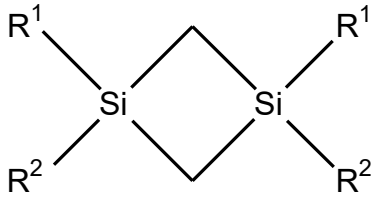
CLAIMS

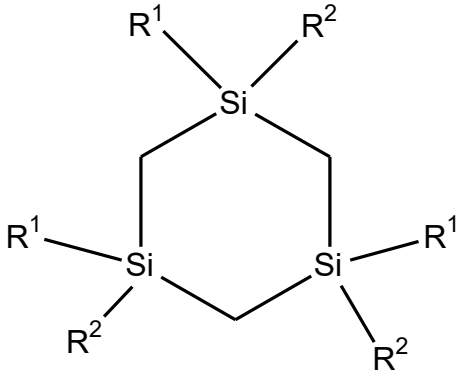
1. A method of forming a dielectric film comprising silicon and carbon onto at least a surface of a substrate, the method comprising the steps of:

a. providing a substrate in a reactor;

b. introducing into the reactor at least one silacycloalkane precursor selected from the group consisting of compounds represented by the structure of Formula IA and compounds represented by the structure of Formula IB:



IA



IB

wherein R^1 is selected from the group consisting of hydrogen, a linear or branched C_1 to C_{10} alkyl group, a cyclic C_3 to C_{10} alkyl group, a linear or branched C_2 to C_{10} alkenyl group, and a linear or branched C_2 to C_{10} alkynyl group; and R^2 is selected from the group consisting of a linear or branched C_2 to C_6 alkenyl group, a linear or branched C_2 to C_6 alkynyl group, and a cyclic C_3 to C_{10} alkyl group, wherein Formula IA or IB comprises at least two carbon-carbon double or triple bonds or at least two cyclic alkane groups, and wherein the at least one silacycloalkane precursor 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 dielectric film is obtained.

2. The method of claim 1 wherein the at least one silacycloalkane precursor is selected from the group consisting of 1,3-divinyl-1,3-disilacyclobutane, 1,3-divinyl-1,3-

dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetravinyl-1,3-disilacyclobutane, 1,3,5-trivinyl-1,3,5-trisilacyclohexane, 1,3,5-trivinyl-1,3,5-trimethyl-1,3,5-trisilacyclohexane, 1,1,3,3,5,5-hexavinyl-1,3,5-trisilacyclohexane, 1,3-diallyl-1,3-disilacyclobutane, 1,3-diallyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetraallyl-1,3-disilacyclobutane, 1,3,5-triallyl-1,3,5-trisilacyclohexane, 1,3,5-triallyl-1,3,5-trimethyl-1,3,5-trisilacyclohexane, 1,1,3,3,5,5-hexaallyl-1,3,5-trisilacyclohexane, 1,3-diacetylenyl-1,3-disilacyclobutane, 1,3-diacetylenyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetraacetylenyl-1,3-disilacyclobutane, 1,3,5-triacetylenyl-1,3,5-trisilacyclohexane, 1,3,5-triacetylenyl-1,3,5-trimethyl-1,3,5-trisilacyclohexane, 1,1,3,3,5,5-hexaacetylenyl-1,3,5-trisilacyclohexane 1,3-dicyclopropyl-1,3-disilacyclobutane, 1,3-dicyclopropyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetracyclopropyl-1,3-disilacyclobutane
and combinations thereof.

3. The method of claim 1 the plasma containing source is selected from the group consisting of hydrogen plasma, hydrogen/helium, hydrogen/argon plasma, hydrogen/neon plasma, helium plasma, argon plasma, neon plasma, and mixtures thereof.

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

5. The method of claim 1 wherein the method is at least one vapor deposition process selected from the group consisting of plasma enhanced atomic layer deposition, plasma enhanced cyclic chemical vapor deposition, and plasma enhanced flowable chemical vapor deposition.

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

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

8. A method of forming a silicon carbide or silicon carbonitride 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 silacycloalkane precursor selected from the group consisting of 1,3-divinyl-1,3-disilacyclobutane, 1,3-divinyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetravinyl-1,3-disilacyclobutane, 1,3,5-trivinyl-1,3,5-trisilacyclohexane, 1,3,5-trivinyl-1,3,5-trimethyl-1,3,5-trisilacyclohexane, 1,1,3,3,5,5-hexavinyl-1,3,5-trisilacyclohexane, 1,3-diallyl-1,3-disilacyclobutane, 1,3-diallyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetraallyl-1,3-disilacyclobutane, 1,3,5-triallyl-1,3,5-trisilacyclohexane, 1,3,5-triallyl-1,3,5-trimethyl-1,3,5-trisilacyclohexane, 1,1,3,3,5,5-hexaallyl-1,3,5-trisilacyclohexane, 1,3-diacetylenyl-1,3-disilacyclobutane, 1,3-diacetylenyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetraacetylenyl-1,3-disilacyclobutane, 1,3,5-triacetylenyl-1,3,5-trisilacyclohexane, 1,3,5-triacetylenyl-1,3,5-trimethyl-1,3,5-trisilacyclohexane, 1,1,3,3,5,5-hexaacetylenyl-1,3,5-trisilacyclohexane 1,3-dicyclopropyl-1,3-disilacyclobutane, 1,3-dicyclopropyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetracyclopropyl-1,3-disilacyclobutane,
and combinations thereof, wherein the at least one silacycloalkane 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.

9. The method of claim 8 wherein the silicon carbide or silicon carbonitride film has a density of 2.2g/cc or greater.

10. The method of claim 8 wherein method is a vapor deposition process selected from the group consisting of plasma enhanced atomic layer deposition, plasma enhanced cyclic chemical vapor deposition, and plasma enhanced flowable chemical vapor deposition.

11. The method of claim 8 wherein the method is conducted at a temperature of 400°C or less.

12. The method of claim 8 wherein the method is conducted at a temperature of 300°C or less.

13. The method of claim 8 wherein the method is conducted at a temperature of 100°C or less.

14. The method of claim 8 where the plasma containing source is selected from the group consisting of hydrogen plasma, hydrogen/helium, hydrogen/argon plasma, hydrogen/neon plasma, helium plasma, argon plasma, neon plasma, 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. A composition for a vapor deposition of a silicon-containing dielectric film comprising at least one silacycloalkane precursor selected from the group consisting of 1,3-bis(tert-butyl)silacycloalkane, 1,3-bis(tert-butyl)-2-methylsilacycloalkane, 1,3-bis(tert-butyl)-2,4-dimethylsilacycloalkane, 1,3-bis(tert-amyl)silacycloalkane, 1,3-bis(tert-amyl)-2-methylsilacycloalkane, 1,3-bis(tert-amyl)-2,4-dimethylsilacycloalkane, 1,3-bis(tert-butyl)-2-chloroclodisilazane, 1,3-bis(tert-butyl)-2,4-dichlorosilacycloalkane, 1,3-bis(tert-amyl)-2-chloroclodisilazane, 1,3-bis(tert-amyl)-2,4-dichlorosilacycloalkane, 1,3-bis(tert-butyl)-2,4,4-trilchlorosilacycloalkane, 1,3-bis(tert-butyl)-2-dimethylsilacycloalkane, 1,3-bis(tert-butyl)-2-chloro-2-methylsilacycloalkane, 1,3-bis(tert-amyl)-2-dimethylsilacycloalkane, 1,3-bis(tert-amyl)-2-chloro-2-methyl-silacycloalkane, 1,3-bis(tert-butyl)-2-vinylsilacycloalkane, 1,3-bis(tert-butyl)-2-ethynyl silacycloalkane, 1,3-dicyclopropyl-1,3-disilacyclobutane, 1,3-dicyclopropyl-1,3-dimethyl-1,3-disilacyclobutane, and 1,1,3,3-tetracyclopropyl-1,3-disilacyclobutane, wherein the silacycloalkane precursor is substantially free of one or more impurities selected from the group consisting of a halide, water, metal ions, and combinations thereof.

16. The composition of claim 15, wherein the halide comprises chloride ions.

17. The composition of claim 15, wherein the chloride ion concentration is less than 50 ppm.

18. The composition of claim 13, wherein the chloride ion concentration is less than 10 ppm.

19. The composition of claim 13, wherein the chloride ion concentration is less than 5 ppm.

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

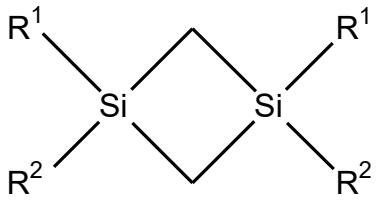
a silacycloalkane precursor selected from the group consisting of 1,3-bis(tert-butyl)silacycloalkane, 1,3-bis(tert-butyl)-2-methylsilacycloalkane, 1,3-bis(tert-butyl)-2,4-dimethylsilacycloalkane, 1,3-bis(tert-amyl)silacycloalkane, 1,3-bis(tert-amyl)-2-methylsilacycloalkane, 1,3-bis(tert-amyl)-2,4-dimethylsilacycloalkane, 1,3-bis(tert-butyl)-2-chloroclodisilazane, 1,3-bis(tert-butyl)-2,4-dichlorosilacycloalkane, 1,3-bis(tert-amyl)-2-chloroclodisilazane, 1,3-bis(tert-amyl)-2,4-dichlorosilacycloalkane, 1,3-bis(tert-butyl)-2,4,4-trilchlorosilacycloalkane, 1,3-bis(tert-butyl)-2-dimethylsilacycloalkane, 1,3-bis(tert-butyl)-2-chloro-2-methylsilacycloalkane, 1,3-bis(tert-amyl)-2-dimethylsilacycloalkane, 1,3-bis(tert-amyl)-2-chloro-2-methyl-silacycloalkane, 1,3-bis(tert-butyl)-2-vinylsilacycloalkane, 1,3-bis(tert-butyl)-2-ethynyl silacycloalkane1,3-bis(tert-butyl)-2-vinylsilacycloalkane, 1,3-bis(tert-butyl)-2-ethynyl silacycloalkane, 1,3-dicyclopropyl-1,3-disilacyclobutane, 1,3-dicyclopropyl-1,3-dimethyl-1,3-disilacyclobutane, and 1,1,3,3-tetracyclopropyl-1,3-disilacyclobutane, wherein the silacycloalkane precursor is substantially free of one or more impurities selected from the group consisting of a halide, water, metal ions, and combinations thereof, wherein the purity of the precursor is about 98% or greater, and wherein the vessel has a headspace comprising at least one inert gas selected from the group consisting of helium, argon, nitrogen and combination thereof.

21. The vessel of claim 24 wherein the vessel is comprised of stainless steel.

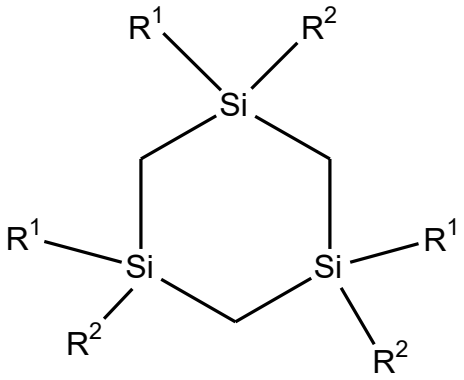
22. A method for depositing a dielectric film comprising silicon and carbon via plasma enhanced flowable chemical vapor deposition, the method comprising the steps of:

placing a substrate comprising a surface feature into a reactor which is at one or more temperatures ranging from -20°C to 200°C;

introducing into the reactor at least one silacycloalkane precursor selected from the group consisting of compounds represented by the structure of Formula IA and compounds represented by the structure of Formula IB:



IA



IB

wherein R^1 is selected from the group consisting of hydrogen, a linear or branched C_1 to C_{10} alkyl group, cyclic C_3 to C_{10} alkyl group, a linear or branched C_2 to C_{10} alkenyl group, and a linear or branched C_2 to C_{10} alkynyl group; and R^2 is selected from the group consisting of a linear or branched C_2 to C_6 alkenyl group, a linear or branched C_2 to C_6 alkynyl group, and a cyclic C_3 to C_{10} alkyl group, wherein Formula IA or IB comprises at least two carbon-carbon double or triple bonds or at least two cyclic alkane groups; and

providing a plasma source into the reactor to at least partially react the first and second compounds to form a flowable liquid, wherein the flowable liquid at least partially fills a portion of the surface feature.

23. The method of claim 22 wherein the at least one silacycloalkane precursor is selected from the group consisting of 1,3-divinyl-1,3-disilacyclobutane, 1,3-divinyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetravinyl-1,3-disilacyclobutane, 1,3,5-trivinyl-

1,3,5-trisilacyclohexane, 1,3,5-trivinyl-1,3,5-trimethyl-1,3,5-trisilacyclohexane, 1,1,3,3,5,5-hexavinyl-1,3,5-trisilacyclohexane, 1,3-diallyl-1,3-disilacyclobutane, 1,3-diallyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetraallyl-1,3-disilacyclobutane, 1,3,5-triallyl-1,3,5-trisilacyclohexane, 1,3,5-triallyl-1,3,5-trimethyl-1,3,5-trisilacyclohexane, 1,1,3,3,5,5-hexaallyl-1,3,5-trisilacyclohexane, 1,3-diacetylenyl-1,3-disilacyclobutane, 1,3-diacetylenyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetraacetylenyl-1,3-disilacyclobutane, 1,3,5-triacetylenyl-1,3,5-trisilacyclohexane, 1,3,5-triacetylenyl-1,3,5-trimethyl-1,3,5-trisilacyclohexane, 1,1,3,3,5,5-hexaacetylenyl-1,3,5-trisilacyclohexane 1,3-dicyclopropyl-1,3-disilacyclobutane, 1,3-dicyclopropyl-1,3-dimethyl-1,3-disilacyclobutane, 1,1,3,3-tetracyclopropyl-1,3-disilacyclobutane
and combinations thereof.

24. The method of claim 22 wherein the deposition process is a plasma enhanced chemical vapor deposition and the plasma is generated *in situ*.

25. The method of claim 22 wherein the deposition process is a plasma enhanced chemical vapor deposition and the plasma is generated remotely.

26. The method of Claim 22 wherein the deposition process is a plasma enhanced chemical vapor deposition and the plasma comprises dual plasma sources wherein one source is generated *in situ* and one source is generated remotely.

27. The method of claim 22 wherein the reactor which is at one or more temperatures ranging from -20°C to 100°C.

28. The method of claim 22 wherein the flowable liquid comprises at least one oligomer.