

$Z_{back} = \frac{1}{2\pi f A \epsilon_0} \cdot \frac{d_1}{9}$. For a showerhead without the plasma-suppressing structure 60,

$Z_{face} > Z_{back}$ due to a high impedance of the gas plenum ($\epsilon=1$). To counteract, the plasma-suppressing structure 60 with a large impedance Z_{supp} is installed on the back plate 20 to insure $Z_{face} \ll Z_{back} + Z_{supp}$.

[0049] The impedance of the plasma-suppressing structure 60 depends mostly on vacuum gaps between the plates 100. If the gaps are too wide, however, capacitive parasitic discharge may occur between the plates 100.

[0050] The impedance model applied above assumes parallel plate capacitors and uniform electric fields. In reality, fringe fields will occur which will alter the above results but this effect is expected to be small. ~~It is~~ The fringe fields are the highest in the immediate vicinity of the RF electrode 50. As a result, a first gap (between the back plate 20 and the first plate 100-1 of the plasma-suppressing structure 60) is the most prone to ignite parasitic discharge.

[0051] In some examples, the inter-plate gaps are uniform. In other examples, the inter-plate gaps are not uniform. For example only in FIG. 3, some or all of inter-plate gaps 200-1, 200-2, 200-3, 200-4 and 200-5 (collectively inter-plate gaps 200) may increase with a distance from the back plate 20. For example only, the inter-plate gaps 200 may increase as follows 40-60-100-150-200 (in mils), although other values may be used. As can be appreciated, ends of the plates ~~200~~100 may be enclosed for example using one or more plugs (not shown).

[0052] Preventing inter-plate parasitic discharge between the plates 100 of the plasma-suppressing structure 60 relies on the relation of gap width and plasma sheath thickness. For example in FIG. 4, improved protection against undesired ignition may

17. The showerhead assembly of claim 1, wherein a first dimension between the electrode and the first surface of the back plate is less than a second dimension between the electrode and a second surface of the back plate, wherein the first surface of the back plate is opposite to the second surface of the back plate.
18. The showerhead assembly of claim 1, wherein the electrode is disc-shaped.
19. The showerhead assembly of claim 2, wherein the one or more conductors includes a cylindrically-shaped conductor that surrounds the gas channel.
20. A substrate processing system comprising:
a processing chamber including a reaction volume;
the showerhead assembly of claim 1 arranged in the reaction volume; and
a pedestal arranged in the reaction volume adjacent to the face plate.
21. The substrate processing system of claim ~~19~~20, further comprising:
a radio frequency (RF) circuit configured to supply an RF signal to the one or more conductors having a frequency greater than 1 MHz; and
a controller configured to control process gases flowing to the gas channel and to control operation of the RF circuit.
22. The substrate processing system of claim 21, wherein the back plate is directly connected to a wall of the processing chamber.