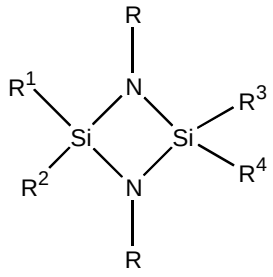
CLAIMS

1. A method of forming a silicon nitride film onto at least a surface of a substrate, the method comprising

a. providing a substrate in a reactor;

b. introducing into the reactor a cyclodisilazane precursor comprising a leaving hydrocarbon group and at least two Si-H groups and represented by the following Formula I:



I

wherein R is selected from a branched C_4 to C_{10} alkyl group; R^1, R^2, R^3, R^4 are selected independently from hydrogen, a linear or branched C_1 to C_{10} alkyl group, a linear or branched C_3 to C_6 alkenyl group, a linear or branched C_3 to C_6 alkynyl group, a C_1 to C_6 dialkylamino group, a C_6 to C_{10} aryl group, an electron withdrawing group, and a halide atom, wherein the at least one cyclodisilazane reacts on at least a portion of the surface of the substrate to provide a chemisorbed layer;

c. purging the reactor with a purge gas;

d. introducing a plasma containing source and an inert gas into the reactor to react with at least a portion of the chemisorbed layer and provide at least one reactive site wherein the plasma is generated at a power density ranging from 0.01 to 1.5 W/cm^2; and

e. optionally purging the reactor with an inert gas; and wherein the steps b through e are repeated until a desired thickness of the silicon nitride film is obtained.

2. A method of forming a silicon nitride film onto at least a surface of a substrate, the method comprising

a. providing a substrate in a reactor;

b. introducing into the reactor at least one cyclodisilazane precursor selected from the group consisting of 1,3-bis(tert-butyl)cyclodisilazane, 1,3-bis(tert-butyl)-2-

methylcyclodisilazane, 1,3-bis(tert-butyl)-2,4-dimethylcyclodisilazane, 1,3-bis(tert-amyl)cyclodisilazane, 1,3-bis(tert-amyl)-2-methylcyclodisilazane, 1,3-bis(tert-amyl)-2,4-dimethylcyclodisilazane, 1,3-bis(tert-butyl)-2-chlorocyclodisilazane, 1,3-bis(tert-butyl)-2,4-dichlorocyclodisilazane, 1,3-bis(tert-amyl)-2-chlorocyclodisilazane, 1,3-bis(tert-amyl)-2,4-dichlorocyclodisilazane, 1,3-bis(tert-butyl)-2,4,4-trichlorocyclodisilazane, 1,3-bis(tert-butyl)-2-dimethylcyclodisilazane, 1,3-bis(tert-butyl)-2-chloro-2-methylcyclodisilazane, 1,3-bis(tert-amyl)-2-dimethylcyclodisilazane, 1,3-bis(tert-amyl)-2-chloro-2-methyl-cyclodisilazane, 1,3-bis(tert-butyl)-2-vinylcyclodisilazane, 1,3-bis(tert-butyl)-2-ethynylcyclodisilazane and combinations thereof;

c. purging the reactor with a purge gas;

d. introducing a plasma containing source and an inert gas into the reactor to react with at least a portion of the chemisorbed layer and provide at least one reactive site wherein the plasma is generated at a power density ranging from 0.01 to 1.5 W/cm^2; and

e. optionally purging the reactor with an inert gas; and wherein the steps b through e are repeated until a desired thickness of the silicon nitride film is obtained .

3. The method of claim 1 or 2 wherein the plasma containing source is selected from the group consisting of a nitrogen/argon plasma, ammonia plasma, nitrogen/ammonia plasma, ammonia/helium plasma, ammonia/argon plasma, ammonia/nitrogen plasma, NF_3 plasma, organoamine plasma, and mixtures thereof.

4. The method of claim 1 or 2 wherein the silicon nitride film has a density of 2.2g/cc or greater.

5. The method of claim 1 or 2 wherein the method is a vapor deposition process and is selected from the group consisting of at least one selected from plasma enhanced chemical vapor deposition and plasma enhanced cyclic chemical vapor deposition.

6. The method of Claim 1 or 2 wherein the method is conducted at one or more temperatures of 400°C or less.

7. The method of claim 1 or 2 wherein the method is conducted at one or more temperatures of 300°C or less.

8. The method of claim 1 or 2 wherein step b further comprises introducing a noble gas into the reactor.

9. A method of forming a silicon nitride film onto at least a surface of a substrate, the method comprising the steps of:

a. providing a substrate in a reactor;

b. introducing into the reactor at least one cyclodisilazane precursor selected from the group consisting of 1,3-bis(tert-butyl)cyclodisilazane, 1,3-bis(tert-butyl)-2-methylcyclodisilazane, 1,3-bis(tert-butyl)-2,4-dimethylcyclodisilazane, 1,3-bis(tert-amyl)cyclodisilazane, 1,3-bis(tert-amyl)-2-methylcyclodisilazane, 1,3-bis(tert-amyl)-2,4-dimethylcyclodisilazane, 1,3-bis(tert-butyl)-2-chlorocyclodisilazane, 1,3-bis(tert-butyl)-2,4-dichlorocyclodisilazane, 1,3-bis(tert-amyl)-2-chlorocyclodisilazane, 1,3-bis(tert-amyl)-2,4-dichlorocyclodisilazane, 1,3-bis(tert-butyl)-2,4,4-trichlorocyclodisilazane, 1,3-bis(tert-butyl)-2-dimethylcyclodisilazane, 1,3-bis(tert-butyl)-2-chloro-2-methylcyclodisilazane, 1,3-bis(tert-amyl)-2-dimethylcyclodisilazane, 1,3-bis(tert-amyl)-2-chloro-2-methyl-cyclodisilazane, 1,3-bis(tert-butyl)-2-vinylcyclodisilazane, 1,3-bis(tert-butyl)-2-ethynylcyclodisilazane and combinations thereof wherein the at least one cyclodisilazane reacts on at least a portion of the surface of the substrate to provide a chemisorbed layer;

c. purging the reactor with a purge gas comprising at least one selected from nitrogen, a noble gas, and combinations thereof;

d. introducing a plasma containing source into the reactor to react with at least a portion of the chemisorbed layer and provide an at least one reactive site wherein the plasma is generated at a power density ranging from 0.01 to 1.5 W/cm^2; and

e. optionally purging the reactor with an inert gas; and wherein the steps b through e are repeated until a desired thickness of the silicon nitride film is obtained.

10. The method of claim 9 wherein the silicon nitride film has a density of 2.2g/cc or greater.

11. The method of Claim 9 wherein the method is a vapor deposition process selected from the group consisting of at least one selected from plasma enhanced chemical vapor deposition and plasma enhanced cyclic chemical vapor deposition.

12. The method of Claim 9 wherein the method is conducted at a temperature of 400°C or less.

13. The method of claim 9 wherein the method is conducted at a temperature of 300°C or less.

14. The method of claim 9 where the plasma containing source is selected from the group consisting of a nitrogen/argon plasma, ammonia plasma, nitrogen/ammonia plasma, ammonia/helium plasma, ammonia/argon plasma, ammonia/nitrogen plasma, NF_3 plasma, organoamine plasma, and mixtures thereof.

15. The method of claim 9 wherein step b further comprises introducing a noble gas into the reactor.

16. The method of claim 9 wherein a plasma comprising hydrogen can be inserted before step d to help remove hydrocarbon generated from the reaction between the cyclodisilazane and the surface.

17. The method of claim 16 wherein the plasma comprising hydrogen is selected from the group consisting of hydrogen plasma, hydrogen/helium, hydrogen/argon plasma, hydrogen/neon plasma and mixtures thereof.

18. A composition for a vapor deposition of a silicon-containing film comprising at least one cyclodisilazane precursor selected from the group consisting of 1,3-bis(tert-butyl)cyclodisilazane 1,3-bis(tert-butyl)-2-methylcyclodisilazane, 1,3-bis(tert-butyl)-2,4-dimethylcyclodisilazane, 1,3-bis(tert-amyl)cyclodisilazane, 1,3-bis(tert-amyl)-2-methylcyclodisilazane, 1,3-bis(tert-amyl)-2,4-dimethylcyclodisilazane, 1,3-bis(tert-butyl)-

2-chlorocyclodisilazane, 1,3-bis(tert-butyl)-2,4-dichlorocyclodisilazane, 1,3-bis(tert-amyl)-2-chlorocyclodisilazane, 1,3-bis(tert-amyl)-2,4-dichlorocyclodisilazane, 1,3-bis(tert-butyl)-2,4,4-trichlorocyclodisilazane, 1,3-bis(tert-butyl)-2-dimethylcyclodisilazane, 1,3-bis(tert-butyl)-2-chloro-2-methylcyclodisilazane, 1,3-bis(tert-amyl)-2-dimethylcyclodisilazane, 1,3-bis(tert-amyl)-2-chloro-2-methyl-cyclodisilazane, 1,3-bis(tert-butyl)-2-vinylcyclodisilazane, 1,3-bis(tert-butyl)-2-ethynyl cyclodisilazane.

19. A vessel which is used to deliver a cyclodisilazane precursor for the deposition of a silicon-containing film, the vessel comprising:

a cyclodisilazane precursor selected from the group consisting of 1,3-bis(tert-butyl)cyclodisilazane, 1,3-bis(tert-butyl)-2-methylcyclodisilazane, 1,3-bis(tert-butyl)-2,4-dimethylcyclodisilazane, 1,3-bis(tert-amyl)cyclodisilazane, 1,3-bis(tert-amyl)-2-methylcyclodisilazane, 1,3-bis(tert-amyl)-2,4-dimethylcyclodisilazane, 1,3-bis(tert-butyl)-2-chlorocyclodisilazane, 1,3-bis(tert-butyl)-2,4-dichlorocyclodisilazane, 1,3-bis(tert-amyl)-2-chlorocyclodisilazane, 1,3-bis(tert-amyl)-2,4-dichlorocyclodisilazane, 1,3-bis(tert-butyl)-2,4,4-trichlorocyclodisilazane, 1,3-bis(tert-butyl)-2-dimethylcyclodisilazane, 1,3-bis(tert-butyl)-2-chloro-2-methylcyclodisilazane, 1,3-bis(tert-amyl)-2-dimethylcyclodisilazane, 1,3-bis(tert-amyl)-2-chloro-2-methyl-cyclodisilazane, 1,3-bis(tert-butyl)-2-vinylcyclodisilazane, 1,3-bis(tert-butyl)-2-ethynyl cyclodisilazane1,3-bis(tert-butyl)-2-vinylcyclodisilazane, 1,3-bis(tert-butyl)-2-ethynyl cyclodisilazane; and

wherein the purity of the precursor is about 98% or greater; and

the headspace of the container comprising inert gas selected from the group consisting of helium, argon, nitrogen and combination thereof.

20. The vessel of claim 19 wherein the vessel is comprised of stainless steel.