

~~What is claimed is:~~

CLAIMS

1. A gapfill deposition method comprising:

~~positioning~~ flowing a gapfill precursor into a processing volume of a processing chamber,
~~the gapfill precursor flowed from a gas distribution assembly spaced above~~ a substrate
~~positioned~~ on an electrostatic chuck within ~~a~~ the 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 and a second 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~~.

- ~~3.~~4. The method of claim 2, wherein the diamond-like carbon material has a stress in a range of
 about -600 MPa to about -300 MPa.

- ~~4.~~5. 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.

6. The method of claim 1, wherein the gapfill precursor comprises a silicon-containing species and the gapfill comprises a dielectric material.

5.7.The method of claim 6, wherein the dielectric material comprises one or more of silicon, silicon oxide or silicon nitride.

6.8.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.

7.9.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.

8.10. The method of claim 1, wherein the substrate is maintained at a temperature from about 10 °C to about 100 °C.

11. The method of claim 1, wherein the gapfill precursor comprises a dilution gas comprising one or more of He, Ar, Xe, N₂, H₂, or combinations thereof.

9.12. 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.

13. The method of claim 1, wherein spacing between the gas distribution assembly and the substrate is maintained at 1,000 to 15,000 mils.

10.14. A gapfill deposition method comprising:
~~positioning a substrate over a first electrode within~~flowing a gapfill precursor into a processing volume of a processing chamber, the ~~substrate~~processing volume containing a

substrate positioned over a first electrode and 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, 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-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 comprising substantially no voids.

11.15. The method of claim 1014, wherein the gapfill precursor comprises a hydrocarbon selected from the group consisting of: C_2H_2 , C_3H_6 , CH_4 , C_4H_8 , 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.

12.16. The method of claim 1115, 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.

13.17. The method of claim 1014, 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.

14.18. The method of claim 1014, 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. 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, 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.