CLAIMS

1. A method of forming a SiC/SiCN film layer on a surface of a semiconductor substrate in a processing chamber, the method comprising:

introducing a silicon-containing film-precursor into the processing chamber;

introducing an organometallic ligand transfer reagent into the processing chamber, wherein the organometallic ligand transfer reagent is a metal alkylamine compound that does not contain a halogen atom;

adsorbing the silicon-containing film-precursor, the organometallic ligand transfer reagent, or both onto the surface under conditions whereby either or both form an adsorption-limited layer;

reacting the silicon-containing film-precursor with the organometallic ligand transfer reagent, after either or both have formed the adsorption-limited layer, to form the film layer and a byproduct which contains substantially all of the metal of the organometallic ligand transfer reagent; and

removing the byproduct from the processing chamber.

2. The method of Claim 1, wherein the SiC/SiCN film layer is a conformal film layer.

3. The method of Claim 2, wherein the surface of the substrate upon which the film is formed has patterned three-dimensional features.

4. The method of Claim 1, wherein the silicon-containing film-precursor is a silane which does not contain a halogen atom.

5. The method of Claim 4, wherein the silane comprises an alkyl group selected from the methyl, ethyl, propyl, and t-butyl functional groups.

6. The method of Claim 5, wherein the silane comprises two alkyl groups selected from the methyl, ethyl, propyl, and t-butyl functional groups.

7. The method of Claim 5, wherein the silane is selected from methylsilane, ethylsilane, isopropylsilane, t-butylsilane, dimethylsilane, trimethylsilane, diethylsilane, di-t-butylsilane, allylsilane, sec-butylsilane, thexylsilane, isoamylsilane, t-butyldisilane, and di-t-butyldisilane.

8. The method of Claim 4, wherein the silane comprises a first amine group.

9. The method of Claim 8, wherein the silane further comprises a second amine group, and wherein the first amine group is substituted with an alkyl group and the second amine group is substituted with an alkyl group.

10. The method of Claim 8, wherein the silane is selected from mono-aminosilane, di-aminosilane, tri-aminosilane, tetra-aminosilane, t-butylaminosilane, methylaminosilane, t-butylsilanamine, n-tert-butyltrimethylsilylamine, t-butyl silylcarbamate, $SiHCH_3(N(CH_3)_2)_2$, $SiH(N(CH_3)_2)_3$, $SiHCl(N(CH_3)_2)_2$, $Si(CH_3)_2(NH_2)_2$, $N(SiH_3)_3$, and $(NR)_2Si(CH_3)_2$ where R is selected from H, Me, Et, i-Pr, n-Pr, and t-butyl.

11. The method of Claim 1, wherein the silicon-containing film-precursor forms the adsorption-limited layer prior to introducing the organometallic ligand transfer reagent into the processing chamber.

12. The method of Claim 1, wherein the organometallic ligand transfer reagent forms the adsorption-limited layer prior to introducing the silicon-containing film-precursor into the processing chamber.

13. The method of Claim 1, wherein the alkyl groups of the metal alkylamine compound are selected from the methyl, ethyl, propyl, and t-butyl functional groups.

14. A semiconductor processing apparatus for forming a SiC/SiCN film layer on a surface of a semiconductor substrate, the apparatus comprising:

a processing chamber having a substrate holder within the chamber;

a reactant delivery system fluidically connected to the processing chamber;

one or more vacuum pumps;

one or more gas outlets fluidically connecting the processing chamber to the one or more vacuum pumps; and

a system controller comprising a non-transitory machine readable medium comprising machine readable code, the code comprising:

instructions for operating the reactant delivery system to introduce a silicon-containing film-precursor into the processing chamber so that the silicon-containing

film-precursor adsorbs onto a surface of the substrate under conditions whereby the silicon-containing film-precursor forms an adsorption-limited layer;

instructions for operating the reactant delivery system to introduce an organometallic ligand transfer reagent into the processing chamber, wherein the organometallic ligand transfer reagent is a metal alkylamine compound that does not contain a halogen atom, and wherein the organometallic ligand transfer reagent is introduced so that it reacts with the adsorbed silicon-containing film-precursor to form a film layer and a byproduct which contains substantially all of the metal; and

instructions for operating the one or more gas outlets to evacuate the byproduct from the processing chamber.

15. The apparatus of Claim 14, wherein the SiC/SiCN film layer is a conformal film layer.

16. The apparatus of Claim 15, wherein the surface of the substrate upon which the film is formed has patterned three-dimensional features.

17. The apparatus of Claim 14, wherein the silicon-containing film-precursor is a silane which does not contain a halogen atom.

18. The apparatus of Claim 17, wherein the silane comprises an alkyl group selected from the methyl, ethyl, propyl, and t-butyl functional groups.

19. The apparatus of Claim 18, wherein the silane comprises two alkyl groups selected from the methyl, ethyl, propyl, and t-butyl functional groups.

20. The apparatus of Claim 18, wherein the silane is selected from methylsilane, ethylsilane, isopropylsilane, t-butylsilane, dimethylsilane, trimethylsilane, diethylsilane, di-t-butylsilane, allylsilane, sec-butylsilane, thexylsilane, isoamylsilane, t-butyldisilane, and di-t-butyldisilane.

21. The apparatus of Claim 17, wherein the silane comprises a first amine group.

22. The apparatus of Claim 21, wherein the silane further comprises a second amine group, and wherein the first amine group is substituted with an alkyl group and the second amine group is substituted with an alkyl group.

23. The apparatus of Claim 14, wherein the silicon-containing film-precursor forms the adsorption-limited layer prior to introducing the organometallic ligand transfer reagent into the processing chamber.

24. The apparatus of Claim 14, wherein the organometallic ligand transfer reagent forms the adsorption-limited layer prior to introducing the silicon-containing film-precursor into the processing chamber.

25. The apparatus of Claim 14, wherein the alkyl groups of the metal alkylamine compound are selected from the methyl, ethyl, propyl, and t-butyl functional groups.

We Claim:

1. A semiconductor processing apparatus for forming a SiC/SiCN film layer on a surface of a semiconductor substrate, the apparatus comprising:

a processing chamber having a substrate holder within the chamber;

a reactant delivery system fluidically connected to the processing chamber;

one or more vacuum pumps;

one or more gas outlets fluidically connecting the processing chamber to the one or more vacuum pumps; and

a system controller comprising machine readable code, the code comprising:

instructions for operating the reactant delivery system to introduce a silicon-containing film-precursor and an organometallic ligand transfer reagent into the processing chamber so that either or both adsorb onto a surface of a substrate held in the substrate holder under conditions whereby either or both form an adsorption-limited layer on the surface and thereafter react with one another to form a film layer and a byproduct which contains substantially all of the metal of the organometallic ligand transfer reagent; and

instructions for operating the one or more gas outlets to evacuate the byproduct from the processing chamber.

2. A semiconductor processing apparatus for forming a SiC/SiCN film layer on a surface of a semiconductor substrate, the apparatus comprising:

a processing chamber having a substrate holder within the chamber;

a reactant delivery system fluidically connected to the processing chamber;

one or more vacuum pumps;

one or more gas outlets fluidically connecting the processing chamber to the one or more vacuum pumps; and

a system controller comprising machine readable code, the code comprising:

instructions for operating the reactant delivery system to introduce a silicon-containing film-precursor into the processing chamber so that the silicon-containing film-precursor adsorbs onto a surface of the substrate under conditions whereby the silicon-containing film-precursor forms an adsorption-limited layer;

instructions for operating the reactant delivery system to introduce an organometallic ligand transfer reagent into the processing chamber so that the organometallic ligand transfer reagent reacts with the adsorbed silicon-containing film-precursor to form a film layer and a byproduct which contains substantially all of the metal of the ligand transfer reagent; and

instructions for operating the one or more gas outlets to evacuate the byproduct from the processing chamber.

3. A semiconductor processing apparatus for forming a SiC/SiCN film layer on a surface of a semiconductor substrate, the apparatus comprising:

a processing chamber having a substrate holder within the chamber;

a reactant delivery system fluidically connected to the processing chamber;

one or more vacuum pumps;

one or more gas outlets fluidically connecting the processing chamber to the one or more vacuum pumps; and

a system controller comprising machine readable code, the code comprising:

instructions for operating the reactant delivery system to introduce an organometallic ligand transfer reagent into the processing chamber so that the organometallic ligand transfer reagent adsorbs onto a surface of the substrate under conditions whereby the organometallic ligand transfer reagent forms an adsorption-limited layer;

instructions for operating the reactant delivery system to introduce a silicon-containing film-precursor into the processing chamber so that the silicon-containing

film-precursor reacts with the adsorbed organometallic ligand transfer reagent to form a film layer and a byproduct which contains substantially all of the metal of the ligand transfer reagent; and

instructions for operating the one or more gas outlets to evacuate the byproduct from the processing chamber.

4. The apparatus of Claim 2, wherein the silicon-containing film-precursor forms an adsorption-limited layer prior to operating the reactant delivery system to introduce the organometallic ligand transfer reagent into the processing chamber.

5. The apparatus of Claim 3, wherein the organometallic ligand transfer reagent forms an adsorption-limited layer prior to operating the reactant delivery system to introduce the silicon-containing film-precursor into the processing chamber.

6. An apparatus according to any one of Claims 1-3, wherein the SiC/SiCN film layer is a conformal film layer.

7. The apparatus of Claim 6, wherein the surface of the substrate upon which the film is formed has patterned three-dimensional features.

8. An apparatus according to any one of Claims 1-3, wherein the metal of the organometallic ligand transfer reagent is selected from zinc, aluminum, and magnesium.

9. An apparatus according to any one of Claims 1-3, wherein the organometallic ligand transfer reagent does not contain a halogen atom.

10. The apparatus of Claim 9, wherein the organometallic ligand transfer reagent is a metal alkyl compound.

11. The apparatus of Claim 10, wherein the alkyl groups of the metal alkyl compound are selected from the methyl, ethyl, propyl, and t-butyl functional groups.

12. The apparatus of Claim 9, wherein the organometallic ligand transfer reagent is a metal alkylamine compound.

13. An apparatus according to any one of Claims 1-3, wherein the silicon-containing film-precursor is a silane which does not contain a halogen atom.

14. The apparatus of Claim 13, wherein the silane comprises an alkyl group selected from the methyl, ethyl, propyl, and t-butyl functional groups.

15. The apparatus of Claim 14, wherein the silane comprises two alkyl groups selected from the methyl, ethyl, propyl, and t-butyl functional groups.

16. The apparatus of Claim 14, wherein the silane is selected from methylsilane, ethylsilane, isopropylsilane, t-butylsilane, dimethylsilane, trimethylsilane, diethylsilane, di-t-butylsilane, allylsilane, sec-butylsilane, thexylsilane, isoamylsilane, t-butyldisilane, and di-t-butyldisilane.

17. The apparatus of Claim 13, wherein the silane comprises a first amine group.

18. The apparatus of Claim 17, wherein the first amine group is substituted with a first alkyl group.

19. The apparatus of Claim 18, wherein the silane further comprises a second amine group substituted with a second alkyl group.

20. The apparatus of Claim 19, wherein the first alkyl group is selected from the methyl, ethyl, propyl, and t-butyl functional groups, and the second alkyl group is selected from the methyl, ethyl, propyl, and t-butyl functional groups.

21. The apparatus of Claim 17, wherein the silane is selected from mono-aminosilane, di-aminosilane, tri-aminosilane, tetra-aminosilane, t-butylaminosilane, methylaminosilane, t-butylsilanamine, n-tert-butyltrimethylsilylamine, t-butyl silylcarbamate, $SiHCH_3(N(CH_3)_2)_2$, $SiH(N(CH_3)_2)_3$, $SiHCl(N(CH_3)_2)_2$, $Si(CH_3)_2(NH_2)_2$, $N(SiH_3)_3$, and $(NR)_2Si(CH_3)_2$ where R is selected from H, Me, Et, i-Pr, n-Pr, and t-butyl.

22. A method of forming a SiC/SiCN film layer on a surface of a semiconductor substrate in a processing chamber, the method comprising:

introducing a silicon-containing film-precursor into the processing chamber;

introducing an organometallic ligand transfer reagent into the processing chamber;

adsorbing the silicon-containing film-precursor, the organometallic ligand transfer reagent, or both onto the surface under conditions whereby either or both form an adsorption-limited layer;

reacting the silicon-containing film-precursor with the organometallic ligand transfer reagent, after either or both have formed the adsorption-limited layer, to form the film layer and a byproduct which contains substantially all of the metal of the organometallic ligand transfer reagent; and

removing the byproduct from the processing chamber.

23. The method of Claim 22, wherein the silicon-containing film-precursor forms the adsorption-limited layer prior to introducing the organometallic ligand transfer reagent into the processing chamber.

24. The method of Claim 22, wherein the organometallic ligand transfer reagent forms the adsorption-limited layer prior to introducing the silicon-containing film-precursor into the processing chamber.