CLAIMS

1. A method comprising:

providing a substrate in a processing station comprising a substrate support and a showerhead, the substrate comprising a gap to be filled; and

depositing silicon-containing film in the gap by a plasma-enhanced atomic layer deposition (PEALD) process comprising multiple cycles of operations (a)-(d):

(a) a dose operation comprising flowing a silicon-containing precursor into the processing station via the showerhead to allow the silicon-containing precursor to adsorb onto the substrate;

(b) after (a), flowing a purge gas into the processing station;

(c) after (b), exposing the substrate to plasma species to react with the adsorbed silicon-containing precursor; and

(d) after (c), flowing a purge gas into the processing station,

wherein the silicon-containing precursor continues to flow into the processing station during at least (b).

2. The method of claim 1, wherein the silicon-containing precursor continues to flow into the processing station during at least part of (c).

3. The method of claim 1, wherein the silicon-containing precursor continues to flow into the processing station during (c) and at least part of (d).

4. The method of claim 1, wherein after (a), the silicon-containing precursor flow continues into flow into the processing station at a decreasing flow rate.

5. The method of claim 1, wherein (a) comprises flowing an inert gas and a vaporized silicon-containing precursor from a silicon-containing precursor source fluidically connected to a gas delivery line via an outlet valve, the gas delivery line fluidically connected to the showerhead, and at the end of (a), closing the outlet valve.

6. The method of claim 5, wherein silicon-containing precursor in the gas delivery line continues to flow into the processing station after the outlet valve is closed.

7. The method of claim 1, further comprising diverting silicon-containing precursor from the processing station during one or more of (c) and (d).

8. The method of claim 1, wherein the plasma in (c) is a dual frequency RF plasma generated using high frequency (HF) and low frequency (LF) RF power.

9. The method of claim 8, further comprising increasing an inert gas flow into the processing station during (c).

10. The method of claim 8, wherein the HF power is at least 4 kW and the LF power is between 500 W and 5 kW.

11. The method of claim 8, further comprising sputtering and re-depositing silicon-containing film in the gap during deposition of the silicon-containing film in the gap.

12. The method of claim 1, wherein the plasma species are generated from oxygen (O_2).

13. The method of claim 1, wherein the plasma species are generated from nitrous oxide (N_2O).

14. The method of claim 1, wherein the plasma species are generated from nitrogen (N_2).

15. The method of claim 1, wherein (b) is between 50–500 milliseconds in duration.

16. The method of claim 1, wherein the gap to be filled is a gap between memory stacks of a 3D NAND structure.

17. The method of claim 1, wherein the gap has aspect ratio of at least 20:1.

18. The method of claim 1, further comprising exposing the deposited film to an inhibition plasma before at least one of the multiple cycles.

19. A method comprising:

providing a substrate having a structure including a gap to be filled;

depositing a silicon-containing protective film selectively at an upper portion of the structure such that it extends only partially into the gap by a plasma-enhanced atomic layer deposition (PEALD) process comprising:

(a) a dose operation comprising flowing a silicon-containing precursor into a processing station via a showerhead to allow the silicon-containing precursor to adsorb onto the substrate;

(b) after (a), flowing a purge gas into the processing station;

(c) after (b), exposing the substrate to plasma species to react with the adsorbed silicon-containing precursor, wherein the plasma in (c) is a dual frequency RF plasma generated using high frequency (HF) and low frequency (LF) RF power; and

(d) after (c), flowing a purge gas into the processing station; and

further comprising: performing one or more cycles of:

exposing the substrate including the protective film to an inhibition plasma comprising halogen species to inhibit deposition on a portion of the gap; and after exposing the substrate to the inhibition, depositing dielectric material in the gap.

20. The method of claim 19, wherein the silicon-containing precursor continues to flow into the processing station during at least (b).

21. The method of claim 19, wherein the protective film is etched during exposure to the inhibition plasma.

22. The method of claim 19, wherein the plasma during (a) is generated from nitrogen trifluoride (NF_3) and the protective liner is a silicon nitride film.

23. The method of claim 1, wherein the protective liner is between 10 and 999 Angstroms thick.

24. The method of claim 1, wherein depositing a protective liner and the performing one or more cycles are performed in the same chamber.

25. The method of claim 1, wherein the structure is a 3D NAND structure, the gap is formed by two stacks each comprising multiple pairs of an oxide layer and a nitride layer and capped by a polysilicon layer and wherein the protective film protects the polysilicon layer.

26. A method comprising:

providing a substrate in a processing station comprising a substrate support and a showerhead;

depositing a silicon-containing film on the substrate by a plasma-enhanced atomic layer deposition (PEALD) process comprising multiple cycles of operations (a)-(d):

(a) a dose operation comprising flowing a silicon-containing precursor into the processing station via the showerhead to allow the silicon-containing precursor to adsorb onto the substrate;

(b) after (a), flowing a purge gas into the processing station;

(c) after (b), exposing the substrate to plasma species to react with the adsorbed silicon-containing precursor; and

(d) after (c), flowing a purge gas into the processing station,

wherein the silicon-containing precursor continues to flow into the processing station during at least (b).

27. The method of claim 26, wherein the silicon-containing film fills a gap on the substrate.

28. The method of claim 26, wherein the silicon-containing film is non-conformally deposited on a structure having two stacks separated by a gap such that the film is deposited at the top of the stacks extending only partially into gap.

29. The method of claim 26, wherein the plasma in (c) is a dual frequency RF plasma generated using high frequency (HF) and low frequency (LF) RF power.

30. A method comprising:

providing a substrate in a processing station comprising a substrate support and a showerhead;

depositing a silicon-containing film on the substrate by a plasma-enhanced atomic layer deposition (PEALD) process comprising multiple cycles of operations (a)-(d):

(a) a dose operation comprising flowing a silicon-containing precursor into the processing station via the showerhead to allow the silicon-containing precursor to adsorb onto the substrate;

(b) after (a), flowing a purge gas into the processing station;

(c) after (b), exposing the substrate to plasma species to react with the adsorbed silicon-containing precursor; and

(d) after (c), flowing a purge gas into the processing station,

wherein the plasma in (c) is a dual frequency RF plasma generated using high frequency (HF) and low frequency (LF) RF power

31. The method of claim 30, wherein the silicon-containing film fills a gap on the substrate.

32. The method of claim 30, wherein the silicon-containing film is non-conformally deposited on a structure having two stacks separated by a gap such that the film is deposited at the top of the stacks extending only partially into gap.

33. A method comprising:

providing a substrate in a processing station comprising a substrate support and a showerhead, the substrate comprising a gap to be filled; and

depositing silicon-containing film in the gap by a plasma-enhanced atomic layer deposition (PEALD) process comprising multiple cycles of operations (a)-(d):

(a) a dose operation comprising flowing a silicon-containing precursor into the processing station via the showerhead to allow the silicon-containing precursor to adsorb onto the substrate;

(b) after (a), flowing a purge gas into the processing station;

(c) after (b), exposing the substrate to plasma species generated from a reactant gas to react with the adsorbed silicon-containing precursor; and

(d) after (c), flowing a purge gas into the processing station, wherein the purge gas is a different gas than the reactant gas and

wherein the reactant gas and/or the plasma species continue to flow into the processing station during at least (a).

34. The method of claim 1, wherein a closed void is formed in the gap to reduce interlevel capacitance.

35. The method of claim 33, wherein a closed void is formed in the gap to reduce interlevel capacitance.

36. The method of claim 30, wherein some of the deposited silicon-containing film is sputtered and re-deposited.