CLAIMS

What is claimed is:

1. An apparatus for abatement of gases, the apparatus comprising:

a toroidal plasma chamber having a first gas inlet receiving an inert gas for ignition into a plasma, a second gas inlet receiving a gas to be abated, a gas outlet, and at least one chamber wall for containing the gas;

one or more magnetic cores disposed relative to the toroidal plasma chamber such that the toroidal plasma chamber passes through each of the one or more magnetic cores; and

a primary winding coupled to the one or more magnetic cores,

the plasma chamber confining a toroidal plasma along a plane extending through the plasma chamber,

and the second gas inlet positioned on the toroidal plasma chamber between the first gas inlet and the gas outlet and at a distance d from the gas outlet along the plane such that a toroidal plasma channel volume between the first gas inlet and the second gas inlet in the is substantially filled by the inert gas, the distance d based on a desired residence time of the gas to be abated.

2. The apparatus of claim 1, wherein the distance d is approximately 2 to 5 inches.

3. The apparatus of claim 1, wherein the second gas inlet is a series of selectable gas inlet ports positioned along the toroidal plasma chamber.

4. The apparatus of claim 1, wherein the gas to be abated is mixed with one or more reactant gases prior to entering the plasma chamber.

5. The apparatus of claim 4, wherein the one or more reactant gases mixed with the gas to be abated is a water vapor.

6. The apparatus of claim 1, further comprising a sensor positioned relative to the gas outlet and configured to monitor an emission from the plasma chamber.

7. The apparatus of claim 6, wherein the sensor comprises an optical and/or an infrared sensor.

8. The apparatus of claim 1, wherein the gas to be abated received by the second gas inlet is a chlorine compound.

9. The apparatus of claim 1, wherein the gas to be abated received by the second gas inlet is a perfluorocarbon compound.

10. The apparatus of claim 9, wherein the perfluorocarbon compound received by the second gas inlet includes carbon tetrafluoride.

11. A method for abating process gas within a plasma source, the method comprising:

flowing via a first gas inlet, a first gas for ignition into a plasma into a toroidal plasma chamber having a primary winding coupled to the plasma chamber and a plurality of magnetic cores oriented such that the plasma chamber passes through each of the plurality of magnetic cores;

generating a toroidal plasma in the plasma chamber along a plane extending through the plasma chamber;

positioning a second gas inlet between the first gas inlet and a gas outlet along the plasma chamber at a distance d from the gas outlet along the plane, the distance d based on a desired residence time of a gas to be abated; and

flowing via the second gas inlet, the gas to be abated into the plasma chamber such that the gas to be abated reacts with the toroidal plasma.

12. The method of claim 11, further comprising adjusting the position of the second gas inlet to control the desired residence time of the gas to be abated.

13. The method of claim 11, further comprising adjusting a flow rate of the first gas flowing into the plasma chamber such that a toroidal plasma channel volume

between the first gas inlet and the second gas inlet in the toroidal plasma channel is substantially filled by the first gas.

14. The method of claim 11, further comprising providing a reactant gas to mix with the gas to be abated before flowing into the plasma chamber via the second gas inlet.

15. The method of claim 11, further comprising monitoring an emission from the plasma chamber via an optical and/or an infrared sensor and adjusting a flow rate of the reactant gas in response to the emission from the plasma chamber such that a concentration of the reactant gas is at a desired level to react with the gas to be abated.

16. The method of claim 11, further comprising coupling the gas outlet to a subsequent treatment device.

17. An apparatus for abatement of gases, the apparatus comprising:

a plasma source having a gas inlet directing a gas to be abated along a gas flow path, a gas outlet, and at least one chamber wall for containing the gas;

a toroidal plasma channel oriented along a plane extending through the plasma source, the toroidal plasma channel having a toroidal plasma channel inlet portion, a main toroidal plasma channel portion, and a toroidal plasma channel outlet portion, the toroidal plasma channel inlet portion and the toroidal plasma channel outlet portion each having a width that is less than a width W of the main toroidal plasma channel portion;

one or more magnetic cores disposed relative to the toroidal plasma channel such that the toroidal plasma channel passes through each of the one or more magnetic cores; and

a primary winding coupled to the one or more magnetic cores,

the plasma source generating a toroidal plasma along the plane extending through the plasma source and confined in the toroidal plasma channel.

18. The apparatus of claim 17, wherein the gas inlet is oriented such that the gas flow path is substantially perpendicular to the plane extending through the plasma source.

19. The apparatus of claim 17, wherein the width W of the main toroidal plasma channel portion is approximately equal to a cross-sectional radius of the toroidal plasma.

20. The apparatus of claim 17, wherein the gas inlet comprises a curved portion that reduces friction and drag of the gas to be abated flowing into the toroidal plasma channel.

21. The apparatus of claim 20, wherein the curved portion of the gas inlet is spherically blunted cone.

22. The apparatus of claim 17, wherein a major diameter of the toroidal plasma channel is greater than or equal to the diameter of the gas inlet.

23. The apparatus of claim 22, wherein the diameter of the gas inlet is between approximately 1 and 10 inches.

24. The apparatus of claim 17, wherein the gas to be abated is mixed with one or more reactant gases prior to entering the toroidal plasma channel.

25. The apparatus of claim 17, wherein the toroidal plasma channel comprises at least one metal layer to shield the toroidal plasma from electrostatic coupling.

26. The apparatus of claim 17, wherein one or more dielectric gaps are positioned along the toroidal plasma channel to prevent an induced electric current from flowing in the toroidal plasma channel.

27. A method for abating process gas within a plasma source, the method comprising:

directing via a gas inlet a gas to be abated along a gas flow path into a plasma source having a primary winding coupled to the plasma source and a plurality of magnetic cores positioned such that a toroidal plasma channel oriented along a plane extending through the plasma source passes through each of the plurality of magnetic cores;

generating a toroidal plasma along the plane extending through the plasma source and confined in the toroidal plasma channel;

positioning the gas inlet such that the gas flow path is substantially perpendicular to the plane extending through the plasma source; and

flowing the gas to be abated into the toroidal plasma channel such that the gas to be abated interacts with a main body of the toroidal plasma having a peak electron density.

28. The method of claim 27, further comprising providing one or more reactant gases to mix with the gas to be abated prior to the gas to be abated entering the toroidal plasma channel.

29. The method of claim 27, further comprising positioning one or more dielectric gaps along the toroidal plasma channel to prevent an induced electric current from flowing in the toroidal plasma channel.

CLAIMS

1. An apparatus for abatement of gases, the apparatus comprising:

a toroidal plasma chamber having a first gas inlet receiving an inert gas for ignition into a plasma, a second gas inlet receiving a gas to be abated, a gas outlet, and at least one chamber wall for containing the gases;

one or more magnetic cores disposed relative to the toroidal plasma chamber such that the toroidal plasma chamber passes through each of the one or more magnetic cores; and

a primary winding coupled to the one or more magnetic cores,

the toroidal plasma chamber confining a toroidal plasma along a plane extending through the toroidal plasma chamber,

wherein the second gas inlet is positioned between the first gas inlet and the gas outlet at a distance d from the gas outlet along the plane such that a first toroidal plasma channel volume between the first gas inlet and the second gas inlet in the toroidal plasma chamber is substantially filled by the inert gas and a second toroidal plasma channel volume between the second gas inlet and the gas outlet is substantially filled with the gas to be abated, the distance d based on a desired residence time of the gas to be abated.

2. The apparatus of claim 1, wherein the distance d is approximately 5.08 to 12.7 cm.

3. The apparatus of claim 1, wherein the second gas inlet is a series of selectable gas inlet ports positioned along the toroidal plasma chamber.

4. The apparatus of claim 1, wherein the gas to be abated is mixed with one or more reactant gases prior to entering the toroidal plasma chamber.

5. The apparatus of claim 4, wherein the one or more reactant gases mixed with the gas to be abated is a water vapor.

6. The apparatus of claim 1, further comprising a sensor positioned relative to the gas outlet and configured to monitor an emission from the toroidal plasma chamber.

7. The apparatus of claim 6, wherein the sensor comprises an optical and/or an infrared sensor.

8. The apparatus of claim 1, wherein the gas to be abated received by the second gas inlet is a chlorine compound.

9. The apparatus of claim 1, wherein the gas to be abated received by the second gas inlet is a perfluorocarbon compound.

10. The apparatus of claim 9, wherein the perfluorocarbon compound received by the second gas inlet includes carbon tetrafluoride.

11. A method for abating process gas within a plasma source, the method comprising:

flowing via a first gas inlet, a first gas for ignition into a plasma into a toroidal plasma chamber having a primary winding coupled to the toroidal plasma chamber and a plurality of magnetic cores oriented such that the toroidal plasma chamber passes through each of the plurality of magnetic cores;

generating a toroidal plasma in the toroidal plasma chamber along a plane extending through the toroidal plasma chamber;

positioning a second gas inlet between the first gas inlet and a gas outlet along the toroidal plasma chamber at a distance d from the gas outlet along the plane, the distance d based on a desired residence time of a gas to be abated; and

flowing via the second gas inlet, the gas to be abated into the toroidal plasma chamber such that the gas to be abated reacts with the toroidal plasma.

12. The method of claim 11, further comprising adjusting the position of the second gas inlet to control the desired residence time of the gas to be abated.

13. The method of claim 11, further comprising adjusting a flow rate of the first gas flowing into the toroidal plasma chamber such that a toroidal plasma channel volume between the first gas inlet and the second gas inlet in the toroidal plasma channel is substantially filled by the first gas.

14. The method of claim 11, further comprising providing a reactant gas to mix with the gas to be abated before flowing into the toroidal plasma chamber via the second gas inlet.

15. The method of claim 11, further comprising monitoring an emission from the toroidal plasma chamber via an optical and/or an infrared sensor and adjusting a flow rate of the reactant gas in response to the emission from the toroidal plasma chamber such that a concentration of the reactant gas is at a desired level to react with the gas to be abated.

16. The method of claim 11, further comprising coupling the gas outlet to a subsequent treatment device.

17. An apparatus for abatement of gases, the apparatus comprising:

a plasma source having a gas inlet directing a gas to be abated along a gas flow path, a gas outlet, and at least one chamber wall for containing the gas;

a toroidal plasma channel oriented along a plane extending through the plasma source, the toroidal plasma channel having a toroidal plasma channel inlet portion, a main toroidal plasma channel portion, and a toroidal plasma channel outlet portion, the toroidal plasma channel inlet portion and the toroidal plasma channel outlet portion each having a width that is less than a width W of the main toroidal plasma channel portion;

one or more magnetic cores disposed relative to the toroidal plasma channel such that the toroidal plasma channel passes through each of the one or more magnetic cores; and

a primary winding coupled to the one or more magnetic cores,

the plasma source generating a toroidal plasma along the plane extending through the plasma source and confined in the toroidal plasma channel.

18. The apparatus of claim 17, wherein the gas inlet is oriented such that the gas flow path is substantially perpendicular to the plane extending through the plasma source.

19. The apparatus of claim 17, wherein the width W of the main toroidal plasma channel portion is approximately equal to a cross-sectional radius of the toroidal plasma.

20. The apparatus of claim 17, wherein the gas inlet comprises a curved portion that reduces friction and drag of the gas to be abated flowing into the toroidal plasma channel.

21. The apparatus of claim 20, wherein the curved portion of the gas inlet is spherically blunted cone.

22. The apparatus of claim 17, wherein a major diameter of the toroidal plasma channel is greater than or equal to the diameter of the gas inlet.

23. The apparatus of claim 22, wherein the diameter of the gas inlet is between approximately 2.54 and 25.4 cm.

24. The apparatus of claim 17, wherein the gas to be abated is mixed with one or more reactant gases prior to entering the toroidal plasma channel.

25. The apparatus of claim 17, wherein the toroidal plasma channel comprises at least one metal layer to shield the toroidal plasma from electrostatic coupling.

26. The apparatus of claim 17, wherein one or more dielectric gaps are positioned along the toroidal plasma channel to prevent an induced electric current from flowing in the toroidal plasma channel.

27. A method for abating process gas within a plasma source, the method comprising:

directing via a gas inlet a gas to be abated along a gas flow path into a plasma source having a primary winding coupled to the plasma source and a plurality of magnetic cores positioned such that a toroidal plasma channel oriented along a plane extending through the plasma source passes through each of the plurality of magnetic cores;

generating a toroidal plasma along the plane extending through the plasma source and confined in the toroidal plasma channel;

positioning the gas inlet such that the gas flow path is substantially perpendicular to the plane extending through the plasma source; and

flowing the gas to be abated into the toroidal plasma channel such that the gas to be abated interacts with a main body of the toroidal plasma having a peak electron density.

28. The method of claim 27, further comprising providing one or more reactant gases to mix with the gas to be abated prior to the gas to be abated entering the toroidal plasma channel.

29. The method of claim 27, further comprising positioning one or more dielectric gaps along the toroidal plasma channel to prevent an induced electric current from flowing in the toroidal plasma channel.