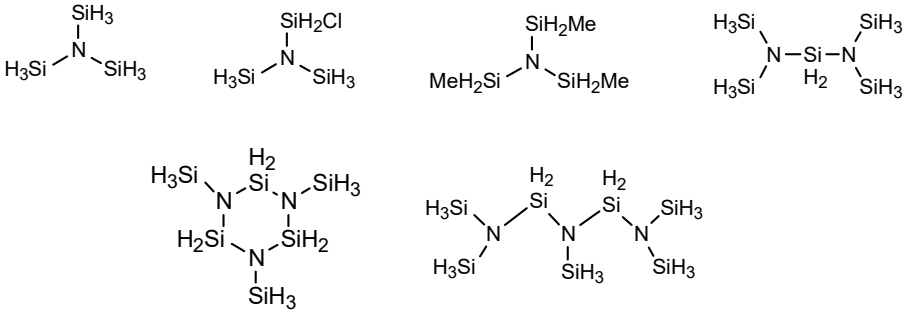
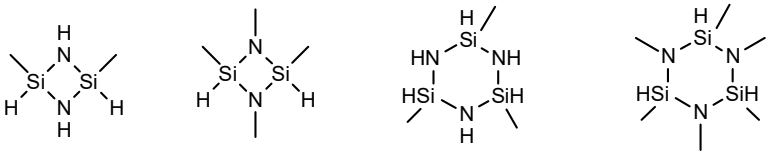


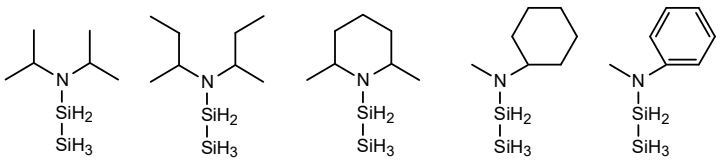
[0038] Exemplary compounds for Formula IIG include, but not limited to, the following:



[0039] Exemplary compounds for Formula IIH include, but not limited to, the following:



[0040] Exemplary compounds for Formula IIIA include, but not limited to, the following:



[0041] In the formulae above and throughout the description, the term “linear or branched alkyl” denotes a linear functional group having from 1 to 10, 3 to 10, or 1 to 6 carbon atoms. In the formulae above and throughout the description, the term “branched alkyl” denotes a linear functional group having from 3 to 10, or 1 to 6 carbon atoms. Exemplary linear or branched alkyl groups include, but are not limited to, methyl (Me), ethyl (Et), isopropyl (Pr^i), isobutyl (Bu^i), sec-butyl (Bu^s), tert-butyl (Bu^t), iso-pentyl, tert-pentyl (am), isohexyl, and

CLAIMS

1. A method for depositing a silicon-containing film in a flowable chemical vapor deposition process, the method comprising:

placing a substrate comprising a surface feature into a reactor which is at one or more temperatures ranging from -20°C to about 400°C;

introducing into the reactor a first compound having at least one carbon-carbon double bond or carbon-carbon triple bond wherein the first compound having the formula $R^1_nSiR_{4-n}$ wherein R is selected a linear or branched C_2 to C_6 alkenyl group, a linear or branched C_2 to C_6 alkynyl group; R^1 is selected from hydrogen and a branched C_1 to C_{10} alkyl group; and n is a number selected from 0, 1, 2, and 3;

introducing into the reactor a second compound having at least one Si-H bond wherein the second compound is selected from the group consisting of the following Formula IIA to IIH and IIIA:

IIA. a polysilane compound having a formula of Si_xH_{2x+2} wherein x is a number from 2 to 6;

IIB. a compound having the formula $R^1_mSiH_{4-m}$ wherein R^1 is selected from hydrogen and a linear or branched C_1 to C_{10} alkyl group; and m is a number selected from 1, 2 and 3;

IIC. a compound having the formula SiH_3-R^2-SiH_3 wherein R^2 is a linear or branched C_1 to C_6 alkylene group;

IID. a compound having the formula R^3SiH_2-R^2-SiH_2R^4 wherein R^2 is a linear or branched C_1 to C_6 alkylene group; R^3 is selected from hydrogen, a linear or branched C_1 to C_{10} alkyl group, and a C_4 to C_{10} aryl group; and R^4 is selected from a linear or branched C_1 to C_{10} alkyl group;

IIE. a compound having the formula $(R^3R^4N)_nSiH_{3-n}R^1$ wherein R^1 is selected from hydrogen and a linear or branched C_1 to C_{10} alkyl group; R^3 is selected from hydrogen, a linear or branched C_1 to C_{10} alkyl group, and a C_4 to C_{10} aryl group; and R^4 is selected from a linear or branched C_1 to C_{10} alkyl group;

IIF. a silacycloalkyl compound;

IIG. a trisilylamine compound or derivatives thereof;

IIH. a silazane compound having the formula of $[(R^3R^4N)_pSiH_{3-p}]_2NR^1$ or $[R^3_pSiH_{2-p}NR^1]_q$ wherein R^1 is selected from hydrogen and a linear or branched C_1 to C_{10} alkyl group; R^3 is selected from hydrogen, a linear or branched C_1 to C_{10} alkyl group, and a C_4 to C_{10} aryl group; and R^4 is selected from a linear or branched C_1 to C_{10} alkyl group; p=0, 1, 2; q=2 or 3; and

IIIA. An organoaminodisilanes having the formula of $(R^3R^4N)SiH_2SiH_3$ wherein R^3 is selected from hydrogen, a branched C_1 to C_{10} alkyl group, and a C_4 to C_{10} aryl group; and R^4 is selected from a linear or branched C_1 to C_{10} alkyl group; and

at least partially reacting the first and second compounds to form a flowable liquid or oligomer wherein the flowable liquid or oligomer at least partially fills a portion of the surface feature.

2. The method of claim 1, wherein at least partially reacting the first and second compounds comprises providing a plasma source into the reactor to induce reaction between the first and second compounds.

3. The method of claim 2 wherein the providing step comprises a plasma source comprising nitrogen is selected from the group consisting of nitrogen plasma, a plasma comprising nitrogen and hydrogen, a plasma comprising nitrogen and helium, a plasma comprising nitrogen and argon, ammonia plasma, a plasma comprising ammonia and helium, a plasma comprising ammonia and argon, a plasma comprising ammonia and nitrogen, NF_3, NF_3 plasma, organic amine plasma, and mixtures thereof.

4. The method of claim 2 wherein the providing step comprises a plasma source selected from but not limited to the group consisting of a carbon source plasma, including a hydrocarbon plasma, a plasma comprising hydrocarbon and helium, a plasma comprising hydrocarbon and argon, carbon dioxide plasma, carbon monoxide plasma, a plasma comprising hydrocarbon and hydrogen, a plasma comprising hydrocarbon and a nitrogen source, a plasma comprising hydrocarbon and an oxygen source, and mixture thereof.

5. The method of claim 2 wherein the plasma source is selected from but not limited to hydrogen plasma, helium plasma, argon plasma, xenon plasma, and mixture thereof.

6. The method of claim 2 wherein the providing step comprises a plasma source comprising oxygen is selected from the group consisting of water (H_2O) plasma, oxygen plasma, ozone (O_3) plasma, NO plasma, N_2O plasma, carbon monoxide (CO) plasma, carbon dioxide (CO_2) plasma and combinations thereof.

7. The method of claim 1 further comprising treating the flowable liquid at one or more temperatures ranging from about 100 ºC to about 1000 ºC to densify at least a portion of the materials.

8. The method of claim 7, wherein the post thermal treatment materials are exposed to a plasma, infrared lights, chemical treatment, an electron beam, or UV light to form a dense film.

9. The method of claim 1 wherein the deposition process is a plasma enhanced chemical vapor deposition and the plasma is generated *in situ*.

10. The method of claim 1 wherein the deposition process is a plasma enhanced chemical vapor deposition and the plasma is generated remotely.

11. The method of claim 1 wherein a pressure of the reactor is maintained at 100 torr or less.

12. The method of claim 1 wherein the silicon-containing film is selected from the group consisting of silicon carbide, silicon nitride, silicon oxide, carbon doped silicon nitride, carbon doped silicon oxide, silicon oxynitride, and carbon doped silicon oxynitride film.

13. A chemical precursor for forming a silicon containing film that fills at least a portion of a surface feature on a substrate, the chemical precursor comprising at least two compounds wherein a first compound comprises at least one member selected from the group consisting of compounds having at least one carbon-carbon double bond or C-C triple bond wherein the compound is represented by the formula $R^1_nSiR_{4-n}$ wherein R is selected from a linear or branched C_2 to C_6 alkenyl group, a linear or branched C_2 to C_6 alkynyl group; R^1 is selected from hydrogen and a branched C_1 to C_{10} alkyl group; and n is a number selected from 0, 1, 2, and 3, and a second compound comprise at least one member selected from the group consisting of the following Formulae:

IIA. a polysilane compound having a formula of Si_xH_{2x+2} wherein x is a number from 2 to 6;

IIB. a compound having the formula $R^1_mSiH_{4-m}$ wherein R^1 is selected from hydrogen and a linear or branched C_1 to C_{10} alkyl group; and m is a number selected from 1, 2 and 3;

IIC. a compound having the formula SiH_3-R^2-SiH_3 wherein R^2 is a linear or branched C_1 to C_6 alkylene group;

IID. a compound having the formula R^3SiH_2-R^2-SiH_2R^4 wherein R^2 is a linear or branched C_1 to C_6 alkylene group; R^3 is selected from hydrogen, a linear or branched C_1 to C_{10} alkyl group, and a C_4 to C_{10} aryl group; and R^4 is selected from a linear or branched C_1 to C_{10} alkyl group;

IIE. a compound having the formula $(R^3R^4N)_nSiH_{3-n}R^1$ wherein R^1 is selected from hydrogen and a branched C_1 to C_{10} alkyl group; R^3 is selected from hydrogen, a linear or branched C_1 to C_{10} alkyl group, and a C_4 to C_{10} aryl group; and R^4 is selected from a linear or branched C_1 to C_{10} alkyl group;

IIF. a silacycloalkyl compound;

IIG. a trisilylamine compound or derivatives thereof;

IIH. a silazane compound having the formula of $[(R^3R^4N)_pSiH_{3-p}]_2NR^1$ or $[R^3_pSiH_{2-p}NR^1]_q$ wherein R^1 is selected from hydrogen and a linear or branched C_1 to C_{10} alkyl group; R^3 is selected from hydrogen, a linear or branched C_1 to C_{10} alkyl group, and a C_4 to C_{10} aryl

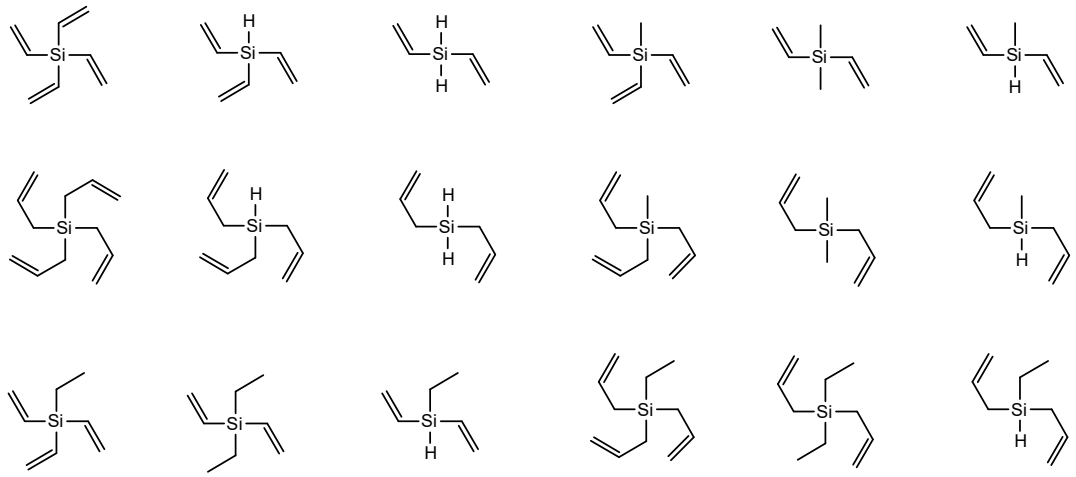
group; and R^4 is selected from a linear or branched C_1 to C_{10} alkyl group; p=0, 1, 2; q=2 or 3; and

IIIA. an organoaminodisilanes having the formula of $(R^3R^4N)SiH_2SiH_3$ wherein R^3 is selected from hydrogen, a branched C_1 to C_{10} alkyl group, and a C_4 to C_{10} aryl group; and R^4 is selected from a linear or branched C_1 to C_{10} alkyl group,

wherein the first and second compounds are capable of at least partially reacting with each other to form a flowable liquid or oligomer, further wherein the flowable liquid or oligomer is capable of at least partially filling a portion of a surface feature on a substrate.

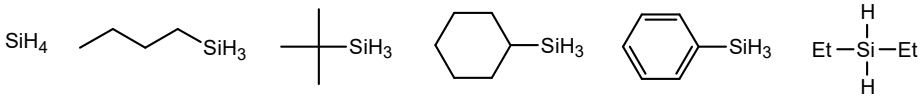
14. The precursor of claim 13, wherein R^3 and R^4 in Formula IIIA are linked to form a ring.

15. The precursor of Claim 13 wherein the first compound comprises at least one member selected from the group consisting of:

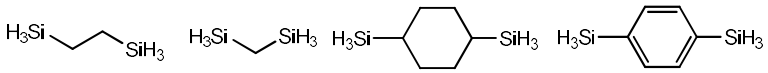


16. The precursor of Claim 13 wherein the second compound comprises at least one member selected from the group consisting of disilane, trisilane, tetrasilane, pentasilane, hexasilane, and combinations thereof.

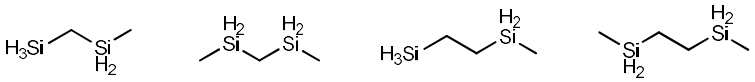
17. The precursor of Claim 13 wherein the second compound comprises at least one member selected from the group consisting of



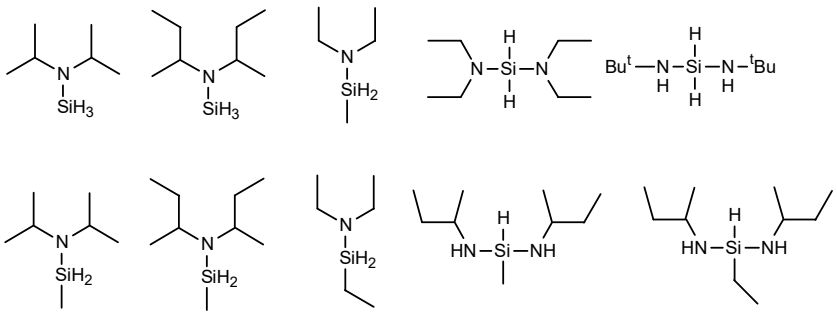
18. The precursor of Claim 13 wherein the second compound comprises at least one member selected from the group consisting of:



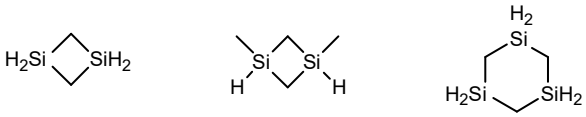
19. The precursor of Claim 13 wherein the second compound comprises at least one member selected from the group consisting of:



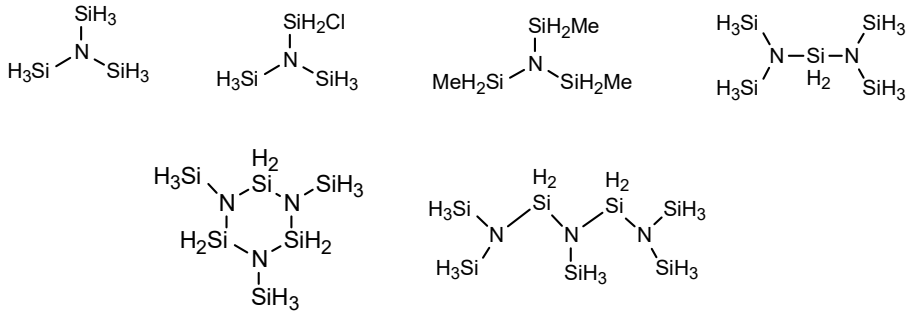
20. The precursor of Claim 13 wherein the second compound comprises at least one member selected from the group consisting of:



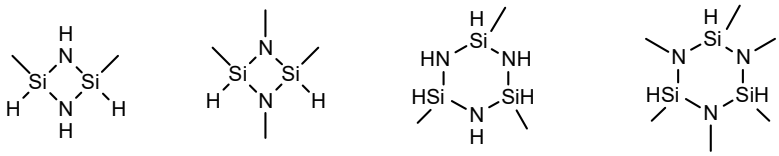
21. The precursor of Claim 13 wherein the second compound comprises at least one member selected from the group consisting of:



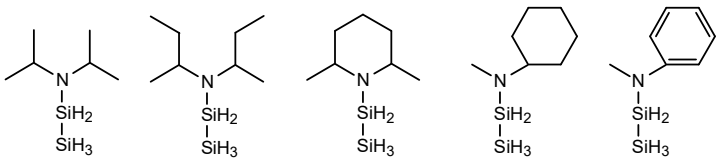
22. The precursor of Claim 13 wherein the second compound comprises at least one member selected from the group consisting of:



23. The precursor of Claim 13 wherein the second compound comprises at least one member selected from the group consisting of:



24. The precursor of Claim 13 wherein the second compound comprises at least one member selected from the group consisting of:



25. A silicon-containing film obtained by the method of Claim 1, wherein the film has a film tensile stress ranging from 150 to 190 MPa after a UV cure.

26. The silicon-containing film of Claim 25 upon at least a portion of a substrate.