

CLAIMS

1. A microwave plasma reactor comprising a reactor chamber, a microwave resonant cavity located within the reactor chamber, a waveguide for conveying microwave radiation to the resonant cavity, the waveguide having a convergent tapered portion, means for forming an electromagnetic standing wave within the resonant cavity from the microwave radiation for initiating and sustaining a plasma within the resonant cavity, the resonant cavity having a gas inlet and a gas outlet, and conduit means extending from the gas outlet for containing a plasma conveyed from the resonant cavity with a gas flowing from the gas inlet to the gas outlet.
2. A reactor according to Claim 1, wherein the tapered portion of the waveguide has a first substantially rectangular first end surface at one end thereof, a second substantially rectangular first end surface at the other end thereof proximate the resonant cavity, and a height orthogonal to the direction of propagation of microwave radiation therethrough, and wherein the height of the tapered portion of the waveguide decreases from the first end portion to the second end portion.
3. A reactor according to Claim 2, wherein the tapered portion of the waveguide comprises two convergent side surfaces each extending between and being inclined at an acute angle to the first end surface.
4. A reactor according to Claim 2 or Claim 3, wherein the height of the first end portion is approximately three times that of the second end portion.

5. A reactor according to any of Claims 2 to 4, wherein the height of the second end portion is approximately equal to the height of the resonant cavity.
6. A reactor according to any preceding claim, wherein the tapered portion of the waveguide is located adjacent the reactor chamber.
7. A reactor according to any preceding claim, wherein the tapered portion of the waveguide has a length in the direction of propagation of microwave radiation therethrough equal to approximately one half of the wavelength of the microwave radiation.
8. A reactor according to any preceding claim, wherein the waveguide comprises a first body portion and a second body portion from which microwave radiation propagating therethrough enters the resonant cavity, the tapered portion of the waveguide being located between the body portions of the waveguide.
9. A reactor according to any preceding claim, comprising means for cooling the conduit means.
10. A reactor according to Claim 9, wherein the cooling means comprises means for spraying a coolant on to the outer surface of the conduit means.
11. A reactor according to any preceding claim, wherein the means for forming an electromagnetic standing wave within the resonant cavity comprises a second chamber mounted on the reactor chamber opposite the waveguide for receiving the microwave radiation from the resonant cavity and having an end surface extending substantially perpendicular to the direction of propagation of the

microwaves through the chamber for reflecting the microwave radiation back into the resonant cavity.

12. A reactor according to Claim 11, wherein the second chamber houses tuning means spaced from the end surface of the second chamber.
13. A reactor according to Claim 12, wherein the tuning means comprises an electrically conducting tuner extending perpendicular to the direction of propagation of microwave radiation through the second chamber.
14. A reactor according to Claim 13, wherein the electrically conducting tuner is moveable relative to the second chamber.
15. A reactor according to Claim 13 or Claim 14, wherein the tuner is substantially cylindrical.
16. A reactor according to any preceding claim, wherein the gas outlet extends orthogonal to the direction of propagation of the microwaves through the chamber.
17. A reactor according to any preceding claim, wherein the resonant cavity comprises at least one dielectric insert located therein defining a substantially cylindrical gas chamber for receiving gas from the gas inlet and conveying gas to the gas outlet, and wherein the gas outlet is substantially co-axial with the gas chamber.
18. A reactor according to Claim 17, wherein the gas chamber has a circular or elliptical cross-section.

19. A reactor according to Claim 17 or Claim 18, wherein said at least one dielectric insert comprises two dielectric plate members each having a curved sidewall portion.
20. A reactor according to any of Claims 17 to 19, wherein the gas inlet extends through said at least one dielectric insert.
21. A reactor according to any of Claims 17 to 20, wherein the gas inlet is arranged to introduce gas into the gas chamber substantially tangentially.
22. A reactor according to any of Claims 17 to 21, wherein the reactor chamber comprises a transparent inspection window located in a sidewall thereof, said at least one dielectric insert having a bore formed therein extending between the gas chamber and the window.
23. A reactor according to any preceding claim, comprising an electrically conducting member protruding into the electromagnetic field within the resonant cavity.
24. A reactor according to Claim 23, wherein the electrically conducting member comprises a replaceable tip protruding into the resonant cavity,
25. A reactor according to Claim 24, wherein the tip is hollow and comprises a plurality of apertures extending thereabout.
26. A reactor according to Claim 25, wherein each of the apertures has a diameter sized to enable the microwave radiation to pass therethrough.

27. A reactor according to any of Claims 24 to 26, wherein the tip is formed from tungsten, copper or a tungsten alloy.
28. A reactor according to any of Claims 24 to 27, wherein the electrically conducting member comprises an electrically conducting body portion engaging the tip.
29. A reactor according to Claim 28, comprising an annular coolant channel extending about the electrically conducting body portion, and means for conveying a coolant to and from the annular channel.
30. A reactor according to Claim 29, wherein the electrically conducting body portion comprises a gas inlet port for receiving a reactant for reacting with a gas conveyed through the resonant cavity, the electrically conducting body portion comprising a passageway for conveying the reactant into the resonant cavity.
31. A reactor according to any of Claims 23 to 30, wherein the electrically conducting member extends into the electromagnetic field substantially perpendicular to the direction of propagation of the microwaves through the reactor chamber.
32. A reactor according to any of Claims 23 to 31, wherein the electrically conducting member is located opposite the gas outlet.
33. A reactor according to any of Claims 23 to 32, wherein the electrically conducting member houses means for igniting a plasma within the resonant cavity.
34. A reactor according to any of Claims 1 to 32, comprising a microwave generator for generating the microwave radiation, the

generator being configured to generate the microwave radiation at a power sufficient to initiate a plasma within the resonant cavity.

35. A reactor according to Claim 34, wherein the generator is configured to reduce the power at which the microwave radiation is generated after a predetermined period of time.

CLAIMS

1. A microwave plasma reactor (10) comprising a housing (12) with a reactor chamber, a microwave resonant cavity (14) located within the reactor chamber, a waveguide (16) for conveying microwave radiation to the resonant cavity, the waveguide having a convergent tapered portion (24), means arranged to form an electromagnetic standing wave within the resonant cavity from the microwave radiation for initiating and sustaining a plasma within the resonant cavity, said electromagnetic standing wave having a maximum intensity of the electromagnetic field formed within the resonant cavity, the resonant cavity having a gas inlet (38) and a gas outlet (44), and conduit means (46) extending from the gas outlet for containing a plasma conveyed from the resonant cavity with a gas flowing from the gas inlet to the gas outlet; the reactor (10) comprising an electrically conducting member (58) protruding into the electromagnetic field within the resonant cavity and characterised in that the electrically conducting member comprises a replaceable tip (64) protruding into the resonant cavity located at said maximum intensity of the electromagnetic field formed within the resonant cavity (14) during use of the reactor (10).
2. A reactor according to Claim 1, wherein the tapered portion of the waveguide has a first substantially rectangular first end surface (20) at one end thereof, a second substantially rectangular first end surface (22) at the other end thereof proximate the resonant cavity, and a height orthogonal to the direction of propagation of microwave radiation therethrough, and wherein the height of the tapered portion of the waveguide decreases from the first end portion to the second end portion.
3. A reactor according to Claim 2, wherein the tapered portion of the waveguide comprises two convergent side surfaces (25c, 25d) each

extending between the end surfaces 25a, 25b and being inclined at an acute angle to the first end surface.

4. A reactor according to Claim 2 or Claim 3, wherein the height of the first end portion is approximately three times that of the second end portion.
5. A reactor according to any of Claims 2 to 4, wherein the height of the second end portion is approximately equal to the height of the resonant cavity.
6. A reactor according to any preceding claim, wherein the tapered portion of the waveguide is located adjacent the reactor chamber.
7. A reactor according to any preceding claim, wherein the tapered portion of the waveguide has a length in the direction of propagation of microwave radiation therethrough equal to approximately one half of the wavelength of the microwave radiation.
8. A reactor according to any preceding claim, wherein the waveguide comprises a first body portion and a second body portion from which microwave radiation propagating therethrough enters the resonant cavity, the tapered portion of the waveguide being located between the body portions of the waveguide.
9. A reactor according to any preceding claim, comprising means for cooling the conduit means.
10. A reactor according to Claim 9, wherein the cooling means comprises means for spraying a coolant on to the outer surface of the conduit means.

11. A reactor according to any preceding claim, wherein the means for forming an electromagnetic standing wave within the resonant cavity comprises a second chamber mounted on the housing opposite the waveguide for receiving the microwave radiation from the resonant cavity and having an end surface extending substantially perpendicular to the direction of propagation of the microwaves through the chamber for reflecting the microwave radiation back into the resonant cavity.
12. A reactor according to Claim 11, wherein the second chamber houses tuning means spaced from the end surface of the second chamber.
13. A reactor according to Claim 12, wherein the tuning means comprises an electrically conducting tuner extending perpendicular to the direction of propagation of microwave radiation through the second chamber.
14. A reactor according to Claim 13, wherein the electrically conducting tuner is moveable relative to the second chamber.
15. A reactor according to Claim 13 or Claim 14, wherein the tuner is substantially cylindrical.
16. A reactor according to any preceding claim, wherein the gas outlet extends orthogonal to the direction of propagation of the microwaves through the chamber.
17. A reactor according to any preceding claim, wherein the resonant cavity comprises at least one dielectric insert located therein defining a substantially cylindrical gas chamber for receiving gas from the gas inlet and conveying gas to the gas outlet, and wherein the gas outlet is substantially co-axial with the gas chamber.

18. A reactor according to Claim 17, wherein the gas chamber has a circular or elliptical cross-section.
19. A reactor according to Claim 17 or Claim 18, wherein said at least one dielectric insert comprises two dielectric plate members each having a curved sidewall portion.
20. A reactor according to any of Claims 17 to 19, wherein the gas inlet extends through said at least one dielectric insert.
21. A reactor according to any of Claims 17 to 20, wherein the gas inlet is arranged to introduce gas into the gas chamber substantially tangentially.
22. A reactor according to any of Claims 17 to 21, wherein the housing comprises a transparent inspection window located in a sidewall thereof, said at least one dielectric insert having a bore formed therein extending between the gas chamber and the window.
23. A reactor according to Claim 1, wherein the tip is hollow and comprises a plurality of apertures extending thereabout.
24. A reactor according to Claim 23, wherein each of the apertures has a diameter sized to enable the microwave radiation to pass therethrough.
25. A reactor according to any of Claims 1, 23 and 24, wherein the tip is formed from tungsten, copper or a tungsten alloy.
26. A reactor according to any of Claims 1 and 23 to 25, wherein the electrically conducting member comprises an electrically conducting body portion engaging the tip.

27. A reactor according to Claim 26, comprising an annular coolant channel extending about the electrically conducting body portion, and means for conveying a coolant to and from the annular channel.
28. A reactor according to Claim 27, wherein the electrically conducting body portion comprises a gas inlet port for receiving a reactant for reacting with a gas conveyed through the resonant cavity, the electrically conducting body portion comprising a passageway for conveying the reactant into the resonant cavity.
29. A reactor according to any of Claims 1 and 23 to 28, wherein the electrically conducting member extends into the electromagnetic field substantially perpendicular to the direction of propagation of the microwaves through the reactor chamber.
30. A reactor according to any of Claims 1 and 23 to 29, wherein the electrically conducting member is located opposite the gas outlet.
31. A reactor according to any of Claims 1 and 23 to 30, wherein the electrically conducting member houses means for igniting a plasma within the resonant cavity.
32. A reactor according to any of Claims 1 to 30, comprising a microwave generator for generating the microwave radiation, the generator being configured to generate the microwave radiation at a power sufficient to initiate a plasma within the resonant cavity.
33. A reactor according to Claim 32, wherein the generator is configured to reduce the power at which the microwave radiation is generated after a predetermined period of time.