CLAIMS

What is claimed is:

1. In a plasma processing chamber, a method for processing a substrate, said substrate being disposed above a chuck and surrounded by an edge ring, said edge ring being electrically isolated from said chuck, comprising:

providing RF power to said chuck;

providing a tunable capacitance arrangement, said tunable capacitance arrangement being coupled to said edge ring to provide RF coupling to said edge ring, resulting in said edge ring having an edge ring potential; and

generating a plasma within said plasma processing chamber to process said substrate, said substrate being processed while said tunable capacitance arrangement is configured to cause said edge ring potential to be dynamically tunable to a DC potential of said substrate while processing said substrate.

2. The method of claim 1, wherein said tunable capacitance arrangement includes a coupling ring assembly.

3. The method of claim 2, wherein said coupling ring assembly comprising:

providing an upper coupling ring;

providing a lower coupling ring, said lower coupling ring is coupled with said upper coupling ring to form a hermetic seal;

providing a hermetically sealed cavity, said hermetically sealed cavity being disposed inside said coupling ring assembly, wherein said hermetically sealed cavity is configured with an inlet and an outlet to transport dielectric material into or out of said hermetically sealed cavity to change the capacitance of said coupling assembly.

4. The method of claim 3, wherein said dielectric material includes at least one of a solid, a liquid, and a gas.

5. The method of claim 4, wherein said dielectric material includes at least one of air, nitrogen, mineral oil, castor oil, water, and glycerol.

6. The method of claim 3, wherein said transport of said predetermined dielectric material is achieved by at least one of an active flow control system and a passive flow control system.

7. The method of claim 2, wherein said coupling ring assembly is formed of a material that includes at least one of conductive material, aluminum and graphite.

8. The method of claim 1, wherein said tunable capacitance arrangement is a mechanical switch.

9. The method of claim 8, wherein said mechanical switch comprises:

a shaft;

a contact foot; and

a moveable connector, said moveable connector being disposed above said shaft, said shaft is configured facilitate moving said moveable connector up or down relative to said contact foot, said contact foot is configured to couple to said edge ring.

10. The method of claim 9, wherein said shaft is RF coupled to said chuck by a strap.

11. The method of claim 9, wherein said edge ring is configured to achieve maximum RF coupling if said moveable connector physically contacts with said contact foot.

12. The method of claim 9, wherein said edge ring is configured to achieve minimum RF coupling if said moveable connector does not physically contact with said contact foot.

13. The method of claim 1, wherein said tunable capacitance arrangement is a mechanical capacitor arrangement.

14. The method of claim 13, wherein said mechanical capacitor arrangement comprising:

providing a first plate;

providing a second plate, said second plate is configured to be parallel with said first plate, said first plate is configured to protrude downward from said edge ring, said first plate and said second plate are separated by an air gap;

providing a plurality of straps, said plurality of straps are configured to RF couple said second plate to said chuck; and

providing means to move said second plate up or down to adjust an overlapping area with said first plate during plasma processing.

15. The method of claim 13, wherein said mechanical capacitor arrangement comprising:

providing a first concentric ring, said first concentric ring is configured with a first plurality of cutouts;

providing a second concentric ring, said second concentric ring is configured with a second plurality of cutouts, said second concentric ring is configured to be parallel with said first concentric ring, said first concentric ring and second concentric ring are separated by an air gap;

providing means to rotate said second concentric ring to adjust an overlapping area with said first plate during plasma processing.

16. The method of claim 15, wherein said cutouts from said first plurality of cutouts have approximately same dimensions.

17. The method of claim 15, wherein said cutouts from said first plurality of cutouts have approximately different dimensions.

18. The method of claim 15, wherein said cutouts from said second plurality of cutouts have approximately same dimensions.

19. The method of claim 15, wherein said cutouts from said second plurality of cutouts have approximately different dimensions.

20. The method of claim 1, wherein said RF power being delivered to said chuck has a set of RF frequencies that includes at least one of about 2 MHz, about 27 MHz, and about 60 MHz.

21. A plasma processing system having a plasma processing chamber configured for processing a substrate, said substrate being disposed above a chuck and surrounded by an edge ring, said edge ring being electrically isolated from said chuck, comprising:

RF power is provided to said chuck;

a tunable capacitance arrangement, said tunable capacitance arrangement being coupled to said edge ring to provide RF coupling to said edge ring, resulting in said edge ring having an edge ring potential; and

said plasma processing chamber is configured to strike plasma to process said substrate, said substrate being processed while said tunable capacitance arrangement is configured to cause said edge ring potential to be dynamically tunable to a DC potential of said substrate while processing said substrate.

22. The plasma processing system of claim 21, wherein said tunable capacitance arrangement includes a coupling ring assembly.

23. The plasma processing system of claim 22, wherein said coupling ring assembly comprising:

an upper coupling ring;

a lower coupling ring, said lower coupling ring is coupled with said upper coupling ring to form a hermetic seal;

a hermetically sealed cavity, said hermetically sealed cavity being disposed inside said coupling ring assembly, wherein said hermetically sealed cavity is configured with an inlet and an outlet to transport dielectric material into or out of said hermetically sealed cavity to change the capacitance of said coupling assembly.

24. The plasma processing system of claim 23, wherein said dielectric material includes at least one of a solid, a liquid, and a gas.

25. The plasma processing system of claim 24, wherein said dielectric material includes at least one of air, nitrogen, mineral oil, castor oil, water, and glycerol.

26. The plasma processing system of claim 23, wherein said transport of said predetermined dielectric material is achieved by at least one of an active flow control system and a passive flow control system.

27. The plasma processing system of claim 21, wherein said tunable capacitance arrangement is a mechanical switch.

28. The plasma processing system of claim 27, wherein said mechanical switch comprises:

a shaft;

a contact foot; and

a moveable connector, said moveable connector being disposed above said shaft, said shaft is configured facilitate moving said moveable connector up or down relative to said contact foot, said contact foot is configured to couple to said edge ring.

29. The plasma processing system of claim 28, wherein said shaft is RF coupled to said chuck by a strap.

30. The plasma processing system of claim 28, wherein said edge ring is configured to achieve maximum RF coupling if said moveable connector physically contacts with said contact foot.

31. The plasma processing system of claim 28, wherein said edge ring is configured to achieve minimum RF coupling if said moveable connector does not physically contact with said contact foot.

32. The plasma processing system of claim 21, wherein said tunable capacitance arrangement is a mechanical capacitor arrangement.

33. The plasma processing system of claim 32, wherein said mechanical capacitor arrangement comprising:

a first plate;

a second plate, said second plate is configured to be parallel with said first plate, said first plate is configured to protrude downward from said edge ring, said first plate and said second plate are separated by an air gap;

a plurality of straps, said plurality of straps are configured to RF couple said second plate to said chuck; and

means to move said second plate up or down to adjust an overlapping area with said first plate during plasma processing.

34. The plasma processing system of claim 32, wherein said mechanical capacitor arrangement comprising:

a first concentric ring, said first concentric ring is configured with a first plurality of cutouts;

a second concentric ring, said second concentric ring is configured with a second plurality of cutouts, said second concentric ring is configured to be parallel with said first concentric ring, said first concentric ring and second concentric ring are separated by an air gap;

means to rotate said second concentric ring to adjust an overlapping area with said first plate during plasma processing.

What is claimed is:

1. A method for processing a substrate in a plasma processing chamber, said substrate being disposed above an electrostatic chuck and surrounded by an edge ring, said edge ring being electrically isolated from said chuck, the method comprising:

providing RF power to said electrostatic chuck;

using a coupling ring assembly to provide RF coupling from said electrostatic chuck to said edge ring said coupling ring assembly surrounding said electrostatic chuck, wherein said coupling ring assembly includes an upper coupling ring and a lower coupling ring coupled with said upper coupling ring, a cavity being formed between said upper coupling ring and said lower coupling ring;

transporting a dielectric material into or out of said cavity to change capacitance of said coupling ring; and

generating a plasma within said plasma processing chamber to process said substrate.

2. The method of claim 1, said transporting said dielectric material is performed when said substrate is processed inside said plasma processing chamber.

3. The method of claim 1, wherein said dielectric material includes at least a solid material.

4. The method of claim 1, wherein said dielectric material includes at least one of air, nitrogen, mineral oil, castor oil, water, and glycerol.

5. The method of claim 1 further comprising transporting additional dielectric material into said cavity to change said dielectric material inside said cavity.

6. The method of claim 1 further comprising transporting a portion of said dielectric material out of said cavity to change said dielectric material inside said cavity.

7. The method of claim 1 further comprising:

flowing a first dielectric material into said cavity to give said coupling ring assembly a first predetermined capacitance for optimizing said RF coupling from said electrostatic chuck to said edge ring; and

flowing a second dielectric material into said cavity to give said coupling ring assembly a second predetermined capacitance for minimizing said RF coupling from said electrostatic chuck to said edge ring.

8. The method of claim 1 further comprising disposing an o-ring inside said coupling ring assembly to seal said cavity.

9. The method of claim 1 wherein said transporting said dielectric material inside said cavity increases said capacitance of said coupling ring assembly to increase RF voltage at a top surface of said edge ring.

10. The method of claim 1 wherein said transporting said dielectric material inside said cavity decreases said capacitance of said coupling ring assembly to decrease RF voltage at a top surface of said edge ring.

11. The method of claim 1 further comprising:

transporting said dielectric material into or out of said cavity to cause said edge ring to have a first electrical property;

etching said substrate when said edge ring has said first electrical property;

transporting said dielectric material into or out of said cavity to cause said edge ring to have a second electrical property; and

cleaning an edge of said substrate when said edge ring has said second electrical property.

12. The method of claim 1 further comprising: sealing an interface between said upper coupling ring and said lower coupling ring.

13. The method of claim 12 wherein said sealing includes resistance welding said interface between said upper coupling ring and said lower coupling ring.

14. The method of claim 12 wherein said sealing includes using solder seal at said interface between said upper coupling ring and said lower coupling ring.

15. The method of claim 12 wherein said sealing includes using glass seal at said interface between said upper coupling ring and said lower coupling ring.

16. The method of claim 12 wherein said sealing includes disposing an o-ring at said interface between said upper coupling ring and said lower coupling ring.

17. The method of claim 12 further comprising matching a seal means used at said interface with a material of said coupling ring assembly.

18. The method of claim 1 wherein said coupling ring assembly is made of graphite.

19. The method of claim 1 further comprising:

flowing said dielectric material into said cavity at a volume; and

preventing said dielectric material from flowing through said cavity when said substrate is processed inside said plasma processing chamber.

20. The method of claim 1 wherein said dielectric material is transported into said cavity via an inlet channel and said dielectric material is transported out of said cavity via an outlet channel.