

THE CLAIMS**What is claimed is:**

1. A method of cleaning a vacuum chamber of a semiconductor manufacturing tool, at least one component, or combination thereof, said method comprising:

- (a) introducing an etchant gas from an etchant container into the vacuum chamber;

- (b) terminating introduction of the etchant gas into the vacuum chamber upon attainment of a predetermined pressure in the vacuum chamber; and

- (c) reacting the etchant gas with a residue in the vacuum chamber for a sufficient time to at least partially remove the residue from the interior of the vacuum chamber, at least one component contained therein, or combination thereof;

wherein the etchant gas is chosen to react selectively with the residue in the vacuum chamber, the residue on the components contained therein, or combination thereof, while being essentially non-reactive with the interior of the vacuum chamber, the components contained therein, or combination thereof.

2. The method of claim 1, wherein the semiconductor manufacturing tool is an ion implanter.
3. The method of claim 2, wherein the at least one component is an ion source region component of the ion implanter.

4. The method of claim 2, wherein the at least one component is a beamline component of the ion implanter.
5. The method of claim 2, wherein the at least one component is a turbomolecular pump situated in communication with the vacuum chamber, and used for pumping the vacuum chamber.
6. The method of claim 1, wherein the etchant gas comprises a gas selected from the group consisting of XeF_2 , XeF_6 , XeF_4 , IF_5 , IF_7 , SF_6 , C_2F_6 and F_2 .
7. The method of claim 1, wherein the etchant gas comprises XeF_2 .
8. The method of claim 1, wherein the residue comprises an element selected from the group consisting of boron, phosphorus, germanium, molybdenum, tungsten, aluminum, and arsenic.
9. The method of claim 1, wherein the predetermined pressure is subatmospheric.
10. The method of claim 7, wherein the predetermined pressure is from about 0.3 Torr to about 4.0 Torr.
11. The method of claim 3, wherein an ion source in the ion source region comprises a source selected from the group consisting of an indirectly heated cathode source, a Freeman source and a Bernas source.
12. The method of claim 1, wherein said time is from about 0.5 minute to about 5 minutes.

13. The method of claim 1, further comprising (d) evacuating the vacuum chamber following completion of said reacting.
14. The method of claim 13, further comprising repeating (a) through (d) at least once.
15. The method of claim 1, wherein the etchant container contains an etchant material, and wherein the etchant container is heated by a heater to increase the rate of physical conversion of the etchant material into the etchant gas.
16. The method of claim 15, wherein the heater is selected from the group consisting of an oven, a conformal heating blanket, electrical heating tape, heated fluids and/or gases, and heater wires.
17. The method of claim 1, wherein an inert gas is introduced into the etchant container to transport the etchant gas to the vacuum chamber.
18. The method of claim 17, wherein the inert gas comprises a gas selected from the group consisting of argon, nitrogen, xenon and helium.
19. The method of claim 1, wherein the etchant container is positioned in the vacuum chamber or positioned upstream of the vacuum chamber.
20. The method of claim 19, wherein the etchant container contains a pre-measured amount of an etchant material for generation of the etchant gas in the vacuum chamber.
21. The method of claim 20, wherein the etchant material is a solid or a liquid.

22. The method of claim 20, wherein the etchant material is pelletized XeF_2 .
23. The method of claim 1, wherein the reaction of the etchant gas with the residue is effectuated without energetic activation.
24. The method of claim 8, wherein a concentration of the elements in the residue is determined by an analytical technique selected from the group consisting of temperature-programmed infrared spectroscopy (TPIR), Fourier Transform Infrared Spectroscopy (FTIR), electron paramagnetic spectroscopy (EPM), residual gas analysis (RGA), mass spectrometry, and combinations thereof.
25. The method of claim 1, wherein the etchant gas is devoid of an oxidizing species and a nitrogen-containing species, wherein the nitrogen-containing species comprises at least one additional element selected from the group consisting of O, F, and Br.
26. A method of cleaning a vacuum chamber of a semiconductor manufacturing tool, at least one internal component, or combination thereof, said method comprising:
- (a) introducing an etchant material from an etchant container into the vacuum chamber;
 - (b) terminating introduction of the etchant gas into the vacuum chamber upon attainment of a predetermined pressure;
 - (c) dissociating the etchant material into a reactive halide species in the vacuum chamber using a plasma source positioned in said vacuum chamber; and

(d) reacting the reactive halide species with a residue in the vacuum chamber for a sufficient time to at least partially remove the residue from the vacuum chamber, the at least one internal component, or combination thereof.

27. The method of claim 26, wherein the etchant material comprises a material selected from the group consisting of XeF_2 , XeF_6 , XeF_4 , NF_3 , IF_5 , IF_7 , SF_6 , C_2F_6 and F_2 .

28. The method of claim 26, further comprising introducing an inert gas from an inert gas source into the vacuum chamber prior to dissociating the etchant material.

29. An apparatus for cleaning a vacuum chamber of a semiconductor manufacturing tool, at least one internal component, or combination thereof, said apparatus comprising:

(a) an etchant material source having an etchant material disposed therein, wherein the etchant material source is communicatively connected to, and is situated upstream of, the vacuum chamber; and

(b) a valve between the etchant material source and the vacuum chamber;

wherein said apparatus is further characterized by comprising at least one of the following components (I) and (II):

(I) a heater for heating the etchant material source; and

(II) an inert gas source having an inert gas disposed therein, wherein the inert gas source is communicatively connected to, and is situated upstream of, the etchant material source.

30. The apparatus of claim 29, wherein the etchant material comprises a compound selected from the group consisting of XeF_2 , XeF_6 , XeF_4 , IF_5 , IF_7 , SF_6 , C_2F_6 and F_2 .
31. The apparatus of claim 29, wherein the at least one component is an ion source of an ion implanter, said ion source selected from the group consisting of an indirectly heated cathode source, a Freeman source and a Bernas source.
32. The apparatus of claim 29, wherein the heater is selected from the group consisting of an oven, a conformal heating blanket, electrical heating tape, heated fluids and/or gases, and heater wires.
33. The apparatus of claim 29, wherein the inert gas comprises nitrogen, argon, xenon, or helium.
34. The apparatus of claim 29, wherein the at least one component is a beamline component of an ion implanter.
35. The apparatus of claim 29, wherein the at least one component is a turbomolecular pump situated in communication with the vacuum chamber, and used for pumping the vacuum chamber.
36. The apparatus of claim 29, wherein the etchant material is devoid of an oxidizing species and a nitrogen-containing species, wherein the nitrogen-containing species

comprises at least one additional element selected from the group consisting of O, F, and Br.

37. A method of *ex situ* cleaning at least one component of a semiconductor manufacturing tool, said method comprising:

- (a) positioning the component in an *ex situ* vacuum chamber;
- (b) introducing an etchant gas from an etchant container into the *ex situ* vacuum chamber;
- (c) terminating introduction of the etchant gas into the vacuum chamber upon attainment of a predetermined pressure in the vacuum chamber; and
- (d) reacting the etchant gas with a residue in the vacuum chamber for a sufficient time to at least partially remove the residue from the at least one component contained therein;

wherein the etchant gas is chosen to react selectively with the residue on the at least one component, while being essentially non-reactive with the interior of the vacuum chamber and the component material itself.

38. The method of claim 37, wherein the semiconductor manufacturing tool is an ion implanter.

39. The method of claim 37, wherein the at least one component comes from an ion source region.

40. The method of claim 38, wherein the at least one component comes from the beamline of the ion implanter.
41. The method of claim 37, wherein the etchant gas comprises a gas selected from the group consisting of XeF_2 , XeF_6 , XeF_4 , NF_3 , IF_5 , IF_7 , SF_6 , C_2F_6 and F_2 .
42. The method of claim 37, wherein the etchant gas comprises XeF_2 .
43. The method of claim 37, wherein the residue comprises an element selected from the group consisting of boron, phosphorus, germanium, molybdenum, tungsten, aluminum, and arsenic.
44. The method of claim 37, wherein the predetermined pressure is subatmospheric.
45. The method of claim 44, wherein the predetermined pressure is from about 0.3 Torr to about 4.0 Torr.
46. The method of claim 37, wherein the at least one component comprises an ion source selected from the group consisting of an indirectly heated cathode source, a Freeman source and a Bernas source.
47. The method of claim 37, wherein said time is from about 0.5 minute to about 5 minutes.
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48. The method of claim 37, further comprising (e) evacuating the vacuum chamber following completion of said reacting.
49. The method of claim 48, further comprising repeating (b) through (e) at least once.

50. A method of cleaning a vacuum chamber of a semiconductor manufacturing tool, at least one component, or combination thereof of the vacuum chamber, said method comprising:

- (a) introducing an etchant gas from an etchant container into the vacuum chamber;
- (b) withdrawing a plurality of gas species from the vacuum chamber using a vacuum pump to effectuate a continuous flow of the etchant gas therethrough; and
- (c) flowing the etchant gas through the vacuum chamber for a sufficient time to react the etchant gas with the residue to at least partially remove the residue from the vacuum chamber and/or at least one component contained therein,

wherein the etchant gas comprises a gas selected from the group consisting of XeF_2 , XeF_6 , XeF_4 , IF_5 , IF_7 , SF_6 , C_2F_6 and F_2 , and wherein the etchant gas is chosen to react selectively with the residue in the vacuum chamber, while being essentially non-reactive with the interior of the vacuum chamber or the components contained therein.

51. The method of claim 50, wherein the semiconductor manufacturing tool is an ion implanter.

52. The method of claim 50, wherein the vacuum chamber comprises an ion source region.

53. The method of claim 50, wherein the vacuum chamber comprises a beamline vacuum chamber.
54. The method of claim 50, further comprising flowing a dopant gas from a dopant source into the vacuum chamber to effectuate ion implantation therein.
55. The method of claim 54, further comprising repeating (a) through (d) at least once.
56. The method of claim 50, further comprising dissociating the etchant gas into a reactive halide species in the vacuum chamber using an energetic source.
57. The method of claim 50, wherein the reactive halide species reacts with the residue to at least partially remove the residue from the vacuum chamber.
58. The method of claim 50, wherein the residue comprises an element selected from the group consisting of boron, phosphorus, germanium, molybdenum, tungsten, aluminum, and arsenic.
59. The method of claim 56, wherein the energetic source comprises a plasma generator.
60. The method of claim 59, wherein the plasma generator comprises an ion source selected from the group consisting of an indirectly heated cathode source, a Freeman source and a Bernas source.
61. The method of claim 56, wherein the energetic source is positioned within or immediately upstream of said vacuum chamber.

62. The method of claim 50, wherein the reaction of the etchant gas with the residue is effectuated without energetic activation.
63. The method of claim 50, wherein the etchant gas further comprises an inert species selected from the group consisting of argon, nitrogen, xenon and helium.
64. The method of claim 50, wherein the etchant gas comprises XeF_2 .
65. The method of claim 50, wherein a concentration of the elements in the residue is determined by an analytical technique selected from the group consisting of temperature-programmed infrared spectroscopy (TPIR), Fourier Transform Infrared Spectroscopy (FTIR), electron paramagnetic spectroscopy (EPM), residual gas analysis (RGA), mass spectrometry, and combinations thereof.
66. The method of claim 50, wherein the etchant gas is devoid of an oxidizing species and a nitrogen-containing species, wherein the nitrogen-containing species comprises at least one additional element selected from the group consisting of O, F, and Br.
67. A method of cleaning accumulated process effluent from the interior of a cryopump, said method comprising purging the cryopump with at least two purge gases, said purge gases including nitrogen and at least one reactive gas selected from the group consisting of oxygen, ozone, nitrogen oxides, species that generate oxygen radicals *in situ*, and combinations thereof, wherein said method is characterized by at least one of the following purge process sequences (I), (II), and (III):
- (I) (a) purging with essentially pure nitrogen for time x; and

(b) purging with the at least one reactive gas for time y, wherein the at least one reactive gas is essentially pure;

(II) (a) purging with essentially pure nitrogen at time zero;

(b) blending the essentially pure nitrogen with the at least one reactive gas, wherein the nitrogen and the at least one reactive gas are no longer essentially pure;

(III) (a) purging with a mixture of nitrogen and at least one reactive gas,

wherein the accumulated process effluent is substantially removed from the interior of the cryopump.

68. The method of claim 67, wherein the reactive gas comprises oxygen.

69. The method of claim 67, wherein the cryopump is purged during cryopump warm-up.

70. The method of claim 67, wherein the cryopump is purged at ambient temperature.

71. The method of claim 67, wherein the accumulated process effluent comprises non-volatile species that were produced during cryopump warm-up.

72. The method of claim 67, comprising Sequence (I), further comprising repeating (a) and (b) at least once.

73. The method of claim 67, comprising Sequence (II), wherein the blending comprises a process selected from the group consisting of continuous, equivalent steps, and non-equivalent steps.
74. The method of claim 67, comprising Sequence (II), wherein the amount of nitrogen is less than the amount of at least one reactive gas.

What is claimed is:

1. A method of cleaning a vacuum chamber of a semiconductor manufacturing tool, at least one component, or combination thereof, said method comprising:
 - (a) introducing an etchant gas from an etchant container into the vacuum chamber;
 - (b) terminating introduction of the etchant gas into the vacuum chamber upon attainment of a predetermined pressure in the vacuum chamber; and
 - (c) reacting the etchant gas with a residue in the vacuum chamber for a sufficient time to at least partially remove the residue from the interior of the vacuum chamber, at least one component contained therein, or combination thereof,

wherein the etchant gas is chosen to react selectively with the residue in the vacuum chamber, the residue on the components contained therein, or combination thereof, while being essentially non-reactive with the interior of the vacuum chamber, the components contained therein, or combination thereof, and

wherein the semiconductor manufacturing tool is an ion implanter and the at least one component is an ion source region component of the ion implanter.

2. The method of claim 1, wherein the at least one component is a turbomolecular pump situated in communication with the vacuum chamber, and used for pumping the vacuum chamber.
3. The method of claim 1, wherein the etchant container contains an etchant material, and wherein the etchant container is heated by a heater to increase the rate of physical conversion of the etchant material into the etchant gas.
4. The method of claim 1, wherein an inert gas is introduced into the etchant container to transport the etchant gas to the vacuum chamber.
5. The method of claim 1, wherein the etchant container is positioned in the vacuum chamber or positioned upstream of the vacuum chamber.
6. A method of cleaning a vacuum chamber of a semiconductor manufacturing tool, at least one internal component, or combination thereof, said method comprising:
 - (a) introducing an etchant material from an etchant container into the vacuum chamber;
 - (b) terminating introduction of the etchant gas into the vacuum chamber upon attainment of a predetermined pressure;

- (c) dissociating the etchant material into a reactive halide species in the vacuum chamber using a plasma source positioned in said vacuum chamber; and
 - (d) reacting the reactive halide species with a residue in the vacuum chamber for a sufficient time to at least partially remove the residue from the vacuum chamber, the at least one internal component, or combination thereof.
7. The method of claim 6, wherein the etchant material comprises a material selected from the group consisting of XeF_2 , XeF_6 , XeF_4 , NF_3 , IF_5 , IF_7 , SF_6 , C_2F_6 and F_2 .
 8. The method of claim 6, further comprising introducing an inert gas from an inert gas source into the vacuum chamber prior to dissociating the etchant material.
 9. An apparatus for cleaning a vacuum chamber of a semiconductor manufacturing tool, at least one internal component, or combination thereof, said apparatus comprising:
 - (a) an etchant material source having an etchant material disposed therein, wherein the etchant material source is communicatively connected to, and is situated upstream of, the vacuum chamber; and
 - (b) a valve between the etchant material source and the vacuum chamber,
 wherein said apparatus is further characterized by comprising at least one of the following components (I) and (II):
 - (I) a heater for heating the etchant material source; and
 - (II) an inert gas source having an inert gas disposed therein, wherein the inert gas source is communicatively connected to, and is situated upstream of, the etchant material source, and the etchant material comprises a material selected from the group consisting of XeF_2 , XeF_6 , XeF_4 , IF_5 , IF_7 , SF_6 , C_2F_6 and F_2 , and
 wherein the semiconductor manufacturing tool is an ion implanter and the at least one component is an ion source region component of the ion implanter.
 10. A method of ex situ cleaning at least one component of a semiconductor manufacturing tool, said method comprising:
 - (a) positioning the component in an ex situ vacuum chamber;
 - (b) introducing an etchant gas from an etchant container into the ex situ vacuum chamber;

- (c) terminating introduction of the etchant gas into the vacuum chamber upon attainment of a predetermined pressure in the vacuum chamber; and
- (d) reacting the etchant gas with a residue in the vacuum chamber for a sufficient time to at least partially remove the residue from the at least one component contained therein,

wherein the etchant gas is chosen to react selectively with the residue on the at least one component, while being essentially non-reactive with the interior of the vacuum chamber and the component material itself, and

wherein the semiconductor manufacturing tool is an ion implanter.

11. The method of any one of claims 1-8 and 10, wherein the etchant gas comprises a gas selected from the group consisting of XeF₂, XeF₆, XeF₄, NF₃, IF₅, IF₇, SF₆, C₂F₆ and F₂.
12. The method of any one of claims 1-8 and 10, wherein the predetermined pressure is subatmospheric.
13. The method of claim 12, wherein the predetermined pressure is from about 0.3 Torr to about 4.0 Torr.
14. The method of any one of claims 1-8 and 10, wherein said time is from about 0.5 minute to about 5 minutes.
15. The method of any one of claims 1-8 and 10, further comprising (e) evacuating the vacuum chamber following completion of said reacting.
16. The method of claim 15, further comprising repeating (b) through (e) at least once.
17. A method of cleaning a vacuum chamber of a semiconductor manufacturing tool, at least one component, or combination thereof, said method comprising:
 - (a) introducing an etchant gas from an etchant container into the vacuum chamber;
 - (b) withdrawing a plurality of gas species from the vacuum chamber using a vacuum pump to effectuate a continuous flow of the etchant gas therethrough; and
 - (c) flowing the etchant gas through the vacuum chamber for a sufficient time to react the etchant gas with the residue to at least partially remove the residue from the vacuum chamber and/or at least one component contained therein,

wherein the etchant gas comprises a gas selected from the group consisting of XeF₂, XeF₆, XeF₄, IF₅, IF₇, SF₆, C₂F₆ and F₂, and wherein the etchant gas is chosen to react selectively with the residue in the vacuum chamber, while being essentially non-reactive with the interior of the vacuum chamber or the components contained therein.

18. The method of any one of claims 6 and 17, wherein the semiconductor manufacturing tool is an ion implanter, and the vacuum chamber comprises an ion source region or a beamline vacuum chamber.
19. The method of claim 17, further comprising flowing a dopant gas from a dopant source into the vacuum chamber to effectuate ion implantation therein.
20. The method of any one of claims 1-8 and 10-19, further comprising repeating (a) through (d) at least once.
21. The method of claim 17, further comprising dissociating the etchant gas into a reactive halide species in the vacuum chamber using an energetic source.
22. The method of claim 17, wherein the reactive halide species reacts with the residue to at least partially remove the residue from the vacuum chamber.
23. The method of any one of claims 1, 6, 10 and 17, wherein the residue comprises an element selected from the group consisting of boron, phosphorus, germanium, molybdenum, tungsten, aluminum, and arsenic.
24. The method of claim 21, wherein the energetic source comprises a plasma generator.
25. The method of claims 1, 6, 10 and 24, wherein the plasma generator comprises an ion source selected from the group consisting of an indirectly heated cathode source, a Freeman source and a Bernas source.
26. The method of claim 21, wherein the energetic source is positioned within or immediately upstream of said vacuum chamber.
27. The method of any one of claims 1-8 and 10-17, wherein the reaction of the etchant gas with the residue is effectuated without energetic activation.
28. The method of claim 17, wherein the etchant gas further comprises an inert species selected from the group consisting of argon, nitrogen, xenon and helium.
29. The method of any one of claims 1-8 and 10-17, wherein the etchant gas is devoid of an oxidizing species and a nitrogen-containing species, wherein the nitrogen-containing species comprises at least one additional element selected from the group consisting of O, F, and Br.