

What is claimed is:

1. A plasma processing apparatus comprising:
  - a) a toroidal-shape plasma vessel comprising a process chamber;
  - b) a magnetic core surrounding a portion of the toroidal-shape plasma vessel;
  - c) an RF power supply having an output that is electrically connected to the magnetic core, the RF power supply energizing the magnetic core, thereby forming a toroidal plasma loop discharge in the toroidal-shape plasma vessel;
  - d) a workpiece holder comprising at least one face that supports the workpiece during growth; and
  - e) a plasma guiding structure being shaped and dimensioned so as to constrain a section of a plasma in the toroidal plasma loop discharge to travel substantially perpendicular to a normal to the at least one face that supports a workpiece during growth;
2. The plasma processing apparatus of claim I wherein the workpiece holder is formed in a generally cylindrical shape.
3. The plasma processing apparatus of claim I wherein the workpiece holder is formed in a generally hexagonal shape.

4. The plasma processing apparatus of claim I wherein the plasma guiding structure is formed in a shape and dimensioned so that workpiece surfaces exposed to the plasma are approximately equidistant from a centerline of the plasma.
5. The plasma processing apparatus of claim I wherein a distance from a center line of the plasma to the at least one face that supports the workpiece is approximately between 0.5 cm and 2.5 cm.
6. The plasma processing apparatus of claim I wherein a distance from a center line of the plasma to the at least one face that supports the workpiece is approximately 1.0 cm.
7. The plasma processing apparatus of claim I wherein the workpiece holder is formed of a material selected from the group consisting of molybdenum, alloys of molybdenum, copper, aluminum, nickel, stainless steel, alloys containing nickel, tungsten, alloys containing tungsten, aluminum nitride, and aluminum oxide.
8. The plasma processing apparatus of claim I wherein the workpiece holder comprises a recessed portion for supporting a workpiece for plasma processing.
9. The plasma processing apparatus of claim I wherein the at least one face that supports the workpiece during growth comprise at least one flat face.
10. The plasma processing apparatus of claim I wherein the at least one face that supports the workpiece during growth comprise at least one rounded face.

11. The plasma processing apparatus of claim 1 wherein the at least one face that supports the workpiece during growth comprise at least one tubular-shaped face.
12. The plasma processing apparatus of claim 1 wherein an outside portion of the workpiece holder comprises a viewport.
13. The plasma processing apparatus of claim 12 further comprising an optical pyrometer that is optically coupled to the viewport.
14. The plasma processing apparatus of claim 1 further comprising an electrical insulating material positioned on the workpiece holder that inhibits plasma arcing to the workpiece holder.
15. The plasma processing apparatus of claim 1 wherein the workpiece holder further comprises at least one gas introduction aperture.
16. The plasma processing apparatus of claim 15 wherein the at least one gas introduction aperture is positioned proximate to at least one sample mounting position on the surface of the workpiece holder.
17. The plasma processing apparatus of claim 1 further comprising a fluid cooled temperature controller attached to the workpiece holder.
18. The plasma processing apparatus of claim 1 further comprising a second magnetic core surrounding the toroidal-shape plasma vessel.
19. The plasma processing apparatus of claim 18 wherein the RF power supply has a second output that is electrically connected to the second magnetic core.

20. The plasma processing apparatus of claim 18 further comprising a second RF power supply having an output that is electrically connected to the second magnetic core, the second RF power supply energizing the second magnetic core.
21. The plasma processing apparatus of claim 1 wherein the workpiece holder comprises at least one pillar for securing individual workpieces.
22. The plasma processing apparatus of claim 21 wherein process gases are supplied proximate to the at least one pillar.
23. The plasma processing apparatus of claim 1 wherein the workpiece holder further comprises a crystal puller that translates the workpiece during the deposition.
24. The plasma processing apparatus of claim 1 wherein the workpiece holder and the plasma guiding structure are the same structure.
25. The plasma processing apparatus of claim 1 wherein the workpiece holder and the plasma guiding structure are physically separate structures.
26. The plasma processing apparatus of claim 1 wherein the plasma guiding structure is positioned to improve delivery of atomic hydrogen to a surface of the workpiece.
27. A plasma processing apparatus comprising:
  - a) a toroidal-shape plasma vessel comprising a process chamber;
  - b) a magnetic core surrounding a portion of the toroidal-shape plasma vessel;

- c) an RF power supply having an output that is electrically connected to the magnetic core, the RF power supply energizing the magnetic core, thereby forming a toroidal plasma loop discharge in the toroidal-shape plasma vessel; and
  - d) a workpiece holder comprising a first and second section each comprising at least one face being shaped and dimensioned so as to constrain a section of a plasma in the toroidal plasma loop discharge to travel substantially perpendicular to a normal surface of the at least one face.
28. The plasma processing apparatus of claim 27 wherein the first section of the workpiece holder comprises a first half of the workpiece holder and a second section of the workpiece holder comprises a second half of the workpiece holder.
29. The plasma processing apparatus of claim 27 wherein the first section of the workpiece holder is formed of a first material and the second section is formed of a second material that is different from the first material.
30. The plasma processing apparatus of claim 28 wherein at least one of the first and second sections of the workpiece holder is formed of a refractory metal.
31. The plasma processing apparatus of claim 27 wherein the first and second sections of the workpiece holder are formed in a generally cylindrical shape.
32. The plasma processing apparatus of claim 27 wherein the first and second sections of the workpiece holder are formed in a generally hexagonal shape.

33. The plasma processing apparatus of claim 27 wherein the first and second sections of the workpiece holder are formed in a shape and dimensioned so that surfaces exposed to the plasma are approximately equidistant from a centerline of the plasma.
34. The plasma processing apparatus of claim 27 wherein a distance from a center line of the plasma to the at least one face of the first and second sections of the workpiece holder is approximately between 0.5 cm and 2.5 cm.
35. The plasma processing apparatus of claim 27 wherein a distance from a center line of the plasma to the at least one face of the first and second sections of the workpiece holder is approximately 1.0 cm.
36. The plasma processing apparatus of claim 27 wherein the workpiece holder comprises a recessed portion for supporting a workpiece for plasma processing.
37. The plasma processing apparatus of claim 27 wherein the at least one face on the first and second sections of the workpiece holder comprises at least one flat face.
38. The plasma processing apparatus of claim 27 wherein the at least one face of the first and second sections of the workpiece holder comprises at least one rounded face.
39. The plasma processing apparatus of claim 27 wherein the at least one face of the first and second sections of the workpiece holder comprises at least one tubular-shaped face.

40. The plasma processing apparatus of claim 27 wherein the workpiece holder further comprises at least one gas introduction aperture on at least one of the first and the second sections.
41. The plasma processing apparatus of claim 40 wherein at least some of the gas introduction apertures are positioned proximate to recesses on the surface of the workpiece holder.
42. The plasma processing apparatus of claim 27 further comprising a high temperature spacing shim positioned between the first and second sections of the workpiece holder.
43. The plasma processing apparatus of claim 27 further comprising a second magnetic core surrounding the toroidal-shape plasma vessel.
44. The plasma processing apparatus of claim 43 wherein the RF power supply has a second output that is electrically connected to the second magnetic core.
45. The plasma processing apparatus of claim 43 further comprising a second RF power supply having an output that is electrically connected to the second magnetic core, the second RF power supply energizing the second magnetic core.
46. A method for growing single-crystal diamond material, the method comprising:
  - a) providing a toroidal-shape plasma vessel comprising a process chamber;
  - b) positioning a magnetic core surrounding a portion of the toroidal-shape plasma vessel;

- c) energizing the magnetic core with RF radiation, thereby forming a toroidal plasma loop discharge in the toroidal-shape plasma vessel;
  - d) providing a workpiece holder comprising at least one face that supports a workpiece during growth;
  - e) providing a plasma guiding structure being shaped and dimensioned so as to constrain a section of a plasma in the toroidal plasma loop to travel substantially perpendicular to a normal to the at least one face that support the workpiece during growth; and
  - f) growing single-crystal diamond material on the workpiece.
47. The method of claim 46 further comprising translating the workpiece holder during growth.
48. The method of claim 47 wherein a rate of the translating the workpiece holder during growth is approximately equal to a growth rate of the single-crystal diamond material.
49. The method of claim 46 further comprising translating the workpiece holder so that a growing surface on the workpiece is at substantially the same position during the growth.
50. The method of claim 46 further comprising introducing process gasses in the process chamber in at least one position.
51. The method of claim 50 wherein the at least one position is chosen to improve

deposition conditions.

52. The method of claim 50 wherein the at least one position is chosen to reduce undesirable deposits on walls of the process chamber.
53. The method of claim 46 further comprising positioning a cooling element adjacent to the workpiece holder to control a temperature of the workpiece to a desired operating temperature.
54. The method of claim 46 wherein the growing the single-crystal diamond material on the workpiece comprises growing the single-crystal diamond material to dimensions that are greater than 1.5 centimeters.