

WHAT IS CLAIMED IS:

1. A method of forming a flowable dielectric layer on a substrate, the method comprising the sequential steps of:

forming a generally conformal silicon oxide liner layer on the substrate by exposing the substrate to a silicon-containing liner precursor and an oxygen-containing liner precursor, wherein the substrate is maintained at a liner deposition temperature; and

forming a carbon-free flowable silicon-nitrogen-and-hydrogen-containing layer on the substrate, wherein the substrate is maintained at a bulk deposition temperature, wherein the bulk-deposition temperature is less than 120°C.

2. The method of claim 1 wherein forming the carbon-free flowable silicon-nitrogen-and-hydrogen-containing layer comprises:

flowing a nitrogen-and-hydrogen-containing gas into a plasma region to produce a radical-nitrogen precursor;

combining a carbon-free silicon-containing precursor with the radical-nitrogen precursor in a plasma-free substrate processing region; and

depositing a silicon-and-nitrogen-containing layer on the substrate.

3. The method of claim 2 wherein the nitrogen-and-hydrogen-containing gas comprises ammonia (NH₃).

4. The method of claim 2 wherein the nitrogen-and-hydrogen-containing gas comprises at least one of nitrogen (N₂), hydrogen (H₂), hydrazine (N₂H₄) and ammonia (NH₃).

5. The method of claim 1 wherein a thickness of the generally conformal silicon oxide liner is less than or about 100Å.

6. The method of claim 2 wherein the carbon-free silicon-containing precursor comprises N(SiH₃)₃.

7. The method of claim 1 wherein the carbon-free flowable silicon-nitrogen-and-hydrogen-containing layer comprises a carbon-free Si-N-H layer.

8. The method of claim 1 wherein the bulk-deposition temperature is lower than the liner deposition temperature.

9. The method of claim 1 wherein the liner deposition temperature is greater than 400°C.
10. The method of claim 1 further comprising a cure step maintaining a temperature of the substrate below or about 400°C in an ozone-containing atmosphere.
11. The method of claim 2 wherein the plasma region is in a remote plasma system.
12. The method of claim 2 wherein the plasma region is a partitioned portion of the substrate processing chamber separated from the plasma-free substrate processing region by a showerhead.
13. The method of claim 1 wherein the oxygen-containing liner precursor comprises ozone.
14. The method of claim 1 wherein the oxygen-containing liner precursor comprises oxygen (O₂).
15. The method of claim 1 wherein the silicon-containing liner precursor comprises TEOS.

What is claimed is:

1. A method of forming a flowable dielectric layer on a substrate, the method comprising the sequential steps of:

forming a generally conformal silicon oxide liner layer on silicon nitride on the substrate by exposing the substrate to a silicon-containing liner precursor and an oxygen-containing liner precursor, wherein the substrate is maintained at a liner deposition temperature;

forming a carbon-free flowable silicon-nitrogen-and-hydrogen-containing layer on the silicon oxide liner layer using radical-component chemical vapor deposition, wherein the substrate is maintained at a bulk deposition temperature, wherein the bulk-deposition temperature is less than 120° C.;

curing the substrate at a substrate temperature below or about 400° C. in an ozone-containing atmosphere, and raising a temperature of the substrate to an oxygen anneal temperature above or about 600° C. in an oxygen-containing atmosphere.

2. The method of claim 1 wherein forming the carbon-free flowable silicon-nitrogen-and-hydrogen-containing layer comprises:

flowing a nitrogen-and-hydrogen-containing gas into a plasma region to produce a radical-nitrogen precursor; combining a carbon-free silicon-containing precursor with the radical-nitrogen precursor in a plasma-free substrate processing region; and

depositing a silicon-and-nitrogen-containing layer on the substrate.

3. The method of claim 2 wherein the nitrogen-and-hydrogen-containing gas comprises ammonia (NH₃).

4. The method of claim 2 wherein the nitrogen-and-hydrogen-containing gas comprises at least one of nitrogen (N₂), hydrogen (H₂), hydrazine (N₂H₄) and ammonia (NH₃).

5. The method of claim 1 wherein a thickness of the generally conformal silicon oxide liner is less than or about 100 Å.

6. The method of claim 2 wherein the carbon-free silicon-containing precursor comprises $\text{N}(\text{SiH}_3)_3$.

7. The method of claim 1 wherein the carbon-free flowable silicon-nitrogen-and-hydrogen-containing layer comprises a carbon-free Si—N—H layer.

8. The method of claim 1 wherein the bulk-deposition temperature is lower than the liner deposition temperature.

9. The method of claim 1 wherein the oxygen-containing liner precursor comprises oxygen (O_2).

10. The method of claim 1 wherein the liner deposition temperature is greater than 400°C .

11. The method of claim 1 wherein the silicon-containing liner precursor comprises TEOS.

12. The method of claim 1 wherein the oxygen-containing atmosphere comprises one or more gases selected from the group consisting of atomic oxygen, ozone, and steam (H_2O).

13. The method of claim 2 wherein the plasma region is in a remote plasma system.

14. The method of claim 2 wherein the plasma region is a partitioned portion of the substrate processing chamber separated from the plasma-free substrate processing region by a showerhead.

15. The method of claim 1 wherein the oxygen-containing liner precursor comprises ozone.

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