CLAIMS

1. A semiconductor wafer processing apparatus, comprising:

a first electrode exposed to a first plasma generation volume, the first electrode defined to transmit radiofrequency (RF) power to the first plasma generation volume, the first electrode further defined to distribute a first plasma process gas to the first plasma generation volume;

a second electrode exposed to a second plasma generation volume, the second electrode defined to transmit RF power to the second plasma generation volume, the second electrode further defined to hold a substrate in exposure to the second plasma generation volume;

a gas distribution unit disposed between the first plasma generation volume and the second plasma generation volume, the gas distribution unit defined to include an arrangement of through-holes that each extend through the gas distribution unit to fluidly connect the first plasma generation volume to the second plasma generation volume, the gas distribution unit further defined to include interior gas supply channels fluidly connected to an arrangement of gas supply ports defined to distribute a second plasma process gas to the second plasma generation volume, wherein the gas distribution unit includes embedded electrodes defined around the through-holes and around portions of the gas supply ports and below horizontal portions of the interior gas supply channels, each of the embedded electrodes defined to connect with any one of one or more direct current bias sources external to the gas distribution unit; and

an exhaust channel configured to circumscribe the first plasma generation volume outside of a radial periphery of the first electrode and outside of a radial periphery of the gas distribution unit.

2. The apparatus of claim 1, wherein the first electrode is defined to include a number of gas supply ports arranged in a number of concentric radial zones facing toward the first plasma generation volume, wherein the gas supply ports within each concentric radial zone are plumbed to a respective gas flow control device, such that the first plasma process gas supply to each concentric radial zone is independently controlled.

3. The apparatus of claim 1, wherein the first electrode forms an upper surface of the first plasma generation volume, and wherein the second electrode forms a lower surface of the second plasma generation volume, and wherein the gas distribution unit is defined as a plate formed to separate the first plasma generation

volume from the second plasma generation volume, such that an upper surface of the plate provides a lower boundary of the first plasma generation volume, and such that a lower surface of the plate provides an upper boundary of the second plasma generation volume, wherein each of the through-holes extend through the plate from the upper surface of the plate to the lower surface of the plate.

4. The apparatus of claim 1, wherein the interior gas supply channels are defined to fluidly separate the arrangement of gas supply ports into multiple concentric regions across the lower surface of the plate, such that flow rates of the second plasma process gas to the gas supply ports within each of the multiple concentric regions is independently controlled.

5. The apparatus of claim 1, wherein the gas distribution unit is formed of an electrically conductive material and is electrically connected to a reference ground potential such that the gas distribution unit provides a ground electrode for both the first and second plasma generation volumes.

6. The apparatus of claim 1, wherein the first electrode is electrically connected to a first RF power source, and wherein the second electrode is electrically connected to a second RF power source separate from the first RF power source.

7. The apparatus of claim 1, wherein the second electrode is defined to hold the substrate through electrostatic attraction.

8. The apparatus of claim 1, wherein the second electrode is movable in a direction toward and away from the gas distribution unit to provide for control of a distance extending across the second plasma generation volume perpendicular to both the second electrode and gas distribution unit.

9. The apparatus of claim 1, further comprising:

a pressure throttle ring configured to move in a controlled manner within the exhaust channel to throttle a flow of gas from the first plasma generation volume through the exhaust channel.

10. The apparatus of claim 9, further comprising:

a pressure measuring device disposed to measure a pressure within the first plasma generation volume; and

a feedback control mechanism defined to control a position of the pressure throttle ring within the exhaust channel based on measured pressure within the first plasma generation volume obtained from the pressure measuring device.

11. The apparatus of claim 9, wherein the second plasma generation volume is defined to exhaust through a set of slotted channels defined to circumscribe the second plasma generation volume outside of a radial periphery of the second electrode and outside of a radial periphery of the gas distribution unit, the semiconductor wafer processing apparatus further comprising a pressure control ring defined to cover the set of slotted channels when placed against the set of slotted channels, the pressure control ring defined to move toward and away from the set of slotted channels to throttle a flow of gas from the second plasma generation volume through the set of slotted channels.

12. The apparatus of claim 11, further comprising:

a pressure measuring device disposed to measure a pressure within the second plasma generation volume; and

a feedback control mechanism defined to control a position of the pressure control ring relative to the set of slotted channels based on measured pressure within the second plasma generation volume obtained from the pressure measuring device.

13. The apparatus of claim 1, wherein each through-hole is defined to extend from an upper surface of the gas distribution unit exposed to the first plasma generation volume to a lower surface of the gas distribution unit exposed to the second plasma generation volume at an angle offset from a reference direction that extends perpendicularly between the upper and lower surfaces of the gas distribution unit, wherein the angle is sufficiently large to prevent an uninterrupted line-of-sight through the gas distribution unit in the reference direction at each through-hole location.

14. The apparatus of claim 1, wherein the embedded electrodes located within the gas distribution unit are defined in multiple separately controllable zones, with each zone connected to a separate direct current bias source.

15. The apparatus of claim 1, wherein the exhaust channel is configured to extend in a radial direction away from the first plasma generation volume so as to extend over a total radial distance as measured in a direction parallel to both a bottom surface of the first electrode and a top surface of the gas distribution unit, the exhaust channel having a top surface and a bottom surface, each of the top and bottom surfaces of the exhaust channel oriented parallel to both the bottom surface of the first electrode and the top surface of the gas distribution unit along the total radial distance over which the exhaust channel extends, the top surface of the exhaust channel positioned below the bottom surface of the first electrode, the bottom surface of the exhaust channel positioned at or above the top surface of the gas distribution unit, the exhaust channel having a vertical size measured perpendicularly between the top and bottom surfaces of the exhaust channel, the vertical size of the exhaust channel less than a vertical size of the first plasma generation volume as measured perpendicularly between the bottom surface of the first electrode and the top surface of the gas distribution unit.

16. A system for semiconductor wafer processing, comprising:

a chamber defined to have an interior cavity and an exhaust port that provides for fluid connection of the interior cavity to an exhaust pump;

a dual plasma processing apparatus disposed within the interior cavity of the chamber and including,

an upper plasma chamber including an upper plasma generation volume,

a showerhead electrode defined above the upper plasma generation volume to supply a first plasma process gas and radiofrequency (RF) power to the upper plasma generation volume,

a lower plasma chamber including a lower plasma generation volume,

a gas distribution unit disposed between the upper and lower plasma generation volumes, the gas distribution unit defined to supply a second plasma process gas to the lower plasma generation volume, the gas distribution unit including an arrangement of through-holes formed to extend from an upper surface of the gas distribution unit facing the upper plasma generation volume to a lower surface of the gas distribution unit facing the

lower plasma generation volume to provide controlled fluid communication between the upper and lower plasma generation volumes, wherein the gas distribution unit includes interior gas supply channels fluidly connected to an arrangement of gas supply ports defined on the lower surface of the gas distribution unit to distribute a plasma process gas to the lower plasma generation volume, wherein the gas distribution unit includes embedded electrodes defined around the through-holes and around portions of the gas supply ports and below horizontal portions of the interior gas supply channels, each of the embedded electrodes defined to connect with any one of one or more direct current bias sources external to the gas distribution unit, and

an exhaust channel configured to circumscribe the upper plasma generation volume outside of a radial periphery of the showerhead electrode and outside of a radial periphery of the gas distribution unit; and

a chuck disposed within the interior cavity of the chamber below the lower plasma generation volume, the chuck defined to hold a substrate in exposure to the lower plasma generation volume, the chuck further defined to supply RF power to the lower plasma generation volume.

17. The system of claim 16, wherein the gas distribution unit is formed from an electrically conductive material and is electrically connected to a reference ground potential such that the gas distribution unit serves as a ground electrode for both the upper and lower plasma chambers.

18. The system of claim 16, wherein the chuck is movable in a direction toward and away from the gas distribution unit to provide for control of a distance extending perpendicularly across the lower plasma generation volume between the chuck and gas distribution unit.

19. The system of claim 16, further comprising:

a pressure throttle ring configured to move in a controlled manner within the exhaust channel to throttle a flow of gas from the upper plasma generation volume through the exhaust channel.

20. The system of claim 16, wherein the lower plasma chamber is defined to exhaust the lower plasma generation volume through a set of slotted channels defined to circumscribe the lower plasma generation volume outside of a radial periphery of the chuck and outside of a radial periphery of the gas distribution unit, the system

further comprising a pressure control ring defined to cover the set of slotted channels when placed against the set of slotted channels, the pressure control ring defined to move toward and away from the set of slotted channels to throttle a flow of gas from the lower plasma generation volume through the set of slotted channels.

21. The system of claim 16, further comprising:

a first RF power source electrically connected to supply RF power to the upper plasma generation volume through the showerhead electrode;

a second RF power source electrically connected to supply RF power to the lower plasma generation volume through the chuck, wherein the second RF power source is independent from the first RF power source;

a first plasma process gas supply fluidly connected to the showerhead electrode; and

a second plasma process gas supply fluidly connected to the gas distribution unit, wherein each of the first and second plasma process gas supplies is independently controllable, such that flow rates of plasma process gases to the upper and lower plasma generation volumes are independently controllable.

22. The system of claim 16, wherein the exhaust channel is configured to extend in a radial direction away from the upper plasma generation volume so as to extend over a total radial distance as measured in a direction parallel to both a bottom surface of the showerhead electrode and a top surface of the gas distribution unit, the exhaust channel having a top surface and a bottom surface, each of the top and bottom surfaces of the exhaust channel oriented parallel to both the bottom surface of the showerhead electrode and the top surface of the gas distribution unit along the total radial distance over which the exhaust channel extends, the top surface of the exhaust channel positioned below the bottom surface of the showerhead electrode, the bottom surface of the exhaust channel positioned at or above the top surface of the gas distribution unit, the exhaust channel having a vertical size measured perpendicularly between the top and bottom surfaces of the exhaust channel, the vertical size of the exhaust channel less than a vertical size of the upper plasma generation volume as measured perpendicularly between the bottom surface of the showerhead electrode and the top surface of the gas distribution unit.

23. A gas distribution unit, comprising:

a plate formed to separate an upper plasma generation volume from a lower plasma generation volume, the plate having an upper surface and a lower surface, wherein the plate includes an arrangement of through-holes that each extend through the plate from the upper surface of the plate to the lower surface of the plate so as to fluidly connect the upper plasma generation volume to the lower plasma generation volume, and wherein the plate includes interior gas supply channels fluidly connected to an arrangement of gas supply ports defined on the lower surface of the plate to distribute a plasma process gas to the lower plasma generation volume; and

electrodes embedded within the plate, the electrodes defined around the through-holes and around portions of the gas supply ports and below horizontal portions of the interior gas supply channels, each of the electrodes defined to connect with any one of one or more direct current bias sources external to the plate.

24. The gas distribution unit of claim 23, wherein the plate is formed of an electrically conductive material, and wherein the plate is electrically connected to a reference ground potential so as to provide a ground electrode for each of the upper and lower plasma generation volumes.

25. The gas distribution unit of claim 23, wherein the interior gas supply channels and gas supply ports are defined between the arrangement of through-holes such that the plasma process gas is distributed to the lower plasma generation volume and is not distributed to the upper plasma generation volume.

26. The gas distribution unit of claim 23, wherein the interior gas supply channels are defined to fluidly separate the arrangement of gas supply ports into multiple concentric regions across the lower surface of the plate, such that flow rates of the plasma process gas to the gas supply ports within each of the multiple concentric regions is independently controlled.

27. The gas distribution unit of claim 23, wherein each through-hole is defined to extend from the upper surface of the plate to the lower surface of the plate at an angle offset from a reference direction that extends perpendicularly between the upper and lower surfaces of the plate, wherein the angle is sufficiently large to prevent an uninterrupted line-of-sight through the plate in the reference direction at each through-hole location.

28. The gas distribution unit of claim 23, further comprising:

a disc formed to be disposed on the upper surface of the plate, the disc including multiple patterns of holes extending through the disc, wherein each of the multiple patterns of holes aligns with a different set of through-holes within the plate, such that disposal of the disc on the upper surface of the plate at a particular rotational position of the disc relative to the upper surface of the plate corresponds to alignment of a particular one of the multiple patterns of holes with its corresponding set of through-holes within the plate, wherein the disc is secured to the plate such that thermal and electrical conduction exists between the disc and the plate.

29. The gas distribution unit of claim 28, wherein each of the multiple patterns of holes extending through the disc is defined to expose a different number or a different spatial pattern of through-holes within the plate.

30. The gas distribution unit of claim 23, further comprising:

a central disc and a number of concentric rings formed to be disposed in a concentric manner on the upper surface of the plate, each of the central disc and the number of concentric rings respectively including multiple patterns of holes extending there through, wherein each of the multiple patterns of holes aligns with a different set of through-holes within the plate, such that disposal of each of the central disc and the number of concentric rings on the upper surface of the plate at a particular rotational position relative to the upper surface of the plate corresponds to alignment of a particular one of the multiple patterns of holes with its corresponding set of through-holes within the plate, wherein the central disc and each of the number of concentric rings is secured to the plate such that thermal and electrical conduction exists between the plate and each of the central disc and the number of concentric rings.

31. The gas distribution unit of claim 30, wherein each of the multiple patterns of holes extending through the central disc and the number of concentric rings is defined to expose a different number or a different spatial pattern of through-holes within the plate.

32. The gas distribution unit of claim 30, wherein the central disc and the number of concentric rings are independently movable to respective rotational positions relative to the upper surface of the plate.