substrate **120** using a hydrocarbon or carbon containing deposition gas provided from the gas panel **136**. In certain embodiments, the carbon deposits **250** form along the interior surface of the foreline **106** as a temperature in the foreline **106** decreases along the first portion **212** and the second portion **214** during processing. For example, in a conventional foreline (e.g., uncoated foreline), a temperature of portions of the foreline during processing may vary such as increasing to about 235 degrees Celsius at the foreline connection **208** near the processing chamber **100**. As the foreline **106** extends farther away from the processing chamber **100**, temperatures of corresponding portions of the foreline during processing may in turn decrease to about 82 degrees Celsius as the foreline approaches the throttle valve **114**. As carbon containing processing by-products exit the process chamber through the foreline, the decrease in temperature in the foreline causes the undesired carbon deposits to form along an interior surface of the foreline.

[0026] The foreline **106** may be constructed from stainless steel, such as 304 stainless steel, 316 stainless steel, and/or 316L stainless steel. Alternatively, the foreline **106** may be constructed from another suitable material. In some embodiments, the foreline **106** may be a pipe having a circular cross-sectional shape. In other embodiments, the foreline **106** may be a tube or various cross-sectional shapes including a triangle, oval, rectangle, pentagon, hexagon, or the like. The foreline **106** has an exterior surface **202** and an interior surface **204**. In a conventional foreline **106**, such as a stainless steel foreline, oxygen radicals from the cleaning gas needed for cleaning the foreline **106** may recombine with the interior stainless steel surface of the foreline **106** in an exothermic reaction. Even with a dedicated oxygen radical remote plasma source, such recombination of the oxygen radicals with the stainless steel surface inside the foreline **106** leads to a decrease in the available oxygen radicals to effectively clean the foreline **106** and/or the throttle valve **114**. Furthermore, the exothermic reaction from the recombination of the oxygen radicals with the stainless steel surface of the foreline **106** may also cause temperature spikes in the foreline **106** that may damage and/or affect the long term reliability of certain components of the exhaust system **160**, such as an O-ring or heater jacket for the foreline **106**.

[0027] In some embodiments, a coating **220** is disposed on the interior surface **204** of the foreline **106**. The coating **220** has an outer surface **216** disposed in contact with the interior surface **204** of the foreline **106**, and an inner surface **218** exposed to a foreline inner volume **222** that runs end-to-end through the foreline **106**. In certain embodiments, the coating **220** comprises a sticking coefficient property configured to reduce recombination of oxygen radicals flowing through the foreline **106** with the stainless steel interior surface **204** of the foreline **106**. As mentioned above, the lower sticking coefficient of the coating **220** may also reduce the tendency for undesired carbon depositions from processing by-products to adhere to the coating **220** coating the interior surfaces of the foreline, thereby decreasing the overall amount of undesired deposit **250** that would have otherwise adhered to an uncoated, or bare, foreline interior surface **204**.

[0028] In some embodiments, the coating **220** comprises aluminum oxide ("Al.sub.2O.sub.3") having a sticking coefficient of about 0.0001. In other embodiments, the coating **220** comprises aluminum ("Al") having a sticking coefficient of about 0.001. The sticking coefficient of aluminum oxide and aluminum are both correspondingly lower than compared to stainless steel ("SST") (e.g., uncoated foreline) having a sticking coefficient between about 0.1 to about 0.2. In some embodiments, the sticking coefficient of the coating **220** or the uncoated interior surface **204** of the foreline **106** may be dependent on the temperature and surface morphology. Without being bound by theory, it was observed that the lower sticking coefficient of aluminum oxide from the coating **220** provided reduced recombination of oxygen radicals in the foreline **106** thereby increasing oxygen radical supply and life in the foreline **106** during the cleaning process. In some embodiments, the coating **220** may comprise a thickness between about 100 nanometers ("nm") and about 525 nm, such as between about 150 nm and about 475 nm thick, or between about 200 nm and about 425 nm thick. In some embodiments, the thickness of the coating **220** may improve adhesion between the interior surface **204** of the foreline **106** and the outer surface **216** of the coating **220**. In some embodiments, the coating **220** is continuous within the foreline **106**. In one embodiment, the thickness of the coating **220** is about 150 nm. In another embodiment, the thickness of the coating **220** is about 475 nm.

[0029] The throttle valve **114** is operable to control pressure within and/or flow exiting the processing chamber **100** during operation. As illustrated in FIG. **2**, the throttle valve **114** comprises a valve body **224** having a rotatable disc **226** disposed therein. The disc **226** is coupled to a stem **228**. The stem **228** is coupled to an actuator (not shown) that is actively controlled by the controller **122**. The actuator rotates the stem **228** which in turn rotates the disc **226** within the valve body **224**. The rotational orientation of the disc **226** controls the distance between an outer edge **230** of the disc **226** and wedges **232** disposed in the valve body **224** to control fluid passage through flow paths **234** of the throttle valve **114**. To reduce the flow through the flow paths **234**, the actuator rotates the stem **228** to abut the disc outer edge **230** of the disc **226** towards the wedge **232**. As described, the throttle valve **114** may open, close, or modulate to regulate the flow or pressure within the processing chamber **100**.

[0030] During deposition operations, the gas panel **136** may utilize carbon containing gases, such as acetylene, for patterning processes. These gases can cause undesired carbon deposits **250** in the foreline **106** and on the throttle valve **114** as illustrated in FIG. **2**. As the deposits **250** build, the pressure or flow control of the throttle valve **114** is reduced leading to ineffective operation of the throttle valve **114**. In other words, the undesired deposits **250** may reduce the area of the flow paths **234** and require the valve to rotate farther than programmed to allow the same amount of flow as compared to a clean disc **226**. Similarly, the deposits **250** may reduce the foreline inner volume **222** leading to process drift and reduced accurate control. In some embodiments, the coating **220** of the foreline **106** may advantageously reduce oxygen radical recombination in the foreline **106** which in turn increases radical oxygen amount and life for cleaning the foreline **106**. The decreased recombination of oxygen radicals in the foreline **106** may dramatically improve cleaning rate resulting in reduced cleaning cycle frequency and the time needed to clean the foreline **106**. In some embodiments, the coating **220** of the foreline **106** may advantageously also reduce the tendency of undesired carbon deposits **250** to form within the foreline **106** due to the coating's low sticking coefficient as compared to an uncoated foreline **106** in which, in one embodiment, may therefore correspond to the higher sticking coefficient of stainless steel. This lower sticking coefficient results in increased oxygen radical life and supply in the inner foreline volume **222**, as well as a lower tendency for formation of the carbon deposits **250** in the inner foreline volume **222** in general as compared to conventional uncoated forelines.

[0031] Cleaning cycles are periodically performed to etch away the deposits **250**. The cleaning gases provided by the gas panel **136** (or alternatively the RPS **152**) may be oxygen containing gases, such as oxygen gas (O.sub.2). In some embodiments, the cleaning gases may alternatively or also comprise other non-oxygen containing gases, such as argon gas (Ar), nitrogen gas (N.sub.2) and nitrogen trifluoride gas (NF.sub.3). The cleaning gases are introduced to the processing chamber **100** from the gas panel **136** via the showerhead **146**. A plasma **116** may be generated from the cleaning gases within the inner volume **104** to excite the oxygen containing gases. In some embodiments, the cleaning gases are excited external to the inner volume **104** via the RPS **152**, and then introduced to the inner volume **104**. Alternatively, the RPS **152** may be coupled directly to the foreline **106**. The excited oxygen containing gases form oxygen radicals. The oxygen radicals effectively etch away the carbon deposits **250**.

[0032] As the oxygen radicals flow out of the processing chamber **100** and into the foreline **106** for cleaning operations, the oxygen radicals react with and etch away the carbon deposits **250** within the foreline inner volume **222**. As discussed above, the oxygen radicals are affected by the lower sticking coefficient of the foreline **106** leading to lower recombination rates due to the coating **220** now blocking the oxygen radicals from contact with the stainless steel interior surface **204** of the foreline **106**. Thus, the presence of the coating **220** on the foreline **106** enables oxygen radicals to travel farther down the foreline **106**, to the throttle valve **114**, and beyond, thereby providing a faster and more thorough removal of unwanted carbon deposits **250**.

[0033] As mentioned above, the recombination of the cleaning gas within the foreline **106** is an exothermic reaction that heats the foreline **106**. In some embodiments, recombination of the cleaning gas within the foreline **106** can heat the foreline **106** to temperatures up to 250 degrees Celsius. In some embodiments, the heat produced from the recombination may exceed safety limits and/or damages adjacent components, such as heater jackets (not shown) at least partially surrounding the foreline **106**. In those embodiments, the heat produced from the recombination reduces the long term reliability of the adjacent components. For example, the coated foreline **106** may operate about 170 degrees Celsius to about 180 degrees Celsius when deposition processes are being performed within the processing chamber **100**. Advantageously, the reduced recombination of radicals provided by the coating **220** inside the foreline limits temperature rises of the coated foreline **106** during cleaning operations to between about 1 degree Celsius and about 10 degrees Celsius, such as about 2 degrees Celsius and about 9 degrees Celsius, such as about 3 degrees Celsius and about 8 degrees Celsius, such as about 4 degrees Celsius and about 6 degrees Celsius, such as about less than 10 degrees Celsius, and such about less than 5 degrees Celsius. Compared to the uncoated foreline, the coated foreline **106** experiences significantly less temperature variation that results in greater operator safety, increased adjacent component reliability, less process drift, and reduced frequency of foreline preventative maintenance.

[0034] FIG. **3** is a schematic side view of the foreline **106** according to some embodiments. The foreline **106** comprises an exterior surface **202** on the first portion **212** coupled to the bend **206**. The one end of the first portion **212** is coupled to foreline connection **208**. The opposite end of the first portion **212** is coupled to an end of the bend **206**. The opposite end of the bend **206** is coupled to foreline connection **210**. In some embodiments, the bend **206** has a bending radius of about 2 inches ("in.") to about 4 in. The bending radius dimensions are selected to enable the cleaning gas radicals to traverse the bend **206** without promoting recombination of the cleaning gas traveling across the bend **206**. In other words, the bending radius is selected to reduce the amount of radical recombination, and consequentially heating of the foreline **106**, as the cleaning gas traverses the bend **206** in the foreline **106**.

[0035] In some embodiments, height **308** is about 11.00 in. to about 11.25 in. from a centerline ("H.sub.C/L") to a top surface **328** of the foreline connection **208**. In some embodiments, the distance **310** between the top surface **330** of the foreline connection **208** to a centerline ("V.sub.C/L") is about 3.25 in. to about 3.75 in. In some embodiments, the foreline **106** may have an outer diameter **302** between about 1.75 in. and about 2.75 in., with a wall thickness between about 0.045 in. to 0.94 in. In such embodiments, the inner diameter **318** is about 2.0 in. to about 2.5 in. In another embodiment, the outer diameter **302** of the foreline is about 2 in. with a wall thickness of about 0.065 in. It is contemplated that the coated foreline may alternatively have different sizes and dimensions.

[0036] The foreline connection **208** comprises a flange **304**. The flange **304** is configured to attach to the processing chamber **100**. The outer diameter **324** is greater than the inner diameter **318**. The inner diameter **318** is coupled a shelf **326** that is stepped down from the top surface **328** of the flange **304**. The shelf **326** provides lateral stability between the foreline flange connection **208** and the processing chamber **100**. In some embodiments, the flange **304** flares in an outward direction producing an angled foreline connection **208**, as illustrated. The flange **304** has cutaways **322**. There may a several cutaways **322** located about the perimeter of the flange **304**. As illustrated, the flange **304** has four cutaways **322**. In some embodiments, the cutaways **322** are bore holes with a diameter **320** of about 0.140 in. to about 0.160 in. In some embodiments, the cutaways **322** may have tangential cuts out to form the rectangular shape with semi-circular ends, as illustrated in FIG. **3**. In some embodiments, the cutaways **322** are disposed at a first angle **314** of about 47 degrees to about 48 degrees from the V.sub.C/L. In those embodiments, other cutaways **322** are disposed a second angle **316** in a direction opposite the V.sub.C/L from the first angle **314**, of about 17 degrees to about 18 degrees. In some embodiments, the cutaways **322** each have a corresponding cutaway **322** disposed across or about 180 degrees around the flange **304**. The cutaways **322** are positioned on the flange **304** to provide support and stability between the foreline connection **208** and the processing chamber **100**.

[0037] The foreline connection **210** comprises a flange **306** having top surface **330**. The flange **306** is configured to attach to the throttle valve **114**. In some embodiments, the flange **306** flares in an outward direction producing an angled foreline connection **210**, as illustrated. Similar to the flange **304**, the flange **306** may have cutaways similar to cutaways **322**.

[0038] FIG. **4** is a method of a cleaning a processing system. The method **400** comprises operation **402**, operation **404**, and operation **406**, and operation **408**. The method **400** may be used to advantageously clean the processing system, particularly the foreline **106** and the throttle valve **114**.

[0039] The method **400** begins at operation **402** by pumping a carbon containing gas out from a processing chamber **100** and into a foreline **106**. In one example, the carbon containing gas is utilized to deposit a carbon containing film on a substrate **120** disposed in the processing chamber **100**. In another example, the gases may contain compounds from a dielectric deposition process or from a metal deposition process. Embodiments of compounds present in the deposition gases include silicon-containing materials, chlorinated hydrocarbons (CHCs), hydrofluorocarbons (HFCs), chlorofluorocarbons (CFCs), or other compounds.

[0040] After the substrate **120** is removed from the processing chamber **100** after operation **402**, the method **400** proceeds to operation **404**. At operation **404**, radicals are generated from a cleaning gas and delivered to the foreline **106**. Stated in a different manner, the cleaning gas radicals are flowed into the coated foreline **106**. As discussed above, the cleaning gas radicals provided to the foreline **106** flow into contact with the exhaust system **160**. The radicals may be generated within the processing chamber **100**, for example, by forming a plasma **116** from a cleaning gas, or provided to the processing chamber **100** via RPS **152**. Alternatively, radicals generated from the cleaning gas may be formed within the foreline **106**, or in another alternative, be provided to the foreline **106** from the remote plasma source directly while by-passing the processing chamber. As discussed above, cleaning gases may be provided to the inner volume **104** of the processing chamber **100** through gas conduits coupled between the gas panel **136** and the showerhead **146**. The cleaning gas may be energized to create plasma **116** from the RF power supply **134**. The plasma **116** creates radicals from the cleaning gases.

[0041] At operation **406**, the cleaning gas radicals etch away deposits **250** as the radicals traverse the foreline **106** and flow through the throttle valve **114**. The coating **220** disposed along the interior surface **204** of the foreline **106** reduces the tendency of carbon deposits to adhere to the inner surface **218** of the coating **220**. By reducing the adhesion of the radicals to the coating **220**, the radicals may travel farther down the foreline **106** and through throttle valve **114** thus providing improved cleaning of the foreline **106** and throttle valve **114**. Additionally, the coating **220** reduces the tendency of deposits **250** to adhere to the foreline **106**, thereby extending the mean time between cleaning operations. In some embodiments, the coating **220** may also be present on the various components of the throttle valve **114** to reduce the tendency of deposits **250** from adhering to the throttle valve **114**.

[0042] As discussed above, the recombination of the radicals may be an exothermic reaction. Uncoated forelines experience hot zones in areas of the foreline such as the first portion **212** of foreline **106** that may cause adjacent component damage, such as a heater jacket, and/or operator injuries. The coating **220** advantageously reduces temperature variations in the foreline **106** between a processing operation and a cleaning operation within 20 degrees Celsius, such as about less than 10 degrees Celsius, such as about less than 5 degrees Celsius. Stated differently, the coated foreline **106** exhibits no undesired excessive temperature rises between a processing operation and a cleaning operation. In some embodiments, the coating **220** enables a substantially stable temperature profile in the foreline **106**. Compared to the uncoated foreline, the coated foreline **106** experiences significantly less temperature variation that results in greater operator safety, increased adjacent component reliability, and reduced frequency of foreline **106** failure.

[0043] The benefits of the present disclosure improve cleaning of the foreline **106** and throttle valve **114** by providing a coating along the interior surface **204** of the foreline **106**. As discussed above, the coating **220** inhibits the recombination of cleaning gas radicals within the foreline, advantageously allowing increased supply of the radicals to reach the throttle valve **114** for effective and efficient cleaning of undesired deposits **250**. In some embodiments, the coating **220** also enables the improved foreline **106** to remain cleaner during normal operation of the processing chamber by decreasing a tendency for undesired deposits **250** to form on the coating **220**, resulting in faster foreline cleans, reduced preventative maintenance, reduced process drift, increased process yield, and lowered cost of ownership.

[0044] While the foregoing is directed to embodiments of the present disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims

1. A processing chamber component, comprising: a foreline having a circular cross sectional shape and an inner surface, the foreline constructed from stainless steel, the foreline comprising: a first portion having a first end configured to couple to a processing chamber, the first end comprising a first flange; a second portion having a second end configured to couple to a valve, the second end comprising a second flange, the first portion and the second portion fluidly coupled together; and a coating disposed on the inner surface of the foreline, the coating having a thickness between about 125 nanometers and about 525 nanometers.

2. The processing chamber component of claim 1, wherein the coating comprises aluminum or aluminum oxide.

3. The processing chamber component of claim 1, wherein the coating comprises a thickness between about 200 nanometer and about 475 nanometer.
4. The processing chamber component of claim 1, wherein the foreline comprises stainless steel.
5. The processing chamber component of claim 1, wherein the first portion and the second portion are fluidly coupled together at a bend.
6. The processing chamber component of claim 1, wherein the foreline comprises a wall thickness between about 0.045 inches to about 0.94 inches.
7. The processing chamber component of claim 1, wherein the first flange has a plurality of cutaways disposed around a perimeter of the first flange, each of the plurality of cutaways having another cutaway directly across the first flange.
8. The processing chamber component of claim 1, wherein the first portion is at least twice as long as the second portion, the first and second portions coupled by a bend.
9. A processing system, comprising: a processing chamber; a foreline having a circular cross sectional shape and an inner surface, the foreline constructed from stainless steel, the foreline comprising: a first portion having a first end configured to couple to a processing chamber, the first end comprising a first flange; a second portion having a second end configured to couple to a valve, the second end comprising a second flange, the first portion and the second portion fluidly coupled together; and a coating disposed on the inner surface of the foreline, the coating comprising a thickness between about 150 nanometers and about 525 nanometer; and a valve directly coupled to the second flange.
10. The processing system of claim 9, wherein the coating comprises aluminum or aluminum oxide.
11. The processing system of claim 9, wherein the coating comprises a thickness between about 200 nanometers and about 475 nanometers.
12. The processing system of claim 9, wherein the foreline comprises stainless steel.
13. The processing system of claim 9, wherein the first flange has a plurality of cutaways disposed around a perimeter of the first flange, each of the plurality of cutaways having another cutaway directly across the first flange.
14. The processing system of claim 9, wherein the valve is a butterfly valve.
15. The processing system of claim 9, further comprising a heater jacket at least partially surrounding the foreline.
16. A method of cleaning a processing system, comprising: pumping a carbon containing gas out from a processing chamber and into a foreline, the foreline having a coating comprising aluminum oxide and having a coating thickness between about 150 nanometers and about 525 nanometers; generating radicals from a cleaning gas and flowing the radicals into the foreline; and etching deposits as radicals flow through the foreline.
17. The method of claim 16, wherein the cleaning gas contains oxygen.
18. The method of claim 16, wherein the foreline comprises stainless steel.
19. The method of claim 16, further comprising removing a substrate from the processing system after pumping the carbon containing gas into the foreline.
20. The method of claim 16, wherein the coating comprises aluminum or aluminum oxide, and a thickness of the coating is between about 200 nanometers and about 475 nanometers.