Claims

1. An apparatus for generating a plasma from a process gas, the apparatus comprising:

a) a power supply,

b) a hollow cathode arc tube comprising:

i) an inert gas inlet,

ii) a cathode tube connected to the power supply and arranged to be negatively biased when the power supply is on,

iii) an anode tube connected to the power supply and arranged to be positively biased when the power supply is on, and

iv) an electron beam outlet

c) an ionisation chamber comprising:

i) an electron beam inlet,

ii) a process gas inlet,

iii) a volume arranged in which ionisation of the process gas can take place to form the plasma, and

iv) a plasma outlet,

d) a first magnetic field source arranged for confining the plasma inside the ionisation chamber, and

e) a second magnetic field source arranged for directing and scanning plasma out of the plasma outlet.

2. An apparatus according to claim 1 further comprising a magnetic field source comprising a solenoid coil surrounding the hollow cathode arc tube.

3. An apparatus according to claim 1 or claim 2 further comprising an electrostatic lens for focussing the electron beam.

4. An apparatus according to claim 3, wherein the electrostatic lens comprises alternating ring of an electrically insulating material and an electrically conducting material.

5. An apparatus according to any one of claims 1 to 4 wherein the first magnetic field source comprises 4 or more magnetic field sources of alternating polarities.

6. An apparatus according to any one of claims 1 to 5, wherein the second magnetic field source comprises an adjustable magnetic field.

7. An apparatus according to any of claims 1 to 6, wherein the second magnetic field source comprises two electromagnets.

8. An apparatus according to any one of claims 1 to 7 wherein the electron beam inlet comprises an annular anode arranged for accelerating the electron beam through the electron beam inlet.

9. A method of generating a plasma beam comprising:

i) generating an inert gas plasma containing electrons and inert gas ions via arc discharge;

ii) accelerating and focussing the electron beam into an ionisation chamber;

iii) injecting a process gas into the ionisation chamber such that it is ionised by the electron beam to form a process gas plasma in the ionisation chamber;

iv) focussing by a magnetic field and scanning the process gas plasma using one or more electromagnets to form a plasma beam.

10. A method according to claim 9, further comprising enhancing the inert gas plasma density using a magnetic field generated by a solenoid.

11. A method according to either claim 9 or 10, further comprising enhancing the process gas plasma density using a multi-cusp magnetic field.

12. A method according to any of claims 9 to 11, wherein the electron beam is collimated by an electrostatic lens.

13. A method according to claim 9 wherein the inert gas is argon.

14. A method according to claim 9 or 10 wherein the process gas is selected from nitrogen, oxygen, hydrocarbon, and any combination of gases thereof.

15. A method of generating a plasma beam according to any of claims 9 to 14 using an apparatus according to any of claims 1 to 8.