

What is claimed is:

1. A gapfill deposition method comprising:
 - positioning a substrate on an electrostatic chuck within a processing volume of a processing chamber, the substrate having a substrate surface comprising at least one feature therein, the at least one feature extending a depth from the substrate surface to a bottom surface, the at least one feature having an opening width at the substrate surface defined by a first sidewall and a second sidewall;
 - flowing a gapfill precursor into the processing volume from a gas distribution assembly spaced above the substrate, the processing volume maintained at a pressure between about 0.5 mTorr and about 10 Torr; and
 - generating a plasma in the processing volume above the substrate by applying a first RF bias to the electrostatic chuck to deposit a gapfill within the at least one feature of the substrate, the gapfill comprising substantially no voids.
2. The method of claim 1, wherein the gapfill precursor comprises a hydrocarbon and the gapfill comprises a diamond-like carbon material.
3. The method of claim 2, wherein the diamond-like carbon material has a density greater than 1.8 g/cm³ and a stress in a range of about -600 MPa to about -300 MPa.
4. The method of claim 2, wherein the hydrocarbon is selected from a group consisting of: C₂H₂, C₃H₆, CH₄, C₄H₈, 1,3-dimethyladamantane, bicyclo[2.2.1]hepta-2,5-diene (2,5-norbornadiene), adamantane (C₁₀H₁₆), norbornene (C₇H₁₀), and combinations thereof.
5. The method of claim 1, wherein the gapfill precursor comprises a silicon-containing species and the gapfill comprises one or more of silicon, silicon oxide or silicon nitride.

6. The method of claim 1, wherein the first RF bias is provided at a power between about 10 Watts and about 3000 Watts at a frequency of from about 350 kHz to about 100 MHz.
- 5 7. The method of claim 1, wherein generating a plasma in the processing volume further comprises applying a second RF bias to the electrostatic chuck and the second RF bias is provided at a power between about 10 Watts and about 3000 Watts at a frequency of from about 350 kHz to about 100 MHz.
- 10 8. The method of claim 1, wherein the substrate is maintained at a temperature from about 10 °C to about 100 °C.
9. The method of claim 1, wherein the at least one feature has a ratio of the depth to the opening width of greater than or equal to about 10:1.
- 15 10. A gapfill deposition method comprising:
 - positioning a substrate over a first electrode within a processing volume of a processing chamber, the substrate having a substrate surface comprising at least one feature therein, the at least one feature extending a depth from the substrate
 - 20 surface to a bottom surface, the at least one feature having an opening width at the substrate surface defined by a first sidewall and a second sidewall, the processing chamber further comprising a second electrode positioned above the first electrode and the substrate, the second electrode having a surface comprising a secondary electrode emission material comprising one or more of a silicon-
 - 25 containing material or a carbon-containing material;
 - flowing a gapfill precursor into the processing volume;
 - applying a first RF power to at least one of the first electrode and the second electrode; and
 - forming a gapfill within the at least one feature of the substrate, the gapfill
 - 30 comprising substantially no voids.
11. The method of claim 10, wherein the gapfill precursor comprises a hydrocarbon selected from the group consisting of: C₂H₂, C₃H₆, CH₄, C₄H₈, 1,3-

dimethyladamantane, bicyclo[2.2.1]hepta-2,5-diene (2,5-norbornadiene), adamantane ($C_{10}H_{16}$), norbornene (C_7H_{10}), and combinations thereof and the gapfill comprises a diamond-like carbon material.

- 5 12. The method of claim 11, wherein the diamond-like carbon material has a density greater than 1.5 g/cm^3 and a stress in a range of about -600 MPa to about 100 MPa.
- 10 13. The method of claim 10, wherein the gapfill precursor comprises a silicon-containing species and the gapfill comprises a dielectric material comprising one or more of silicon, silicon oxide or silicon nitride.
14. The method of claim 10, wherein the at least one feature has a ratio of the depth to the opening width of greater than or equal to about 10:1.
- 15 15. A diamond-like carbon gapfill within a feature of a substrate, the gapfill having a density in a range of about 1.8 g/cm^3 to about 2.5 g/cm^3 , from about 50 percent to about 90 percent sp^3 hybridized carbon atoms and a stress of less than 100 MPa, the feature extending a depth from a surface of the substrate to a bottom surface,
- 20 the feature having an opening width at the surface defined by a first sidewall and a second sidewall, the feature having a ratio of the depth to the opening width of greater than or equal to about 10:1.