

SYSTEM AND METHOD FOR CLEANING GAS INJECTORS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application Serial No. 61/567,693, filed December 7, 2011 and U.S. Non-Provisional Application Serial No. 13/650,429, filed October 12, 2012.

BACKGROUND

Field

[0002] The present disclosure relates to a system and method of cleaning the interior surfaces of a gas injector.

Technical Background

[0003] Gas injectors are used as part of plasma processing systems for plasma processing of substrates such as semiconductor wafers. These applications require the gas injectors to be free of contaminants because contaminants would potentially yield unacceptable work product. Conventionally, injectors are cleaned by manually scrubbing the interior surfaces to the extent accessible augmented with ultrasonic cleaning. Such a procedure is believed to not render the injector free of particulate contaminants such as ceramic and Yttria particles. The present inventors have recognized a need for alternatives to the aforementioned cleaning process and, more particularly, more effective alternatives for removing particles, such as ceramic and Yttria particles, from the confined surfaces of an injector.

BRIEF SUMMARY

[0004] According to the subject matter of the present disclosure, an injector cleaning apparatus is provided to clean the interior surfaces of a gas injector. The injector cleaning apparatus and associated procedure is intended to remove particles, for example ceramic and

Yttria particles, from the confined surfaces of an injector. The injector cleaning apparatus may serve to clean or flush out particles following conventional scrub and ultrasonic cleaning.

[0005] In accordance with one embodiment of the present disclosure, an injector cleaning apparatus comprises a concentric dual flow introducer and a flow-dispersing injector seat. The concentric dual flow introducer comprises an inner concentric cleaning fluid flowpath configured to communicate with a central passage of a gas injector, an outer concentric cleaning fluid flowpath configured to communicate with a plurality of peripheral passages of a gas injector, and an input-side injector engaging interface. The input side injector engaging interface comprises a compressible sealing portion and a rigid facing portion. The compressible sealing portion of the input-side injector engaging interface has compressibility sufficient to yield under fluid cleaning surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus and resiliency sufficient to prevent abutment of a gas injector and the rigid facing portion of the input-side injector engaging interface and maintain an input-side injector floating gap between an injector and the rigid facing portion of the input-side injector engaging interface. The flow-dispersing injector seat comprises an output-side injector engaging interface having a compressible sealing portion and a rigid facing portion. The compressible sealing portion of the output-side injector engaging interface has compressibility sufficient to yield under fluid cleaning surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus and resiliency sufficient to prevent abutment of a gas injector and the rigid facing portion of the output-side injector engaging interface and maintain an output-side injector floating gap between an injector and the rigid facing portion of the output-side injector engaging interface.

[0006] In accordance with another embodiment of the present disclosure, an injector cleaning apparatus comprises a concentric dual flow introducer, a flow-dispersing injector seat, an inner flow control module, and an outer flow control module. The concentric dual flow introducer comprises an inner concentric cleaning fluid flowpath configured to communicate with a central passage of a gas injector, an outer concentric cleaning fluid

flowpath configured to communicate with a plurality of peripheral passages of a gas injector, and an input-side injector engaging interface. The input-side injector engaging interface has a compressible sealing portion and a rigid facing portion. The compressible sealing portion of the input-side injector engaging interface has compressibility sufficient to yield under fluid cleaning surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus and resiliency sufficient to prevent abutment of a gas injector and the rigid facing portion of the input-side injector engaging interface and maintain an input-side injector floating gap between an injector and the rigid facing portion of the input-side injector engaging interface. The flow-dispersing injector seat includes an inner base ring, an outer base ring, and an output-side injector engaging interface comprising a compressible sealing portion and a rigid facing portion. The compressible sealing portion of the output-side injector engaging interface has compressibility sufficient to yield under fluid cleaning surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus and resiliency sufficient to prevent abutment of a gas injector and the rigid facing portion of the output-side injector engaging interface and maintain an output-side injector floating gap between an injector and the rigid facing portion of the output-side injector engaging interface. The inner flow control module is configured to regulate flow of deionized water and compressed dry air to the inner concentric cleaning fluid flowpath and the outer flow control module is configured to regulate flow of deionized water and compressed dry air to the outer concentric cleaning fluid flowpath.

[0007] In accordance with another embodiment of the present disclosure, a method of cleaning a gas injector is disclosed. The method comprises providing an injector cleaning apparatus comprising a concentric dual flow introducer, a flow-dispersing injector seat, an inner control module, and an outer control module. The concentric dual flow introducer comprises an inner concentric cleaning fluid flowpath configured to communicate with a central passage of a gas injector and an outer concentric cleaning fluid flowpath configured to communicate with a plurality of peripheral passages of a gas injector. The method further comprises introducing deionized water and compressed dry air into the inner concentric cleaning fluid flowpath and introducing deionized water and compressed dry air into the

outer concentric cleaning fluid flowpath. The concentric dual flow introducer also includes an input-side injector engaging interface comprising a compressible sealing portion and a rigid facing portion. The compressible sealing portion of the input-side injector engaging interface has compressibility sufficient to yield under fluid cleaning surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus and resiliency sufficient to prevent abutment of a gas injector and the rigid facing portion of the input-side injector engaging interface and maintain an input-side injector floating gap between an injector and the rigid facing portion of the input-side injector engaging interface. The flow-dispersing injector seat comprises an output-side injector engaging interface comprising a compressible sealing portion and a rigid facing portion. The compressible sealing portion of the output-side injector engaging interface has compressibility sufficient to yield under fluid cleaning surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus and resiliency sufficient to prevent abutment of a gas injector and the rigid facing portion of the output-side injector engaging interface and maintain an output-side injector floating gap between an injector and the flow-dispersing injector seat. The inner flow control module regulates flow of deionized water and compressed dry air to the inner concentric cleaning fluid flowpath and the outer flow control module regulates flow of deionized water and compressed dry air to the outer concentric cleaning fluid flowpath.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0008] The following detailed description of specific embodiments of the present disclosure can be best understood when read in conjunction with the following drawings, where like structure is indicated with like reference numerals and in which:

[0009] Fig. 1 is a schematic illustration of an injector cleaning apparatus according to one embodiment of the present disclosure;

[0010] Fig. 2A is a cut side view of an injector cleaning apparatus according to one embodiment of the present disclosure (injector shown as silhouette for clarity of injector cleaning apparatus);

[0011] Fig. 2B is a detail cut view of an injector cleaning apparatus according to one embodiment of the present disclosure (injector shown as silhouette for clarity of injector cleaning apparatus);

[0012] Fig. 3A is an isometric view of a concentric dual flow introducer according to one embodiment of the present disclosure;

[0013] Fig. 3B is a cut view of Fig. 3A;

[0014] Fig. 3C is an alternate cut view of Fig. 3A;

[0015] Fig. 4 is an isometric view of an injector;

[0016] Fig. 5 is an isometric view of an injector;

[0017] Fig. 6 is an isometric view of an injector cleaning apparatus according to one embodiment of the present disclosure;

[0018] Fig. 7 is an isometric view of an injector cleaning apparatus according to one embodiment of the present disclosure with the spacer ring removed;

[0019] Fig. 8 is an isometric view of an injector cleaning apparatus according to one embodiment of the present disclosure with the concentric dual flow introducer further removed;

[0020] Fig. 9 is an isometric view of an injector cleaning apparatus according to one embodiment of the present disclosure with the outer base ring further removed;

[0021] Fig. 10 is a side view of an injector in conjunction with injector seals according to one embodiment of the present disclosure

[0022] Fig. 11 is an isometric view of the upper portion of an injector cleaning apparatus according to one embodiment of the present disclosure with the spacer ring removed;

[0023] Fig. 12 is an isometric view of a discharge chamber according to one embodiment of the present disclosure;

[0024] Fig. 13A is an isometric view of a concentric dual flow introducer according to one embodiment of the present disclosure;

[0025] Fig. 13B is a detail view of Fig. 13A;

[0026] Fig. 14A is an isometric view of the upper portion of an injector cleaning apparatus according to one embodiment of the present disclosure;

[0027] Fig. 14B is an isometric view of the upper portion of an injector cleaning apparatus according to one embodiment of the present disclosure with the outer base ring removed;

[0028] Fig. 14C is an isometric view of the upper portion of an injector cleaning apparatus according to one embodiment of the present disclosure with the inner base ring further removed;

[0029] Fig. 14D is an isometric view of the upper portion of an injector cleaning apparatus according to one embodiment of the present disclosure with the spacer ring further removed;

[0030] Fig. 15A is an isometric cut view of an injector cleaning apparatus according to one embodiment of the present disclosure; and

[0031] Fig. 15B is a detail view of 15A.

DETAILED DESCRIPTION

[0032] Referring to the drawings in general and to Fig. 1 in particular, it will be understood that the illustrations are for the purpose of describing a particular embodiment of the invention and are not intended to limit the invention thereto. An injector cleaning

apparatus **100** for cleaning injectors comprises an associated outer flow control module **102** and inner flow control module **106**. The outer flow control module **102** and inner flow control module **106** comprise valves, pressure regulators, flow regulators, and/or other known hardware and instrumentation. The outer flow control module **102** and inner flow control module **106** control flow of deionized water and compressed dry air (CDA) to different portions of the injector cleaning apparatus **100** and clean different parts of the injector **140**. The outer flow control module **102** and inner flow control module **106** have independent pressure control allowing for different pressures or flow rates of deionized water and/or CDA.

[0033] Referring to Figs. 2A and 2B, the injector **140** is shown as a silhouette for enhanced clarity of the injector cleaning apparatus **100**. In an embodiment, the injector cleaning apparatus **100** has an Inner Zone **110** and an Outer Zone **112**. The Inner Zone **110** and Outer Zone **112** are distinct and independent fluid pathways which communicate with different parts of the injector **140**. The Inner Zone **110** communicates with the central passage **148** of the injector **140**. The Outer Zone **112** communicates with the peripheral passages **146** of the injector **140**. The design ensures uniform flow across the different peripheral passages **146** of the injector **140**.

[0034] Referring further to Figs. 1, 2A and 2B, in an embodiment, the outer flow control module **102** supplies inputs to the Outer Zone **112** of the injector cleaning apparatus **100**. An outer fluid supply **104** directs deionized water to the outer zone aperture **124** and an outer air supply **105** directs compressed dry air to the outer zone aperture. The deionized water and CDA, controlled by the outer flow control module **102**, clean the peripheral passages **146** of the injector **140**. The outer flow control module **102** regulates flow of deionized water into the outer zone aperture **124** and peripheral passages **146** with one selected example flow rate being approximately 3.5 to approximately 4.0 gallons per minute. The outer flow control module **102** regulates flow of compressed dry air into the outer zone aperture **124** and peripheral passages **146** with one selected example compressed dry air pressure being between approximately 40 and approximately 45 psi. An additional selected embodiment

includes a deionized water flow of approximately 5.5 to approximately 6.5 gallons per minute and a compressed dry air pressure of between approximately 30 and approximately 40 psi.

[0035] In an embodiment, the inner flow control module **106** supplies inputs to the Inner Zone **110** of the injector cleaning apparatus **100**. An inner fluid supply **107** directs deionized water to the inner zone aperture **122** and an inner air supply **108** directs compressed dry air to the inner zone aperture. The deionized water and CDA, controlled by the inner flow control module **106**, clean the central passage **148** of the injector **140**. The inner flow control module **106** regulates flow of deionized water into the inner zone aperture **122** and central passage **148** with one selected example flow rate being approximately 3.5 to approximately 4.0 gallons per minute. The inner flow control module **106** regulates flow of compressed dry air into the inner zone aperture **122** and central passage **148** with one selected example compressed dry air pressure being between approximately 40 and approximately 45 psi. An additional selected embodiment includes a deionized water flow of approximately 5.5 to approximately 6.5 gallons per minute and a compressed dry air pressure of between approximately 30 and approximately 40 psi.

[0036] Referring to Fig. 3A, the injector cleaning apparatus **100** comprises a concentric dual flow introducer **120**. The concentric dual flow introducer **120** comprises apertures to introduce fluids into the Inner Zone **110** and the Outer Zone **112**; specific examples of apertures include an Inner Zone aperture **122** and an Outer Zone aperture **124**.

[0037] Referring to Fig. 3B, a cut view of Fig. 3A, the structure of an embodiment of the Inner Zone **110** and Outer Zone **112** is shown. The Outer Zone **112** comprises an outer passage **126** and the Inner Zone **110** comprises an inner passage **128**. Referring to Fig. 3C, an alternate cut view of Fig. 3A, the outer passage **126** and the inner passage **128** are further illustrated.

[0038] Referring to Fig. 4, an injector **140** is shown. The injector **140** comprises a plurality of peripheral outlets **142** and a plurality of central outlets **144**.

[0039] Referring to Fig. 5, an alternate view of injector **140** is shown. The injector **140** further comprises a plurality of peripheral passages **146** and at least one central passage **148**. The peripheral passages **146** terminate at the peripheral outlets **142**. The central passage **148** terminates at the central outlets **144**. Fluid used in an injector cleaning operation is introduced into the injector **140** via the peripheral passages **146** and central passage **148** and then ejected from the injector via peripheral outlets **142** and central outlets **144**.

[0040] Referring to Fig. 6, an embodiment of the assembled injector cleaning apparatus **100** is shown. In addition to the concentric dual flow introducer **120**, the injector cleaning apparatus **100** further comprises a spacer ring **150**, a discharge chamber **152**, and an outer base ring **154**.

[0041] Referring to Fig. 7, an embodiment of the injector cleaning apparatus **100** is shown with the spacer ring **150** removed to reveal the injector **140**.

[0042] Referring to Fig. 8, an embodiment of the injector cleaning apparatus **100** is shown with the concentric dual flow introducer **120** and spacer ring **150** removed to reveal a flow introducer seal **156**. A spacer ring seal **158** is also shown which separates the outer base ring **154** and the spacer ring **150**. While an O-ring type seal is shown for the flow introducer seal **156** and the spacer ring seal **158**, other embodiments include other types and styles of seals known in the art.

[0043] Referring to Fig. 9, the injector cleaning apparatus **100** is shown with the outer base ring **154** removed to reveal an inner base ring **160**. The inner base ring **160** and outer base ring **154** are separated by an inner base ring seal **162** and an outer base ring seal **164**. While an O-ring type seal is shown for the inner base ring seal **162** and outer base ring seal **164**, alternate embodiments include other types and styles of seals known in the art.

[0044] In an embodiment (not shown) the outer base ring **154** and the inner base ring **160** are a single component. The outer base ring **154** and the inner base ring **160**, either as a single component or multiple components, are collectively called the flow-dispersing injector seat **166**.

[0045] Referring to Fig. 10, the injector **140** is shown removed from the injector cleaning apparatus **100**. When installed in the injector cleaning apparatus **100**, the injector **140** is separated from the concentric dual flow introducer **120** by an upper injector seal **170** and separated from the inner base ring **160** by a lower injector seal **172**. The upper injector seal **170** and the lower injector seal **172** are compressible and allow the injector **140** to float in the injector cleaning apparatus **100** between the inner base ring **160** and the concentric dual flow introducer **120** while remaining engaged with the upper injector seal and lower injector seal. The floating arrangement of the injector **140** in the injector cleaning apparatus **100** allows for improved shock absorption when the pressure or flow rate of fluid through the injector cleaning apparatus and injector changes. While an O-ring type seal is shown for the upper injector seal **170** and the lower injector seal **172**, alternate embodiments include other types and styles of seals known in the art.

[0046] Referring to Fig. 11, the relationship between the injector **140**, the outer base ring **154**, and the concentric dual flow introducer **120** is shown for an embodiment of the present invention. The injector **140** interfaces with the flow-dispersing injector seat **166** at one end of the injector and interfaces with the concentric dual flow introducer **120** at the other end of the injector.

[0047] Referring again to Figs. 2A and 2B, the injector **140** disposed in the injector cleaning apparatus is shown. The injector **140** is shown as a silhouette without any internal details for clarity of the surrounding injector cleaning apparatus **100** structure. The concentric dual flow introducer **120** comprises an input-side injector engaging interface **114**. The input-side injector engaging interface **114** includes a compressible sealing portion and a rigid facing portion. The compressible sealing portion of the input-side injector engaging interface **114** preferably has compressibility sufficient to yield under fluid cleaning surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus **100**. The compressible sealing portion of the input-side injector engaging interface **114** preferably also has resiliency sufficient to prevent abutment of a gas injector and the rigid facing portion of the input-side injector engaging interface and maintain an input-side injector floating gap between an injector and the rigid facing portion of the input-side injector

engaging interface. In an embodiment, the upper injector seal **170** is the compressive sealing portion of the input-side injector engaging interface **114**.

[0048] The flow-dispersing injector seat **166** comprises an output-side injector engaging interface **116**. The output-side injector engaging interface **116** includes a compressible sealing portion and a rigid facing portion. The compressible sealing portion of the output-side injector engaging interface **116** preferably has compressibility sufficient to yield under fluid cleaning surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus **100**. The compressible sealing portion of the output-side injector engaging interface **116** preferably also has resiliency sufficient to prevent abutment of a gas injector and the rigid facing portion of the output-side injector engaging interface and maintain an output-side injector floating gap between an injector and the rigid facing portion of the output-side injector engaging interface. In an embodiment, the lower injector seal **172** is the compressive sealing portion of the output-side injector engaging interface **116**.

[0049] Referring to Fig. 12, the end detail of the discharge chamber **152** is shown. The periphery of an end of the discharge chamber **152** comprises an optional outer base ring seal channel **180**. The outer base ring seal channel **180** is a recessed channel, sized to hold the outer base ring seal **164**. The discharge chamber **152** also comprises at least one discharge port **182** to provide a pathway for fluid discharge from the injector **140** during an injector cleaning operation.

[0050] Referring to Fig. 13A, the end detail of the concentric dual flow introducer **120** is shown. The periphery of an end of the concentric dual flow introducer **120** comprises an optional flow introducer seal channel **184** and an optional upper injector seal channel **186**. The flow introducer seal channel **184** is a recessed channel sized to hold the flow introducer seal **156**. The upper injector seal channel **186** is a recessed channel sized to hold the upper injector seal **170**. Further, Fig. 13B, a detailed view of Fig. 13A, shows the outer passage **126** and the inner passage **128**.

[0051] Referring to Fig. 14A, the inner base ring **160** is shown. The inner base ring **160** has at least one perforation **190** to allow the discharge from the peripheral outlets **142** and the central outlets **144** of the injector **140** to pass through the inner base ring. The at least one perforation **190** is in alignment with the peripheral outlets **142** and the central outlets **144** of the injector **140** allowing the injector discharge to pass through unimpeded. Fig. 14B shows the outer base ring **154** removed to reveal the positioning of the outer base ring seal **164**. Fig. 14C further shows the inner base ring **160** removed to reveal the positioning of the inner base ring seal **162** and lower injector seal **172**. Fig. 14D still further shows the spacer ring **150** removed to reveal the spacer ring seal **158** and the flow introducer seal **156**.

[0052] Referring to Figs. 15A and 15B, a cross-section of an embodiment of the injector cleaning apparatus **100** with an injector **140** in place is shown. Structures previously disclosed and their relationships are shown.

[0053] The parts of the injector cleaning apparatus **100** touching the injector **140** may be polypropylene or other material which is suitable to be in contact with the injector. The remainder of the parts may be made from nylon or other material suitable for the conditions. All wetted surfaces may not be made from stainless steel.

[0054] The injector cleaning apparatus **100** serves to clean the injector **140**. The cleaning procedure is intended to remove particles, for example ceramic and Yttria particles, from the injector's **140** confined surfaces. It is believed particles, such as ceramic and Yttria particles, are not removed by conventional rinsing or ultrasonic cleaning methods. The injector cleaning apparatus **100** serves to clean and flush out particles following conventional scrub and ultrasonic cleaning.

[0055] Removal of particles from the injector **140** is important for defect-free performance. During operation, such as plasma processing of a semiconductor wafer substrate, debris and particulates in the injector **140** can result in defects in the finished product.

[0056] An embodiment of the injector cleaning process comprises introduction of a fluid into the Inner Zone **110** and the Outer Zone **112** of the injector cleaning apparatus **100**. Fittings which interface with the inner zone aperture **122** and the outer zone aperture **124** may be used to connect the outer flow control module **102** and inner flow control module **106** to the injector cleaning apparatus **100**. Fluid introduced through the inner zone aperture **122** passes through the inner passage **128**. Fluid introduced through the outer zone aperture **124** passes through the outer passage **126**. These independent pathways allow different pressures and flow rates to be used for fluids passing through the Inner Zone **110** and the Outer Zone **112**. Additionally, it is envisioned that secondary cleaning agents such as a detergent or enzyme could be included in one flow stream and excluded from another.

[0057] After passing through the inner passage **128** and the outer passage **126**, the fluid is introduced into the injector **140** to complete the cleaning function. Fluid from the inner passage **128** is introduced into the central passage **148** of the injector **140**, passes through the central passages, and is ejected through the central outlets **144**. Fluid from the outer passage **126** is introduced into the peripheral passages of the injector **140**, passes through the peripheral passages, and is ejected through the peripheral outlets **142**. The fluid discharged from the peripheral outlets **142** and central outlets **144** passes through the at least one perforation **190** of the inner base ring **160** allowing the fluid to enter the discharge chamber **152**. From the discharge chamber **152**, the fluid exits the injector cleaning apparatus **100** through the at least one discharge port **182**.

[0058] Bevels, tapers, chamfers, fillets, rounding, and other corner treatments are shown throughout the disclosed drawings. These corner treatments may not be required and the present disclosure includes those unillustrated embodiments where the corner treatments are not present. Further, embodiments are envisioned in which corners and edges which are not shown with corner treatment are beveled, tapered, chamfered, filleted, rounded, or treated with another corner treatment.

[0059] Throughout the disclosed drawings fasteners are shown to hold components of the injector cleaning apparatus **100** together in an assembled configuration. The type and style of

fastener shown is illustrative only with further types and styles of fasteners known in the art envisioned as further embodiments.

[0060] It is also noted that recitations herein of “at least one” component, element, etc., should not be used to create an inference that the alternative use of the articles “a” or “an” should be limited to a single component, element, etc.

[0061] It is noted that terms like “preferably,” “commonly,” and “typically,” when utilized herein, are not utilized to limit the scope of the claimed invention or to imply that certain features are critical, essential, or even important to the structure or function of the claimed invention. Rather, these terms are merely intended to identify particular aspects of an embodiment of the present disclosure or to emphasize alternative or additional features that may or may not be utilized in a particular embodiment of the present disclosure.

[0062] Having described the subject matter of the present disclosure in detail and by reference to specific embodiments thereof, it is noted that the various details disclosed herein should not be taken to imply that these details relate to elements that are essential components of the various embodiments described herein, even in cases where a particular element is illustrated in each of the drawings that accompany the present description. Rather, the claims appended hereto should be taken as the sole representation of the breadth of the present disclosure and the corresponding scope of the various inventions described herein. Further, it will be apparent that modifications and variations are possible without departing from the scope of the invention defined in the appended claims. More specifically, although some aspects of the present disclosure are identified herein as preferred or particularly advantageous, it is contemplated that the present disclosure is not necessarily limited to these aspects.

[0063] It is noted that one or more of the following claims utilize the term “wherein” as a transitional phrase. For the purposes of defining the present invention, it is noted that this term is introduced in the claims as an open-ended transitional phrase that is used to introduce

a recitation of a series of characteristics of the structure and should be interpreted in like manner as the more commonly used open-ended preamble term “comprising.”

CLAIMS

1. An injector cleaning apparatus comprising a concentric dual flow introducer and a flow-dispersing injector seat, wherein:

the concentric dual flow introducer comprises an inner concentric cleaning fluid flowpath configured to communicate with a central passage of a gas injector, an outer concentric cleaning fluid flowpath configured to communicate with a plurality of peripheral passages of the gas injector, and

an input-side injector engaging interface comprising a compressible sealing portion and a rigid facing portion, the compressible sealing portion of the input-side injector engaging interface having compressibility sufficient to yield under cleaning fluid surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus and resiliency sufficient to prevent abutment of the gas injector and the rigid facing portion of the input-side injector engaging interface and maintain an input-side injector floating gap between the gas injector and the rigid facing portion of the input-side injector engaging interface, wherein the concentric dual flow introducer interfaces with a first end of the gas injector at the input-side injector engaging interface; and

the flow-dispersing injector seat comprises

an output-side injector engaging interface comprising a compressible sealing portion and a rigid facing portion, the compressible sealing portion of the output-side injector engaging interface having compressibility sufficient to yield under cleaning fluid surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus and resiliency sufficient to prevent abutment of the gas injector and the rigid facing portion of the output-side injector engaging interface and maintain an output-side injector floating gap between the gas injector and the rigid facing portion of the output-side injector engaging interface, the flow-dispersing injector seat interfacing with a second end of the gas injector.

2. The injector cleaning apparatus of claim 1, wherein the injector cleaning apparatus further comprises an inner flow control module to regulate flow of deionized water and compressed dry air to the inner concentric cleaning fluid flowpath and an outer flow control module to regulate flow of deionized water and compressed dry air to the outer concentric cleaning fluid flowpath.
3. The injector cleaning apparatus of claim 2 wherein the inner flow control module, the outer flow control module, or both comprise at least one valve, at least one pressure regulator, and at least one flow regulator.
4. The injector cleaning apparatus of claim 1 wherein the compressible sealing portion of the input-side injector engaging interface; the compressible sealing portion of the output-side injector engaging interface or both the compressible sealing portion of the input-side injector engaging interface and the compressible sealing portion of the output-side injector engaging interface comprise O-ring type seals.
5. The injector cleaning apparatus of claim 4 wherein both the compressible sealing portion of the input-side injector engaging interface and the compressible sealing portion of the output-side injector engaging interface comprise O-ring type seals.
6. The injector cleaning apparatus of claim 1 wherein the compressible sealing portion of the input-side injector engaging interface is disposed in a recessed channel formed in the concentric dual flow introducer and the compressible sealing portion of the output-side injector engaging interface is disposed in a recessed channel formed in the flow-dispersing injector seat.
7. The injector cleaning apparatus of claim 1 wherein the injector cleaning apparatus further comprises a discharge chamber to collect and drain fluid discharge from the flow-dispersing injector seat.

8. The injector cleaning apparatus of claim 1 wherein the injector cleaning apparatus further comprises a spacer ring disposed between the flow-dispersing injector seat and the concentric dual flow introducer.
9. The injector cleaning apparatus of claim 1 wherein the flow-dispersing injector seat further comprises an inner base ring and an outer base ring.
10. The injector cleaning apparatus of claim 1 wherein all wetted surfaces are not comprised of stainless steel.
11. The injector cleaning apparatus of claim 1 wherein the flow-dispersing injector seat and concentric dual flow introducer are comprised of polypropylene.
12. An injector cleaning apparatus comprising a concentric dual flow introducer, a flow-dispersing injector seat, an inner flow control module, and an outer flow control module, wherein:
 - the concentric dual flow introducer comprises an inner concentric cleaning fluid flowpath configured to communicate with a central passage of a gas injector, an outer concentric cleaning fluid flowpath configured to communicate with a plurality of peripheral passages of the gas injector, and
 - an input-side injector engaging interface comprising a compressible sealing portion and a rigid facing portion, the compressible sealing portion of the input-side injector engaging interface having compressibility sufficient to yield under cleaning fluid surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus and resiliency sufficient to prevent abutment of the gas injector and the rigid facing portion of the input-side injector engaging interface and maintain an input-side injector floating gap between the gas injector and the rigid facing portion of the input-side injector engaging interface, wherein the concentric dual flow introducer interfaces with a first end of the gas injector at the input-side injector engaging interface; and
 - the flow-dispersing injector seat comprises an output-side injector engaging interface comprising a compressible sealing portion and a rigid facing portion, the

compressible sealing portion of the output-side injector engaging interface having compressibility sufficient to yield under cleaning fluid surges attributable to initiation and termination of cleaning fluid flow through the injector cleaning apparatus and resiliency sufficient to prevent abutment of the gas injector and the rigid facing portion of the output-side injector engaging interface and maintain an output-side injector floating gap between the gas injector and the rigid facing portion of the output-side injector engaging interface and the flow-dispersing injector seat further comprises an inner base ring and an outer base ring, the flow-dispersing injector seat interfacing with a second end of the gas injector at the output-side injector engaging interface;

the inner flow control module is configured to regulate flow of deionized water and compressed dry air to the inner concentric cleaning fluid flowpath; and

the outer flow control module is configured to regulate flow of deionized water and compressed dry air to the outer concentric cleaning fluid flowpath.